NJ Department of Environmental Protection
Water Monitoring and Standards

New Jersey Nutrient Criteria Enhancement Plan

April 2009

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New Jersey Nutrient Criteria Enhancement Plan

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April 2009

ACKNOWLEDGEMENTS

The Department of Environmental Protection would like to take this opportunity to acknowledge the various individuals listed below for their efforts and contributions regarding the New Jersey Nutrient Criteria Enhancement Plan. This document was developed based on the work of the Department's Nutrient Assessment Work Group under the direction of Debra Hammond, Chief, Bureau of Water Quality Standards and Assessment and overseen by Administrator Leslie McGeorge. The principal authors were Sandra Cohen and Steve Lubow (retired). Final revisions were made by Jack Pflaumer.

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Some of the material presented in this Plan grew from earlier work performed by the Phosphorus Evaluation Team (Team), a work group within the Department that met between 2003 and 2008. Many members of that Team are also members of the Nutrient Assessment Work Group and are acknowledged above. There are, however, Team members that are not part of the current Nutrient Workgroup and the Department would like to thank them as well for their contribution to the current Plan. They are (in alphabetical order):

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Table of Contents

I. Introduction

The New Jersey Department of Environmental Protection (Department) has prepared a plan for developing and enhancing nutrient criteria for all waters of the State. This Nutrient Criteria Enhancement Plan (Plan) was developed in conformance with a United States Environmental Protection Agency (USEPA) requirement that states develop nutrient criteria plans to outline a process for adopting nutrient criteria into state water quality standards. USEPA has encouraged all states to accelerate their efforts and give priority to adopting numeric nutrient standards or numeric translators for narrative standards for all waters that contribute nutrient loadings to their waterways. The New Jersey Plan was prepared with the input of a multi-program, departmental Nutrient Assessment Team, which also included a representative from the U.S. Geological Survey.

While USEPA has developed nutrient criteria on an ecoregion basis, it has given states the option of adopting these criteria or developing their own criteria based on USEPA guidance. New Jersey's Surface Water Quality Standards at N.J.A.C. 7:9B (SWQS) already contain numeric and narrative nutrient criteria for freshwaters. Due to a lack of sufficient nutrient and ecosystem response data, nutrient criteria have not yet been developed for the State's coastal waters. In addition, significant data and research developments have recently expanded the knowledge base about the general and site-specific factors that cause or contribute to nutrient impairment in New Jersey's waterways since these criteria were promulgated. Therefore, the Department has developed this Plan to enhance New Jersey's existing nutrient criteria to better address the sources and causes of nutrient impairment and its adverse impact on the beneficial uses of the State's waters and to guide development of nutrient criteria in other waters.

This Plan provides a detailed description of the Department's strategy for enhancing the existing nutrient criteria for freshwaters and developing new nutrient criteria for other (estuarine, marine) waters of the State. Nutrient criteria development requires an understanding of the complex causal relationships between nutrient over-enrichment, various response variables, and documented impacts on attainment of designated and existing uses of New Jersey waters. Nutrient criteria (which may include numeric criteria and numeric translators of narrative criteria) will be developed to address and prevent nutrient-related use impairment in New Jersey waters. New Jersey's Plan outlines the following steps to support and enhance nutrient criteria development:

1. Enhanced monitoring and data collection on nutrients and response variables;
2. Research on causal relationships for nutrients and response variables; selection of appropriate indicators of aquatic life use impairment;
3. Development of new assessment methodologies to define thresholds of use impairment based on ecosystem response variables;
4. Development of new/enhanced criteria; and
5. Promulgation of the new criteria through amendments to the Surface Water Quality Standards and implementation of the new assessment methodology through the Integrated Monitoring and Assessment Reporting process.

This Plan explains the details of each of these steps, including priorities, milestones, and timelines for nutrient criteria development, nutrient management strategies, and further study.

Public Involvement

The Department published a draft version of the Plan on its Web site at http://www.state.nj.us/dep/wms/bwqsa/nutrient_criteria.htm. On January 22, 2009, the Department held an informational meeting at Rutgers University's EcoComplex which was attended by approximately 60 people. The Department had the opportunity to address questions and comments at the meeting and accepted written comments until February 17, 2009. Comments were received from Clean Ocean Action, Delaware Riverkeeper, Hall & Associates, OMNI Environmental, and Sussex County Municipal Utilities Authority. The following key comments were provided:

- The nutrient plan is well conceived and the proposed nutrient criteria are a significant improvement over the current practice of considering only numeric criteria for total phosphorus (TP).
- Switching from numeric criteria for TP to narrative criteria will weaken current standards.
- Nutrient controls alone will not result in water quality restoration and use attainment because canopy restoration and stream bank stabilization are also necessary to control algae/plant growth and improve invertebrate communities.
- The link between total phosphorus concentrations and periphyton/macroinvertebrates has not been documented sufficiently to serve as the basis for water quality restoration.
- Nitrogen criteria are needed for freshwaters.
- Immediate action must be taken to reduce nitrogen pollution and nitrogen-related problems in New Jersey's marine waters.
- Adequate funding and staffing must be provided to support crucial monitoring and assessment activities described in the Plan.
- The 3 mg/l swing in dissolved oxygen (DO) concentration is not an appropriate indicator of eutrophication since many New Jersey locations exhibit such variations under natural conditions. The DO swing should be derived using statistics.
- Clarification is needed on how the response variables are being linked to nutrient impacts.
- The Plan does not establish deadlines for developing criteria for coastal waters.
- The Department should require the removal of run-of-the-river shallow impoundments that decrease water quality and obstruct fish movement.
- The Department should not use "peak" biomass to determine nutrient-related impacts
- The Department should require nutrient removal technologies on wastewater treatment facilities to address the cumulative and downstream impacts of nutrients.

The Department considered all of the comments and suggestions. Many of the comments recommended action to address the impacts from nutrients rather than the development of nutrient criteria. The comments did influence the Department's amendments to the nutrient criteria in the Surface Water Quality Standards proposed on April 20, 2009 (see 41 N.J.R. 1565(a)) and the new nutrient assessment method proposed in the *2010 Integrated Water Quality Monitoring and Assessment Methods*. As a result, no major changes were made to the Plan, although based on the comments some sections have been rewritten and clarified. However, these comments may result revisions to the Plan in the future.

This final Plan will serve as a "living" document that will be modified as program priorities and resources dictate. The Department will publish an annual progress report on its Web site and will submit an updated Plan to USEPA Region 2 every three years or as needed to address any substantive changes. Since monitoring is a critical component of the Plan, changes to the Plan will also be reflected in updates to the *New Jersey Water Monitoring & Assessment Strategy (2005-2014)* (NJDEP, 2004).

II. Background

USEPA has identified nutrients (nitrogen and phosphorus) as one of the leading causes of water quality impairment in U.S. rivers, lakes, and estuaries. Nutrients, primarily total phosphorus (TP), have long been identified as the primary cause of cultural eutrophication in New Jersey's non-tidal freshwaters (see Section III.A. Conceptual Approach). Unlike many states, New Jersey's Surface Water Quality Standards (SWQS) already contain numeric and narrative surface water quality criteria for phosphorus and policies for nutrients in freshwaters of the State, which were first promulgated in 1981. The narrative nutrient policies prohibit nutrient concentrations that cause objectionable algal densities, nuisance aquatic vegetation, or otherwise render waters unsuitable for designated uses. However, the SWQS do not include numeric translators that would be used to measure conformance with the narrative criteria; therefore, the Department has relied on the numeric phosphorus criteria for use assessment as well as regulatory purposes, such as establishing effluent limitations and development of total maximum daily loads (TMDLs) for waters assessed as impaired for phosphorus.

Nutrient data is currently available from a number of monitoring networks, Department research studies, non-departmental monitoring and assessment efforts, and water quality studies conducted by New Jersey Pollutant Discharge Elimination System (NJPDES) permittees as part of the development of water quality-based effluent limits and TMDL studies. This newly available data is now being used to inform assessment and regulatory decisions. The Passaic River TMDL was recently developed based on an assessment of compliance with the narrative phosphorus criteria using response indicators, including dissolved oxygen, pH, and chlorophyll *a*. These data and TMDLs provide much-needed information on the relationship between nutrient concentrations and the biological responses, which has been considered in the development of this Plan.

