Mississippi's Plan for Nutrient Criteria Development

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I. INTRODUCTION

The Environmental Protection Agency (EPA) has published recommendations of water quality criteria for nutrients under section 304(a) of the Clean Water Act (66 FR 1671). EPA has stated that they developed the recommended criteria with the intention that these values serve as starting points for states to develop more refined, state specific, numeric nutrient criteria using EPA technical guidance for each water body type along with other scientifically defensible approaches. EPA emphasized that the states have several options available to them in developing and adopting water quality criteria for nutrients. One of the EPA recommended approaches is that wherever possible, the states develop nutrient criteria that fully reflect localized conditions and protect specific designated uses using the processes outlined in the EPA technical guidance manuals. In addition, EPA recommended that states develop a plan for nutrient criteria development that outlinesthe process for how and when they intend to adopt numeric nutrient criteria into their water quality standards.

The purpose of this plan is to provide EPA with a better understanding of Mississippi's approach to nutrient criteria development. The plan allows the State to take advantage of the flexibility to develop criteria that reflect local water conditions as opposed to EPA's national criteria recommendations. The Mississippi Department of Environmental Quality (MDEQ) considers this plan to be an interactive and adaptive plan and will continue to work with EPA Region IV to refine the plan as needed during the coming years. Because of the significance and magnitude of this undertaking, MDEQ may need to revise this plan over time as water quality data collection, assessment activities, and criteria development activities are completed. It is realistic to expect that as new information is considered, some steps may take longer or shorter than anticipated.. Data collection, assessment activities, and criteria development activities may also be limited if sufficient funding and resources are not available.

MDEQ's Nutrient Criteria Development Plan includes the following objectives: (1) establish a Nutrient Work Group or Groups comprised of Federal and State experts to review historical nutrient data, identify data gaps, help develop MDEQ's approach, recommend additional monitoring and data collection, recommend water body classification systems, review data, and analyze data; (2) periodically prepare reports which present MDEQ's progress of developing nutrient criteria; and (3) MDEQ's submittal of scientifically defensible numeric nutrient criteria to EPA for review and approval in accordance with agreed-upon timelines. MDEQ plans to develop numeric nutrient criteria using a system-wide approach. Therefore, MDEQ will coordinate nutrient criteria established for each water body type to ensure consistency throughout the water body systems and address concerns related to downstream use protection. MDEQ plans for numeric nutrient criteria for Lakes and Reservoirs, Wadeable Streams, Non-Wadeable Streams, and Coastal and Estuarine Waters to be released for public comment by June 2013. Numeric nutrient criteria for Delta Waters are planned to be released for public comment by November 2014.

II. CONCEPTUAL APPROACH

The focus of our strategy will be to develop nutrient criteria based primarily on the linkage between nutrient concentrations and impairment of designated uses. For the purposes of this document, "nutrient criteria" are defined as one of, or potentially a combination of, three forms:

- Causal and/or response variables expressed as numerical concentrations and/or mass quantities or loadings
- Causal and/or response variables expressed as narrative statements with a translator mechanism to derive or calculate numerical concentrations and/or mass quantities or loadings
- Casual and/or response variables expressed as narrative statements only.

MDEQ will consider all of the above criterion forms when establishing criteria for causative variables (such as phosphorus and nitrogen) and response variables (such as chlorophyll *a* and turbidity) that are associated with the prevention and assessment of eutrophic conditions. It is possible that a combination of numeric criteria and narrative criteria with translators will be developed for some Mississippi water bodies. Also, it is possible that Mississippi may derive criteria based on a "reference condition approach." Using a reference condition