The Department now has a significant amount of nutrient and nutrient response data from freshwater lakes and wadeable streams. Additional monitoring, as well as biological indicator development, is needed in other types of waters to support nutrient criteria development. Specifically, monitoring data is needed to identify the causes and effects of excessive nutrients on riverine, estuarine, and marine ecosystems and to determine if aquatic life use is impaired, if impairment is due to nutrients, and if so, to develop appropriate nutrient criteria and/or reduction strategies for these types of waters.

A. New Jersey's Existing Nutrient Criteria

New Jersey's SWQS contain both numeric and narrative surface water quality criteria for phosphorus, at N.J.A.C. 7:9B-1.14(d)5, as well as narrative nutrient policies, at N.J.A.C. 7:9B-1.5(g), that apply to all freshwaters of the State.

Existing Nutrient Criteria (apply to all FW2 waters):

Lakes: Phosphorus as total P shall not exceed 0.05 mg/l in any lake, pond, or reservoir, or in a tributary at the point where it enters such bodies of water, except where watershed or site-specific criteria are developed pursuant to N.J.A.C. 7:9B-1.5(g)3. (N.J.A.C. 7:9B-1.14(d)5i)

Streams: Except as necessary to satisfy the more stringent criteria above or where watershed or site-specific criteria are developed pursuant to N.J.A.C 7:9B-1.5(g)3, phosphorus as total P shall not exceed 0.1 mg/l in any stream, unless it can be demonstrated that total P is not a limiting nutrient and will not otherwise render the waters unsuitable for the designated uses. (N.J.A.C. 7:9B-1.14(d)5ii)

Existing Nutrient Policies (apply to all FW waters):

Except as due to natural conditions, nutrients shall not be allowed in concentrations that cause objectionable algal densities, nuisance aquatic vegetation, abnormal diurnal fluctuations in dissolved oxygen or pH, changes to the composition of aquatic ecosystems, or otherwise render the waters unsuitable for the designated uses. (N.J.A.C. 7:9B-1.5(g)2)

The Department may establish watershed or site-specific water quality criteria for nutrients in lakes, ponds, reservoirs or streams, in addition to or in place of the criteria in N.J.A.C. 7:9B-1.14, when necessary to protect existing or designated uses. Such criteria shall become part of these Water Quality Standards. (N.J.A.C. 7:9B-1.5(g)3)

Existing Effluent Standard

An effluent standard for phosphorus discharged by NJPDES-regulated facilities to freshwater lakes, ponds, reservoirs, or tributaries was adopted by the Department in 1984:

The effluent standard for phosphorus discharged to a freshwater lake, pond, or reservoir, or tributaries to these waterbodies is that, at a minimum, no effluent shall contain more than 1.0 mg/l total phosphorus (as P), as a monthly average, unless the discharger(s) to such a waterbody can demonstrate that a less stringent requirement will not result in a violation of the Surface Water Quality Standards (N.J.A.C. 7:9B) or that the control of point sources alone, in the absence of effective nonpoint source controls, will not result in a significant reduction of phosphorus loadings to the waterbody. (N.J.A.C. 7:14A-5.3(b))

From 1984 to 2002, facilities located upstream of lakes, ponds, or reservoirs received an effluent limit of 1.0 mg/l total phosphorus (TP) in their NJPDES permits based on the existing effluent standard. Permit renewals for facilities that were not expanding received the same phosphorus limits as contained in the previous permit, if any, while decisions about more stringent water quality-based phosphorus limits were deferred pending the completion of a TMDL if necessary. New and expanding treatment plants received water quality-based effluent limits (WQBELs) based on meeting the existing numeric water quality criterion of 0.1 mg/l TP in the stream, outside of any mixing zone, taking into consideration the design flow of the stream and the permitted discharge flow of the treatment plant.

In 2002, the Department began incorporating water quality based effluent limits into NJPDES permits based on the 0.1 mg/l TP criteria, as part of permit renewal. For facilities discharging to impaired waters, the facilities received a limit of 0.1 mg/l TP as an end-of-pipe limitation because the receiving waters already exceeded the numeric criterion. This action was intended to ensure that the discharge would not cause or contribute to further violation of the SWQS. However, since the SWQS include both numeric and narrative criteria, as well as narrative policy statements, acknowledging that TP concentrations could exceed 0.1 mg/l in some waterbodies without rendering the waters unsuitable for their designated uses, the Department provided each permittee an opportunity to demonstrate compliance with the nutrient criteria and policy. The Department developed a "Technical Manual for Phosphorus Evaluations (N.J.A.C. 7:9-1.14 (c)) for NJPDES Discharge to Surface Water Permits" in 2003, which outlines the steps necessary to demonstrate that phosphorus is not the limiting nutrient and the waters are not being rendered unsuitable for their designated uses. The manual was revised in 2008 (see Section III.D.1. for more information).

B. National Nutrient Policy

USEPA's *National Water Quality Inventory: 1996 Report to Congress Executive Summary* cites nutrients (nitrogen and phosphorus) as one of the leading causes of water quality impairment in U.S. rivers, lakes, and estuaries. Forty percent of the U.S. rivers were impaired due to nutrient enrichment; fifty-one percent of the surveyed lakes and fifty-seven percent of the surveyed estuaries were similarly adversely affected. Nutrients have also been implicated with respect to the large hypoxic zone in the Gulf of Mexico, hypoxia observed in several East Coast States, and *Pfiesteria*-induced fish kills and human health problems in the coastal waters of several East Coast and Gulf States. A single national approach to nutrient criteria development was determined by USEPA to be inappropriate due to regional variations in geology, vegetation, climate, and soil types that exist and the lack of a clear technical understanding of the relationship between nutrients, algal growth, and other factors such as flow, light, and substrata.

USEPA determined that, to better protect water quality from the adverse impacts of nutrient over-enrichment, ecoregional variations must be taken into account when setting water quality criteria for a particular waterbody. Therefore, in January 2001, the USEPA announced publication of recommended water quality criteria for nutrients under Section 304(a) of the federal Clean Water Act (see 66 F.R. 1671). USEPA's recommended ecoregion nutrient criteria were developed based on water quality conditions that are minimally impacted by human activities. Section 304(a) directs USEPA to develop and publish criteria guidance to assist states

and authorized tribes in developing water quality standards that are protective of designated uses. Water quality criteria developed under Section 304(a) are based solely on data and scientific judgments and do not consider economic impacts or the technological feasibility of meeting any specific level of water quality in ambient water. Establishing water quality criteria based on the concentrations measured at these minimally impacted locations was intended to protect the existing and designated uses. These recommended criteria were intended by USEPA to support the development of more localized, waterbody-specific state and tribal nutrient criteria that would provide a basis for controlling discharges or releases of pollutants and ultimately result in the protection of aquatic life and recreational uses (USEPA, 2007).

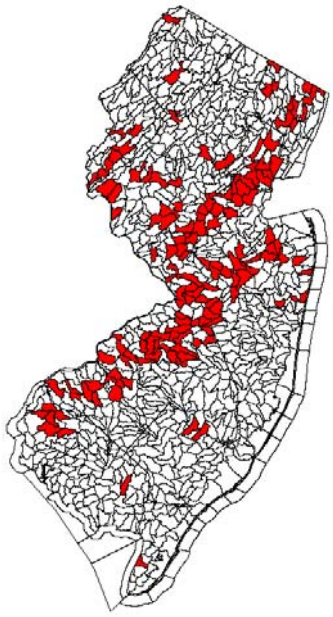
The USEPA announcement recommended three options for states to develop and adopt nutrient criteria: 1) develop criteria that reflect localized conditions and protect specific designated uses, pursuant to the USEPA technical guidance documents 2) adopt USEPA's recommended Section 304(a) criteria for nutrients, either as numeric criteria or as a translator for state narrative criteria; or 3) use other scientifically defensible methods and water quality data to develop criteria protective of designated uses. Additional guidance was provided to states in November 14, 2001 (USEPA, 2001).

III. Criteria Development Process

A. Conceptual Approach

In New Jersey, the primary cause of eutrophication in non-tidal freshwaters is generally attributed to excessive amounts of phosphorus (expressed as total phosphorus, or TP). New Jersey's 2008 Integrated Water Quality Monitoring and Assessment Report (Integrated Report) found that almost 30% of all freshwaters were not attaining applicable designated uses due to exceedances of the numeric TP criteria, as illustrated in Figure 1. To date, the Department's water quality assessment methodology has relied on the existing numeric surface water quality criteria for TP and has not addressed the response indicators described in the narrative nutrient policy. One reason for this inability to address the response variables is the lack of a scientific basis for interpreting when nutrient concentrations "cause objectionable algal densities, nuisance aquatic vegetation … or otherwise render the waters unsuitable for the designated uses."

Figure 1: Subwatersheds Where TP Exceeds 0.1 mg/L



While the adverse effects of excessive nutrients (i.e., eutrophication) are well documented: mats of algae covering lakes and streams, blocking sunlight needed by submerged aquatic vegetation, reducing dissolved oxygen levels and causing fish kills, these effects are not easily reproduced in a laboratory or assessed using traditional methods. The adverse effects of nutrients are strongly influenced by site-specific factors such as shading, color, turbidity, and flow as well as regional

and seasonal conditions, and are expressed as impacts to entire ecosystems. New Jersey's enhanced nutrient approach will use information obtained from recent studies that quantify cause and response variables under a variety of conditions and define the set of conditions that "render the waters unsuitable for designated uses" for each type of use and waterbody based on the "weight of evidence". The Department is ready to begin implementing this approach by developing a new nutrient assessment methodology for assessing aquatic life use attainment in freshwater wadeable streams. As resources allow, a similar approach will be developed for other surface waters and other nutrients as more information becomes available.

The Department plans to use ecosystem response variables such as dissolved oxygen and biological indicators (e.g., benthic macroinvertebrates, chlorophyll *a*) and related indices to evaluate use attainment and its relationship to TP over-enrichment in freshwater wadeable streams. This new nutrient assessment methodology will be used to determine if aquatic life use impairment is due to TP over-enrichment, by correlating chemical and biological response variables on a waterbody-specific basis. If both chemical and biological variables (or indices) indicate use impairment, then the use will be assessed as not attained because of TP. When a subwatershed is not attaining the aquatic life use due to phosphorus, a TMDL will be developed using a site-specific criterion, a watershed-specific translator of the narrative nutrient criteria or the SWQS criterion.

The various scenarios and outcomes of the new nutrient assessment method will be described in the draft 2010 Integrated Water Quality Monitoring and Assessment Methods Document (Methods Document), used to support development of the 2010 Integrated Report, that the Department expects to release for public comment in May 2009. The 2010 Methods Document will describe the types of data required for the new nutrient assessment method and the conditions under which nutrient-related monitoring should be conducted. The 2010 Methods Document will also explain how the new nutrient assessment method will be used by the Department to list and delist waters for the 2010 Integrated List of Waters and 2010 303(d) List of Water Quality Limited Waters, as part of the 2010 Integrated Report.

The Department will also be proposing amendments to the SWQS rules, which specify that the existing numeric nutrient criteria apply only to non-tidal freshwaters where the Department has determined that the narrative nutrient criteria are not met. Such determinations will be made using the new nutrient assessment methodology explained above. The Department's regulatory programs (NJPDES, TMDL) will apply the existing numeric nutrient criteria as regulatory targets until a site-specific criterion or watershed-specific translator of the narrative criteria has been developed through a TMDL.

B. Effects of Nutrients on Use Attainment

Nutrients (i.e., nitrogen and phosphorus), in and of themselves, are not generally harmful to the environment; in fact, they are necessary to promote growth among living things (USEPA, 2007). Under healthy conditions, nutrients exist as part of a balanced natural aquatic system (Smithee, 2007). Excessive concentrations of nitrogen or phosphorus (i.e., over-enrichment of nutrients) can cause adverse ecological impacts to surface waterbodies such as acceleration of or "cultural" eutrophication, an otherwise natural aging condition of such waterbodies, which in turn can

cause impairment of existing and designated uses such as aquatic life, drinking water, and recreation. Accelerated eutrophication is characterized by reduced dissolved oxygen, extreme diurnal swings of dissolved oxygen or pH, increased turbidity (or decreased water clarity), loss of beneficial submerged aquatic vegetation, and increase in nuisance vegetation (excessive algae or macrophytes) that occur during the summer.

New Jersey's SWQS establish designated uses and the water quality criteria designed to protect those uses. Each stream is assigned a surface water classification that specifies the uses to be protected. Designated uses of New Jersey waters are categorized as aquatic life, recreation, drinking water supply, industrial and agricultural water supply, and fish and shellfish consumption. Designated uses potentially affected by excessive nutrients are aquatic life, recreation, and drinking water supply. However, for recreation and drinking water supply uses, the threshold for "excessive" nutrients can be subjective and may be related more to personal preference than science. For instance, while some amount of vegetation in a lake is necessary to support aquatic life, that same amount of vegetation may be perceived as a nuisance to bathers and boaters. Similarly, any change in the taste of drinking water, whether caused by algae or simply different source waters, may be perceived as "bad" or unacceptable. The Department must balance the competing demands of multiple-use waterbodies and may need to establish a "primary use" and corresponding response indicators or thresholds to objectively assess use attainment. Addressing aquatic life use impairments due to nutrients will also improve other uses.

1. Aquatic Life

All New Jersey waters are designated for aquatic life use, which includes the maintenance, propagation, and migration of natural and established fish, amphibians, reptiles, invertebrates, plants, and algae. Excessive nutrients may cause increases in algal growth. Chronic symptoms of over-enrichment include large diurnal swings in dissolved oxygen or pH, reduced spawning grounds and nursery habitats, fish kills, and the replacement of the natural flora and fauna with nutrient tolerant biota (USEPA, 2007). These problems can exhibit themselves locally or much further downstream leading to degraded estuaries, lakes and reservoirs, and to oxygen-starved hypoxic or "dead" zones where fish and aquatic life can no longer survive. Thus, nutrient over-enrichment can cause impairment of aquatic life uses of surface waters (maintenance, migration, and propagation of the natural and established biota).

2. Recreation

Recreation includes aesthetics, (i.e., the perceived appeal of the water body as a natural resource for public use), swimming, fishing, and boating. While all New Jersey waters are designated for recreational use, swimming may not be feasible in all waters due to factors unrelated to water quality, including physical constraints such as water depth or flow, and other safety considerations. In addition, as discussed above, bathers generally prefer to swim in waters that are clear and free of vegetation, conditions that would not support aquatic life uses. Such factors must be taken into consideration in assessing the effects of nutrients on attainment of the recreational use.

Many of New Jersey's lakes are shallow stream impoundments constructed for such purposes as real estate enhancement, flood, and sediment control. Such lakes are highly prone to accelerated eutrophication. Eutrophication occurs naturally as lakes age; however, this process can be accelerated with excessive input of nutrients and suspended sediments from the surrounding watershed. When this occurs, lakes often experience excessive growth of aquatic weeds and algae, shallow depths (as sediments fill the lake), and elevated temperatures. Where algal growth is excessive, be it planktonic or rooted, it can create aesthetically unpleasant conditions for swimming and difficult conditions for boating (NJDEP, 2006). Hazardous algal blooms can cause respiratory distress and neurological problems in swimmers resulting from exposure to toxic microbes such as cyanobacteria (USEPA, 2007). Thus, nutrient over-enrichment can cause impairment of recreational uses of surface waters, including recreation and aesthetics.

3. Drinking Water Supply

All freshwaters in New Jersey are designated as potential drinking water supplies. However, actual use as drinking water may not be feasible for all waters due to factors unrelated to water quality, such as accessibility, and natural factors such as color, clarity, and taste. Such factors must be taken into consideration in assessing attainment of the drinking water supply use.

Adverse impacts to potable water supplies resulting from high nutrient concentrations include increased treatment costs and taste and odor complaints. High levels of nutrients may increase the amount of algae and turbidity in the water supply, to which purveyors respond by adding increased amounts of various chemicals, including coagulants, oxidants, and disinfectants such as chlorine, before the water can be used for drinking purposes. Increased levels of chlorine added to potable water results in the formation of higher levels of disinfection by-products (e.g., bromodichloromethane, bromoform, chloroform, dichloroacetic acid, and bromate) that have been shown to increase the risk of cancer (USEPA, 2007). Thus, nutrient over-enrichment can cause impairment of waters used by water purveyors for drinking water supplies.

It should be noted that New Jersey's existing surface water quality criterion for nitrate is designed to protect human-health, not aquatic life, so it is not related to eutrophication. The nitrate criterion is intended to protect infants from a potentially fatal blood disorder called methemoglobinemia or "blue baby syndrome."

C. Prioritization of Waterbody Types for Nutrient Criteria Development

1. Lakes and Reservoirs

While lakes and reservoirs may be grouped together as a geographic feature, the designated uses, and thus the SWQS and assessment methods, for lakes may be quite different from reservoirs. Most of New Jersey's lakes and reservoirs are actually impoundments whose primary purpose is recreation, specifically, boating, fishing, and swimming (in the case of lakes), or drinking water supply (in the case of reservoirs), although all are designated for multiple uses.

a. Lakes:

New Jersey has about 1,750 impoundments of at least two acres in size, totaling 37,837 acres, based on GIS calculations. The Department's ambient lake monitoring network involves the testing of 200 lakes randomly (probabilistically) selected from the State's approximately 1100 named lakes. Water quality measurements conducted at each lake include parameters such as DO, pH, nutrients, and chlorophyll *a*. Sampling is conducted seasonally, with one sampling event each spring, summer, and fall, at several sites within, and one at each outlet of, the randomly selected lakes. Beginning in 2004, all lakes in the network are sampled once every five years, with each lake being sampled at least three times during the year (spring, summer, and fall). A fourth winter sampling period is added if weather conditions and resources permit.

Many New Jersey lakes are shallow, run-of-the-river, constructed impoundments, which renders them highly susceptible to accelerated eutrophication. As a result, many New Jersey lakes have exhibited water quality problems for decades, primarily with respect to nutrient over-enrichment. This predisposition is enhanced in lakes with large watersheds. The Department has developed phosphorus TMDLs for the 48 lakes in New Jersey where water quality data indicated an exceedance of the numeric TP criterion for lakes (0.05 mg/l). In developing these lake TMDLs, water quality models predicted that some lakes could never attain the numeric TP criterion, even if there were no anthropogenic inputs, because of the large size of the contributing drainage area relative to the impounded volume. For these lakes, reference conditions were used as "end points" for calculating phosphorus reductions, even though these phosphorus concentrations would exceed the existing numeric criterion. This determination was made in accordance with the SWQS provision that allows naturally occurring conditions to prevail over numeric criteria.

The Department assessed nutrient impacts in lakes by assessing lake data along with other data from waters within the same U.S. Geological Survey Hydrologic Unit Code (HUC) 14 subwatershed, and from the probabilistic lakes monitoring program, for the 2008 Integrated Report. The 2010 Integrated Report will be developed using the Department's new nutrient assessment methodology for freshwaters that will incorporate and evaluate nutrient-related data, including response indicators, from both streams and lakes for each HUC 14 subwatershed. However, since there is generally less data available from lakes, additional monitoring may be required to fully assess nutrient impacts in subwatersheds that contain lakes. Where sufficient information is available and the Department determines that a given subwatershed is not attaining the aquatic life use due to phosphorus, a TMDL will be developed using a site-specific criterion, a watershed-specific translator of the narrative nutrient criteria or the SWQS criterion.

b. Reservoirs:

There are forty-three Water Supply Reservoirs in New Jersey, totaling approximately 15,000 acres. Although most reservoirs are multiple use waterbodies (like most lakes), those distinguished as water supply reservoirs are not part of any regular statewide monitoring program; however, water supply reservoirs are monitored extensively by the purveyors who own and operate the reservoirs. Water purveyors monitor the quality of the water used in treatment processes. The monitoring varies depending on the level of treatment needed for the source waters. The data that purveyors collect to support treatment of the water are not generally reported to the Department. This data gap has been identified in the Department's Long Term Monitoring & Assessment Strategy.

The Department has developed TMDLs for the several reservoirs for which nutrient-related data was available. The Wanaque Reservoir and Dundee Lake TMDLs used the response indicator, chlorophyll a, as a target for nutrient reduction. TMDLs were also completed for total phosphorus in Pompton Lake and the recreation area portion of Round Valley reservoir, based on a target concentration of 0.05 mg/l. Additional information is needed to assess nutrient impairment in other reservoirs. In addition, without readily available data for reservoirs, the Department is unable to assess nutrient impacts to these waterbodies as part of the Integrated Water Quality Monitoring and Assessment Report. Once the Department has successfully developed a new nutrient assessment methodology for wadeable streams and lakes, the Department will consider developing a similar methodology for assessing nutrient impairment in reservoirs for which TMDLs have not been developed, if sufficient data becomes available.

2. Freshwater Rivers and Streams

There are roughly 18,000 miles of rivers and streams in New Jersey (at 1:24,000 scale of resolution), of which 12,000 miles are non-tidal and roughly 6,000 miles are tidal. For the purposes of this Plan, streams are considered "wadeable" and rivers are considered "non-wadeable". "Wadeable" means that the waters are conducive to monitoring on foot, rather than by boat, such as rapid bioassessment of benthic macroinvertebrates. Most of New Jersey's non-tidal waterbodies are wadeable. Wadeable streams may exhibit a variety of habitats including shallow, weed-dominated areas and deeper pools where floating algae may occur. Rivers are larger and deeper than streams and must be monitored via bridges and by boat.

a. Wadeable Streams:

Much of the Department's research into the impact of nutrients on water quality has been conducted using data collected primarily from streams. The Department's current water quality assessment methodology relies on stream monitoring to compare sampling data with numeric water quality criteria and other relevant factors. Exceedance of the numeric phosphorus criterion for streams (0.1 mg/L) has been presumptively identified as the cause of non-attainment of the general aquatic life use for slightly less than one third of the applicable assessment units, according to the 2008 Integrated Report. Exceedance of the numeric phosphorus criterion was the fifth most frequent cause of use impairment overall, affecting 143 of New Jersey's 970 assessment units. According to the 2008 Integrated Report, the phosphorus numeric criterion is exceeded in almost 30% of all assessed waters (compared to 53% in 2006). Since streams comprise the majority of New Jersey's freshwaters, and since most of the waters in New Jersey that have been assessed as nutrient-impaired are streams, nutrient controls and the development of watershed or site- specific nutrient translators to replace default criteria, as appropriate, are a very high priority for New Jersey waters. In proceeding with this endeavor, the Department intends to draw upon its extensive water quality database to establish correlations between nutrient concentrations, response variables, and use attainment in New Jersey streams.

New Jersey has generated a significant amount of water quality data from its extensive monitoring networks, including the Ambient Surface Water Monitoring Network (ASWMN) for chemical/physical water quality monitoring (including continuous monitoring for diurnal DO),

the Ambient Biological Monitoring Network (AMNET) for monitoring of benthic macroinvertebrates in streams, and the Fish Index of Biological Integrity Network (FIBI) for monitoring fish populations in streams. The State's monitoring networks are described in more detail below:

Ambient Surface Water Monitoring Network (ASWMN): ASWMN is a cooperative monitoring program conducted by the Department and the U.S. Geological Survey that was established in the mid-1970's and redesigned in 1997, specifically to address nontidal surface water quality issues through the following objectives: (1) track status and trends in ambient water quality; (2) establish background water quality; (3) obtain water quality data that can be correlated with specific land uses (urban/suburban, agricultural and undeveloped); and (4) coordinate water chemistry and biological networks.

Figure 2: NJ ASWMN

A second revision occurred in 2005 with the addition of 100 monitoring stations to improve statewide spatial coverage for the network. The network is comprised of five station types: (1) *background/reference sites* – waterways located in undeveloped watersheds (generally county, state or federal parks and forests), (2) *land use indicator sites* – waterways which reflect a dominant land use (urban/suburban, agricultural or undeveloped) within a watershed management area, (3) *watershed integrator sites* – waterways that reflect large drainage areas and multiple pollution sources, (4) *statewide status sites* –sites randomly reselected every two years from the Department's 829-station biological (macroinvertebrate – AMNET) monitoring network, and (5) *spatial infill sites* – sites added in 2005 to provide a minimum of one site in each HUC 11. These sites were selected from a group of stations formerly referred to as the "Supplemental Network". The overall ASWMN consists of 215 stations (see Figure 2) that are sampled quarterly for parameters including nutrients. Diurnal dissolved oxygen (DO) is measured annually at selected sites.

The Ambient Biological Network (AMNET): In 1992, a network of over 800 stream sites was initiated in New Jersey to provide long-term biological data reflecting the quality of surface waters throughout the State (see Figure 3). The Ambient Biological Monitoring Network (AMNET) program routinely samples and analyzes aquatic macroinvertebrate populations at each site, employing USEPA-developed Rapid Bioassessment methods to provide an index of stream water and habitat quality. Biological monitoring programs, including both ambient and intensive surveys, were initiated by the Department because the micro and macro flora and fauna of various trophic levels can integrate the effects of water quality changes over time, thus making

them efficient pollution indicators. Macroinvertebrates, largely benthic (bottom-dwelling) organisms, provide a primary, cost-effective biomonitoring tool. These organisms are ubiquitous in distribution, more stationary than fish but less transient than algae and other microscopic communities, and they are easily collected and quantified.

Figure 3: NJ AMNET

Establishment of the AMNET system in 1992 was facilitated by USEPA's introduction of the Rapid Bioassessment Protocols (RBP). Sites in each of the State's five Water Regions (Upper Delaware, Northeast, Raritan, Atlantic, and Lower Delaware) are sampled on a five-year rotational basis to establish trends in water and habitat quality. As of November 2008, all of the network stations have been sampled three times and 30% of the network stations have been sampled four times.

Three different metrics are used to assess the State's benthic macroinvertebrates to reflect regional ecological differences. A High Gradient Macroinvertebrate Index (**HGMI**) is employed in waters above the Fall Line, a Coastal Plain Macroinvertebrate Index (**CPMI**) is used in the low gradient New Jersey coastal plain excluding the Pinelands, and a Pinelands Macroinvertebrate Index (**PMI**) is employed in waters within and immediately surrounding the Pinelands region of the state. Before these three indices were developed, a single index was used statewide, the New Jersey Impairment Score (NJIS), which is based on family level taxonomic identifications. All current assessments employ identifications down to the genus level. Results from each of the three indices fall into one of four assessment descriptive categories: "Excellent", "Good", "Fair", and "Poor" as explained in the Department's Assessment Scoring Criteria.

All three metrics compare benthic communities found at a site in question to communities found in relatively undisturbed reference waters. The degree of diversion from the reference community is an indication of the degree of biological degradation the test site has undergone. Currently, the data use is restricted to assessing degrees of disturbance due to anthropogenic activity, which can include alterations of a wide range of physical and/or chemical characteristics of the waters and stream channel. These data are used as indicators of biological impairment but are not sufficient to identify the specific agent causing the biological disturbance.

Fish Index Of Biotic Integrity Network: The Department began implementing a Fish Index of Biotic Integrity (FIBI) sampling program in 2000 to assess stream quality. The network consists of 100 fixed stations contained within the northern part of the state and monitored on a five-year rotation (twenty stations per year), as illustrated in Figure 4. The FIBI evaluates environmental conditions based on assessments of fish populations and thus provides a second trophic level of biological assessment critical to an accurate determination of environmental impairment. The FIBI is an index that measures the health of a stream based on multiple attributes of the resident fish assemblage. Each site sampled is scored based on its deviation from reference conditions (i.e., what would be found in an unimpacted stream) and classified as "poor", "fair", "good" or "excellent". In addition, habitat is evaluated at each site and classified as "poor", "marginal", "suboptimal," or "optimal".

Figure 4: NJ FIBI Network

Once fish from sample collections have been identified, counted, examined for disease and anomalies, and recorded, several biometrics are applied to evaluate biotic integrity. Fish community analysis is accomplished using a regional modification of the original FIBI (Karr *et al*,. 1986). The modified FIBI uses the following ten biometrics: 1) total number of fish species, 2) number and identity of benthic insectivorous species, 3) number and identity of trout (non-stocked) and/or sunfish species, 4) number and identity of intolerant species, 5) proportion of individuals as white suckers, 6) proportion of individuals as generalists, 7) proportion of individuals as insectivorous cyprinids, 8) proportion of individuals as non-stocked trout or proportion of individuals as piscivores (excluding American eel), 9) number of individuals in the sample and, 10) proportion of individuals with disease or anomalies.

In the southern portion of the state, the Department is building on work initially performed to develop an IBI for the inner coastal plain (southern New Jersey exclusive of the Pinelands Area). "Least impacted" sites have been sampled while stressed and validation site sampling is ongoing.

b. Freshwater Non-tidal Rivers:

While New Jersey's Ambient Surface Water Monitoring Network collects physical/chemical water quality data in New Jersey's non-wadeable rivers (via bridges and boats), biological data

(AMNET or FIBI) are not available for rivers in New Jersey. Since the Department's conceptual approach is based on the identification of nutrient-impaired waters that will correlate nutrient concentrations (in this case, TP) with ecosystem response variables that include biological indicators, and since benthic indicators are not currently available for New Jersey rivers, there is insufficient information to assess nutrient-related aquatic life use impairment in these types of waterbodies at this time. However, a study is currently being conducted by the Delaware River Basin Commission to develop nutrient criteria for the Delaware River above Trenton. Criteria may include narrative and numeric limits for total phosphorus, total nitrogen, water clarity, chlorophyll *a* and biocriteria consisting of selected algal (i.e., periphyton) and macroinvertebrate (i.e., benthic) metrics. The Department will develop a new methodology to assess the impact of nutrient over-enrichment on biological indicators in freshwater non-tidal rivers excluding the Delaware River above Trenton, but this is a very low priority since there are not many river miles in this category. The Department may also use response indicators such as DO, pH, and chlorophyll *a* to evaluate nutrient impairment in rivers through specialized studies such as TMDLs.

3. Coastal Waters (Tidal, Estuarine, and Marine):

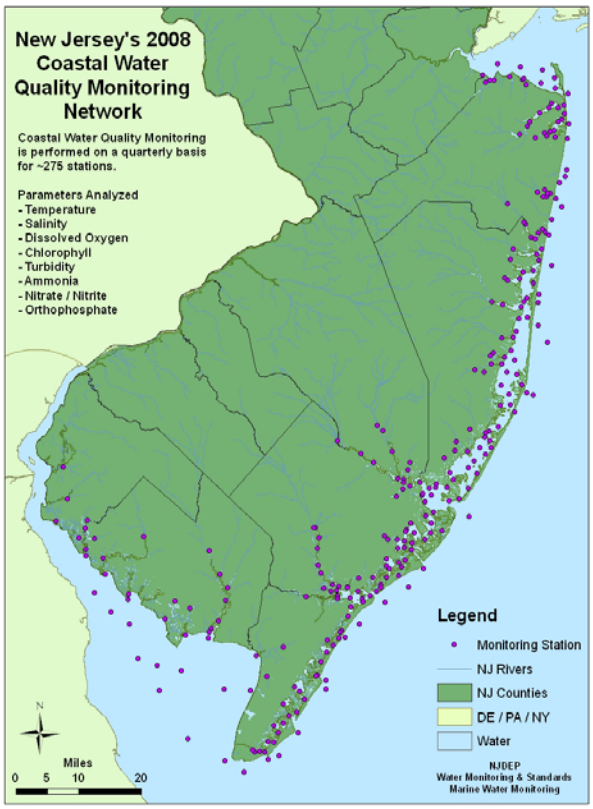
The Department currently assesses aquatic life use attainment in coastal waters based on grab sample measurements of dissolved oxygen because benthic indicators or other biological measures are not yet available for assessment purposes. The Department is working to develop a benthic indicator that will provide a more accurate assessment of the aquatic life use in ocean waters, particularly nutrient impairment.

Such work is especially difficult in tidal waters. Tidal waters (freshwater and saline) comprise 35% of New Jersey's total river miles. Tidal freshwaters are characterized by interplay of flowing and static water combining flowing riverine conditions with complexes of marsh and wetland ecosystems. New Jersey's freshwater tidal rivers are located primarily in the Lower Delaware Region and the New York/New Jersey Harbor Estuary. Assessing the impact of nutrient over-enrichment in tidal freshwaters is extremely complicated, as it requires an assessment methodology that distinguishes between the levels of nutrients and response indicators that would be present in a healthy, well-functioning wetland complex and those that would otherwise be associated with use impairment.

The Department's routine monitoring and assessment activities in coastal waters are summarized below.

NJDEP Coastal Monitoring Network: The Department's Coastal Water Quality Monitoring Network (see Figure 5) provides basic measures of the ecological health of New Jersey's coastal waters, which include ocean, estuarine, and tidal river waters. Samples are collected four times per year (once each quarter) at approximately 270 locations. Parameters include dissolved oxygen, salinity, nitrogen, phosphorus, secchi depth, temperature, chlorophyll a, and suspended solids. Temperature, salinity, suspended solids, and oxygen measurements provide information on the degree of environmental stress to which organisms are exposed. Nutrients (nitrogen and phosphorus) and chlorophyll relate to the amount of plant material in the water. Too much or too little plant material in the water can be detrimental to other organisms in the bay and ocean.

Figure 5: NJ Coastal Monitoring Network



National Coastal Assessment: The Department also participates in and uses data from the National Coastal Assessment (NCA), a federally funded program to assess the ecological condition of the nation's estuarine resources. Since 2000, NCA's annual summer sampling has collected water, sediment, and benthic invertebrate samples at 35 locations in New Jersey's coastal bays. Samples are analyzed for water chemistry (e.g., nutrients, dissolved oxygen), sediment chemistry/toxics, sediment toxicity, and benthic diversity. Results from NCA sampling are also used by the Department to assess general aquatic life use in the NY/NJ Harbor Estuary.

Some data gaps have recently been filled with chemical water quality data provided by the Delaware River Basin Commission for the Delaware River tidal tributaries, and by the New Jersey Harbor Dischargers Group (NJHDG), a group of entities who discharge wastewater to the Passaic River, for the New York/New Jersey Harbor Estuary (see Figure 6). In addition to bridge monitoring in freshwater tidal waters of the Estuary, the NJHDG has agreed to conduct a long-term, water quality monitoring program to address a gap in estuarine data in the Coastal Monitoring Network. This volunteer monitoring program will generate ambient water quality data for the Hackensack River, New Jersey portion of the Hudson River, Passaic River, Rahway River, Elizabeth River, Raritan River, Newark Bay, Upper New York Harbor, Raritan Bay, and the Arthur Kill (see Figure 6). The data should provide a characterization of the general water quality and variability of receiving waters in the in the New Jersey portion of the New York/New Jersey Harbor Estuary (and associated tributaries). Biological indicators need to be developed and integrated with this chemical water quality data to assess nutrient impairment of aquatic life uses in these tidal waters. The Department plans to work cooperatively with the other state and federal agencies to evaluate and develop nutrient criteria and/or management measures for these waters.

The following regional efforts are currently underway to develop benthic indicators for aquatic life use assessment and nutrient impairment:

- **New York/New Jersey Harbor Estuary (NY/NJ Harbor):** The NY/NJ Harbor is identified on the 2008 Integrated List as not attaining the general aquatic life use because of low dissolved oxygen (DO). Monitoring data for DO in tidal waters is available from existing monitoring networks but it consists primarily of grab sample and limited continuous monitoring data. A Benthic Index of Biotic Integrity has been developed for the NY/NJ

Figure 6: Harbor Discharger Data

Harbor through the USEPA's REMAP program. A workgroup consisting of the Department, USEPA Region 2, USEPA Office of Research and Development, and Rutgers University determined that this benthic indicator was appropriate for use in the NY/NJ Harbor area and the Department used it to assess the waters of Raritan Bay, the Arthur Kill, and the Kill van Kull for the 2008 Integrated Report. The Department, along with New York and USEPA Region 2, are currently developing a TMDL to address impacts from tidal rivers and streams flowing into the NY/NJ Harbor that are causing the low DO problem and partly attributable to nutrient inputs.

- **Delaware Estuary:** A multi-state/regional effort is currently underway to address the impact of nutrients in the Delaware Estuary/Bay from the tidal rivers flowing to the Delaware River Estuary through the development of nutrient criteria. The Department is participating in the nutrient criteria development project initiated by the Delaware River Basin Commission for the Delaware River Watershed.

- **Nearshore Ocean:** The Department is working with Rutgers, USEPA Region 2, USEPA Office of Research and Development, and NOAA to develop indicators of ecosystem health for the benthic communities in near shore ocean (marine) waters. USEPA grab samples collected via helicopter through the coastal monitoring program have found benthic low DO conditions off the New Jersey Coast for most of its length during the quiescent periods of the summer and early fall. These low DO conditions are brought about by thermal stratification that establishes during this period. Storms and the onset of autumn bring about surface to bottom mixing resulting in a breakup of these low DO conditions until the onset of warmer temperatures in June. The impacts to benthic aquatic life and the possible anthropogenic contributions to these benthic conditions are currently unknown. Benthic samples were collected in the summer of 2007 and a benthic indicator is being developed for nearshore ocean waters. The Department has recently received USEPA funding to purchase a glider for continuous DO monitoring. This should provide a better evaluation of aquatic life condition and, in the future, the Department will reassess aquatic life use in nearshore ocean waters based on correlations between the new benthic indicator and continuous DO data.

- **Shallow Coastal Bays (including Barnegat Bay):** The federal government (USEPA and NOAA) has already developed a suite of indicators (e.g., EPA's National Coastal Assessment Report 2005 and NOAA's National Estuarine Eutrophication Assessment update) and applied them to New Jersey's coastal bays. The Department is working with Rutgers, USEPA Region 2, USEPA Office of Research and Development, and NOAA to evaluate existing indicators and establish New Jersey-specific benthic indicators to assess aquatic life use in New Jersey's shallow coastal bays by 2010. The Department has also begun collecting real-time diurnal DO data, in partnership with Monmouth University and the Barnegat Bay Estuary Program. These benthic indicators will also help identify aquatic life use impairments that are nutrient related. Existing data on benthic communities in the near shore ocean waters and estuaries of New Jersey has been compiled and additional data has been collected; however, additional research is needed to develop cause/response indicators to determine if nutrients are the cause of any use impairment found in these waters. The Department has applied for a USEPA grant to collect sediment cores from the tidal region of Barnegat Bay and determine the chronology of nutrient changes (N/P) and associated ecosystem level responses. Changes in various biogeochemical proxies (biogenic Si, stable isotopes of C and N, etc), along with changes in diatom community structure, will be used to infer changes in nutrient loading and land use throughout the watershed.

These benthic indicators for coastal waters, once they are developed, will be used to reassess aquatic life uses in these waters. Where assessment results indicate use impairment based on these new indicators, the Department will need to determine if nutrients are the cause of impairment before proceeding with nutrient criteria development for these waters.

D. Current Nutrient Management Initiatives

New Jersey's Nutrient Criteria Enhancement Plan focuses initially on nutrient controls and criteria development in freshwater wadeable streams, a significant percent of which are currently listed as impaired on the 303(d) List of Water Quality Limited Waters. Sufficient information now exists to enhance the nutrient criteria for these waters, which will serve as the basis for reassessment. The following initiatives are already being implemented by the Department. Additional measures to be undertaken are identified under Section E, below.

1. Permit Actions

As explained under Section II.A., the Department has imposed water quality-based effluent limitations (WQBELs) upon renewal of NJPDES discharge to surface water permits to ensure that the existing SWQS numeric criteria for TP are not exceeded. SWQS include both numeric criteria as well as narrative policy statements, which acknowledge that TP concentrations could exceed 0.1 mg/l without rendering the waters unsuitable. Recognizing this, the Department provided each permittee receiving a new limit an opportunity to demonstrate compliance with the narrative nutrient criteria and policy where the numeric criteria are exceeded, based on the Department's *"Technical Manual for Phosphorus Evaluations (N.J.A.C. 7:9-1.14 (c)) for NJPDES Discharge to Surface Water Permits"* (NJDEP, 2008).

The demonstration requires a showing that phosphorus levels do not cause symptoms of eutrophication and thus do not render the receiving waters unsuitable for their uses due to nutrients. The '"rendered unsuitable" demonstration looks at: 1) diurnal fluctuations in dissolved oxygen (DO) levels 3 mg/l or more; 2) violations of minimum DO criteria at night 10% of the time; 3) violation of daily (24 hour) average criteria; 4) phytoplankton biomass (measured as chlorophyll *a*); and 5) periphyton biomass (measured as chlorophyll a). The demonstration is based upon an evaluation of near-field conditions. Far-field considerations are considered during TMDL development. This approach has provided the Department with data to refine its understanding of the relationships between TP and aquatic life use impacts in streams. This understanding is being further refined through the TMDL process and additional research.

2. TMDL Development

TMDLs developed for numerous waterbodies throughout the State have been instrumental in advancing our understanding of nutrient dynamics and its impact on water quality, including the relationships between response indicators (e.g., dissolved oxygen, chlorophyll a, pH) and nutrient levels (i.e., phosphorus concentrations). Several TMDL studies currently underway are investigating the factors that impact the degree by which nutrient enrichment may impact primary productivity, including temperature, solar radiation, turbidity, residence time, water depth, as well as other physical, chemical, and biological characteristics of a waterbody. These TMDL studies are providing information needed to address nutrient impacts using response variables other than TP, to establish appropriate reduction targets for those factors (including TP concentrations other than the existing numeric criteria), and to verify when use impairment is caused by factors other than nutrients. This will enable the Department to develop and implement management strategies that address the actual cause of use impairment so that use attainment can ultimately be achieved.

3. Nutrient Studies

New Jersey recognized in the mid-1990s that relying on chemical concentrations alone as indicators of nutrient impacts did not adequately identify or protect waters with nutrient-related problems. Nutrient-related problems (e.g., excessive algae or excessively low dissolved oxygen (DO)) were sometimes observed in waters with low concentrations of total phosphorus and sometimes not observed in waters with high concentrations of total phosphorus. In addition, DO monitoring was traditionally conducted during daylight hours, periods that represent the least stressful conditions for DO in waterways. DO levels are lowest in early morning hours when waters are not traditionally monitored (grab sampling). If DO levels have reached a level that violates criteria during the day, when it would be detected by traditional monitoring, the impairment is normally not attributable to nutrient enrichment, but more likely caused by oxygen demanding substances such as carbonaceous biochemical oxygen demand (CBOD) and nitrogenous biochemical oxygen demand (NBOD).

The Department is conducting technical studies linking stressors (i.e., total phosphorous, nitrogen) with biological responses (i.e., periphyton diatoms, biomass, chlorophyll a, diurnal DO, turbidity, etc.). Active field investigations and site-specific studies are currently underway to investigate the relationships between nutrients (stressors) and response indicators (e.g.,

chlorophyll a, algal biomass and algal community structure) to determine if predictive stressor–response models can be developed that are protective of designated uses and can be used in future assessments. The following studies are being conducted to develop appropriate biological indicators and indices to correlate between chemical concentrations of nutrients and the biological responses.

a. Trophic Diatom Index (TDI)

In 2000, the Department initiated a multi-year research project to investigate whether algal indicators of wadeable streams eutrophication could be developed for New Jersey. These indicators would be based on an understanding of algal dynamics in New Jersey streams. During the course of the project, different regions of New Jersey were studied, i.e., the Piedmont, Highlands, Ridge and Valley, Inner Coastal Plain, and Outer Coastal Plain physiographic provinces. Multivariate analysis of the data showed that nutrient concentrations explained significant proportions of the variation in diatom species composition and that one Trophic Diatom Index (TDI) could be developed and used for North Jersey (i.e., the Piedmont, Highlands, Ridge, and Valley physiographic provinces). Another TDI would be needed for the New Jersey Coastal Plain Ecoregion and possibly one more for the Pinelands. As part of the TDI project, a methods manual was developed for use by New Jersey scientists that describes all field and laboratory procedures, along with a listing of diatom flora based on sampled New Jersey streams, and additional taxonomic and ecological data for each species to help facilitate analysis of diatom assemblages. This use of taxonomic information should help the Department identify sources of nutrient impairment.

The objective of the TDI is to provide a relative numerical indicator of community structure from best to worst. The USEPA developed a Biological Condition Gradient (BCG) model, which describes biological communities that reflect changes (from pristine to completely degraded) that take place in flowing waters with increased anthropogenic degradation. Using the BCG, TDI values will be selected to identify waters that are unimpaired, impaired, and transitional. This effort is expected to be completed in 2009. The Department plans to conduct additional sampling for periphyton speciation at approximately 40 stations, starting in 2009. Half of the sites will be selected from the existing statewide status network to verify the periphyton monitoring protocol. The remaining stations will be selected deterministically from sites that reflect the full range of water quality conditions present in New Jersey.

b. Nutrient Biotic Index (NBI)

New York's Department of Environmental Conservation (NYDEC) has developed a Nutrient Biotic Index (NBI) for evaluating benthic macroinvertebrate communities as it pertains to nutrients (Smith et al., 2006). Aquatic macroinvertebrates have been among the principal biological communities used for freshwater monitoring and assessment for several decades in both New Jersey and New York but macroinvertebrate sampling techniques have not yet incorporated nutrient measures into assessment strategies. The two nutrient biotic indices developed by NYDEC were found to correlate with increasing phosphorus and nitrate concentrations (specifically, mean TP and NO_3 values), and a three-tiered scale of eutrophication was established (oligotrophic, mesotrophic and eutrophic) through cluster analysis of

invertebrate communities among the three trophic states. Therefore, the NBIs were determined to accurately reflect changes in stream trophic state.

As an indicator of nutrient levels, the NBI approach shows potential for usefulness in New Jersey. The Department applied NYDEC's NBI methodology to New Jersey's extensive macroinvertebrate dataset to determine if it was applicable to New Jersey waters and to compare the boundary results (i.e., oligotrophic, mesotrophic and eutrophic) to the TDI outputs to determine whether diatom algae and macroinvertebrates reflect similar thresholds of eutrophic condition (i.e., impairment). The New Jersey NBI scores displayed good agreement with existing nutrient data and previously well-established diatom-based TN and TP indices. When calculating NBI scores from an invertebrate dataset that was different from the one used to calculate the nutrient tolerance values for each taxon, however, the scores showed little relationship to nutrient levels. This lack of validation, though, may point more to limitations with the nutrient dataset than to a problem with the applicability of the NBI approach to New Jersey. A number of factors dampened the strength of the nutrient dataset: the use of several different parameters and methods, long and inconsistently-timed intervals between nutrient and invertebrate sample collection, and variation in the number of samples averaged to yield nutrient values for each site. The idea that limitations of the nutrient dataset could be responsible for the poor nutrient-NBI relationship is further evidenced by the fact that the NBI scores are more closely related to nutrient levels among shared invertebrate-diatom sites than they are across all sites in our study. Nutrient sampling for the diatom study involved greater consistency in technique and sample number, and that consistency could be responsible for the stronger relationship between nutrient levels and NBI scores seen among those sites.

Another issue encountered was the apparent indifference to nutrient levels among most of the New Jersey taxa studied, as shown by the preliminary ordination analysis. The tolerance values calculated for these taxa may be more a function of the nutrient dataset's composition than on the taxa's actual preferences. Furthermore, some degree of correlation between phosphorus and nitrate NBI scores was found, suggesting that the scores may not be reflecting separate responses to each nutrient but rather a general response to nutrient enrichment or pollution as a whole.

Given these issues, the Department believes that the NBI shows a potential for usefulness in New Jersey, but must first be improved with a) an analysis that identifies taxa that are strongly associated with certain nutrient levels and weighs those taxa more heavily in the index calculations, and b) further study utilizing an infusion of more appropriate nutrient and invertebrate data. Specifically, this additional dataset should be more uniform in terms of methodology and number of samples taken per site, and corresponding nutrient and invertebrate samples should be collected simultaneously (or at least with short and consistently-timed intervals between sampling events). This additional dataset would serve to strengthen, expand, and validate the existing dataset.

The methods discussed above provide tools to assess the more recent/current conditions of the State's waters. However, they do not provide information on whether the more recent/current conditions differ from historical conditions (i.e., in colonial times, before major anthropogenic influences associated with development emerged throughout the State). This information can be critical in deciding whether remedial measures are needed in a waterbody or if the conditions

identified using the indices simply reflect the natural/historic condition. The Department has initiated a paleolimnological study to begin addressing this issue. The study will take core samples of various waterbodies and examine the strata of the core representing the conditions that have existed historically. This will allow the Department to make waterbody-specific determinations as to whether the current/existing conditions reflect anthropogenic impacts or simply the natural/historic conditions. Some lakes have already been sampled. The Department received USEPA funding to collect sediment cores in the Barnegat Bay Estuary.

4. Monitoring And Use Assessment

Currently, implementation of New Jersey's existing nutrient criteria relies on ambient concentrations of TP in the water column in freshwaters. Based on current methods, only waters with TP concentrations over 0.1 mg/l are assessed as impaired for phosphorus and not attaining aquatic life uses. However, biological and other data exist which indicate that TP in excess of 0.1 mg/l is not always indicative of nutrient impairment. There are sites in New Jersey that have high phosphorus concentrations but do not exhibit symptoms of eutrophication. Conversely, a number of sites exhibit nuisance levels of algae and other biomass, or excessive diurnal swings in DO, and yet have relatively low phosphorus concentrations. The improved methodology will objectively correlate ecosystem response variables, TP-over-enrichment, and use impairment.

The Department is currently developing a revised assessment method for wadeable streams that will consider DO and biological data as indicators of nutrient-caused impairment of the aquatic life use. In the future, and currently through TMDL studies, pH may also be considered. The new assessment method is based upon the assumption that biological impacts evidenced by changes to the composition of aquatic ecosystems coupled with low dissolved oxygen levels and abnormal diurnal fluctuations (taking into account percent saturation and changes in temperature), provide an indication that the waters are rendered unsuitable for aquatic life uses due to excessive phosphorus. At this time, the Department will be relying upon benthic macroinvertebrates as a measure of biological health (see AMNET, p. 12-13) and periphyton chlorophyll *a* as a measure of nutrient effects, but is developing new biological indices related to nutrients, as discussed earlier (see TDI and NBI, p.20-22). As they become available, these new biological indices will be integrated into the aquatic life use assessment. Once the new assessment methods are established, they will be used to reassess any waters listed on the 303(d) List of Water Quality Limited Waters (303(d) List) as impaired by phosphorus.

The Department intends to apply this same basic approach in developing new assessment methods for all New Jersey waters. The factors may be different to reflect the cause/response variables at play in the different aquatic ecosystems, but the scientific process used to identify these relationships will be the same:

- Collect/compile sufficient chemical and biological data to be able to make statistical correlations and establish cause/effect relationships;
- Select a biological indicator specific to the ecology of the waterbody type and develop a biological index for assessment purposes;
- Assess aquatic life use;
- Identify cause of use impairment (i.e., nutrients or other).

E. Schedule

2009

- **Evaluate Existing Data from Freshwater Wadeable Streams to Develop Correlations Between Nutrient Levels And Measured Responses**

  The Department will compile existing diurnal DO monitoring data, biological data, and nutrient concentrations, along with short-term studies completed by NJPDES facilities or as part of TMDL development, which include diurnal DO, nutrient data and chlorophyll *a*/biomass data. This data set will be provided to USEPA N-STEPS for statistical analysis to determine if any direct correlations exist between nutrient concentrations, confounding variables (such as turbidity and color), response indicators, and impairment thresholds, to support development of a new assessment method for these waters.

- **Benthic Indicator Development for Coastal Waters**

  In 2006, a technical workgroup was established to identify a minimum dataset, standardize sample collection methods, and select appropriate measurements/indices to evaluate ecosystem health. Data was collected in 2007 to fill the necessary data gaps. In 2008, work commenced on developing one or more indexes for New Jersey coastal waters. The index for nearshore ocean waters should be completed in 2009 and for shallow coastal bays in 2010.

- **Develop Nutrient Assessment Methodology for Delaware River, Estuary/Bay.**

  Continue working with the Delaware River Basin Commission on developing methods to evaluate whether nutrients adversely impact the Delaware River, Delaware Estuary, and Bay and determine appropriate response indicators and thresholds.

- **Propose Amendments to the SWQS Rules to Revise Existing Nutrient Criteria and Implementation**:

  The Department proposed amendments to the SWQS rules at N.J.A.C. 7:9B on April 20, 2009 that allows the Department to implement the approach described in this Plan. Specifically, these amendments clarify that the numeric TP criterion in streams serves as a default criterion until the Department determines that the TP concentration does not render the waters unsuitable for their designated uses or unless/until the Department establishes watershed-based numeric translators to interpret the narrative criteria.

- **Initiate Development of Nutrient Criteria for NJ Shallow Coastal Bays**

  Participate on the Technical Team overseeing the nutrient studies contracted through the New England Interstate Water Pollution Control Commissioners (NEIWPCC) to develop the benthic indicators necessary to assess shallow coastal bays of New Jersey and New York, possibly leading to nutrient criteria development.

- **Conduct Pilot Study of Periphyton Speciation Monitoring in NJ**

  The Department will sample periphyton (diatom speciation) at approximately 20 randomly-selected existing status stations and approximately 20 additional locations where TP is suspected of rendering the waters unsuitable for designated uses.

- **Conduct Supplemental Nutrient Monitoring if Necessary to Support the Development of a New Jersey Nutrient Biotic Index (NBI).**

  Nutrient concentration and benthic data are available from 115 stations. If necessary, monitoring will be conducted at additional stations to validate the NBI for New Jersey waters. The NBI will be evaluated in 2009 to determine if additional monitoring would be needed in 2010.

- **Revise the Integrated Water Quality Monitoring and Assessment Method**

  Develop a new nutrient assessment method to evaluate aquatic life impacts due to phosphorus based upon the new weight of evidence approach and provide the public with an opportunity to review and comment. The new nutrient assessment method will be implemented as part of the 2010 Methods Document in developing the 2010 Integrated Water Quality Monitoring and Assessment Report.

- **Trophic Diatom Index (TDI)**

  The Philadelphia Academy of Natural Sciences will convene a workgroup to explore the feasibility of developing a Biological Condition Gradient (BCG) for diatom communities in New Jersey. If feasible, the workgroup will proceed to develop the gradient as resources allow. The gradient will provide a tool to help determine what TDI values represent an impairment to diatom communities resulting from excessive nutrient inputs. Feasibility will be decided in 2009. If BCG development ensues and resources allow, completion is expected within two years.

- **Nutrient and Ecological Histories (Sediment Core Sampling in Barnegat Bay)**

  Collect sediment cores and reconstruct water quality conditions based upon diatom community assemblages in the wetland sediment.

- **Nitrogen**

  Evaluate whether there is a need to establish nitrogen criteria, in addition to phosphorus criteria, to address nutrient-related impacts in freshwaters and estuarine waters.

2010

- Adopt amendments to the SWQS rules proposed in 2009 for nutrient criteria.

- Finalize new nutrient assessment methods into the 2010 Integrated Water Quality Monitoring and Assessment Methods.

- Apply new nutrient assessment methods for freshwater wadeable streams to 2010 Integrated Listing Process to delist waters previously listed as impaired based solely on the numeric criteria, and list waters based on the new assessment method.

- Modify the Department's monitoring program based on the outcome of the Pilot Study of Nutrient Assessment Method including Periphyton Speciation Monitoring in NJ, as necessary and as resources allow.

- Explore the feasibility of implementing remote sensing for submerged aquatic vegetation (SAVs) and macro-algae. The Department and Rutgers, the State University of New Jersey are seeking grant opportunities to support this effort.

- Complete NBI and TDI studies.

F. Conclusion

Pursuant to the National Nutrient Policy, the Department has reevaluated New Jersey's nutrient policies articulated in the Surface Water Quality Standards at N.J.A.C. 7:9B (SWQS) and has developed a plan to enhance its existing nutrient criteria to better identify and address nutrient-related use impairment of our State's waters. While our existing narrative nutrient policies prohibit nutrient concentrations in freshwaters that cause objectionable algal densities, nuisance aquatic vegetation, or otherwise render waters unsuitable for designated uses, they do not include numeric translators to objectively implement these narrative policies, nor do they adequately address nutrient impairment in tidal or marine waters, for the purpose of use assessment pursuant to Section 305(b) or listing under Section 303(d) of the federal Clean Water Act.

This Plan sets forth the steps needed to improve New Jersey's nutrient criteria through additional research, monitoring, data evaluation, and development of biological indicators. The Department intends to adopt amendments to the SWQS rules and revise the Department's use assessment methodology to identify and address non-attainment of aquatic life use in streams caused by nutrient impairment. However, while many of these steps are already underway, other critical steps must be completed to successfully implement this Plan in other types of waterbodies. Additional monitoring will be needed to collect chemical and biological data to be able to make statistical correlations and establish cause/effect relationships in rivers and coastal waters. Additional technical studies will be needed to select the appropriate biological indicators and develop a biological index for assessing aquatic life use in rivers and coastal waters. Further evaluations will be required to identify the cause(s) of aquatic life use impairment in rivers and

coastal waters and, where nutrients are the cause, to develop appropriate nutrient criteria for rivers and coastal waters.

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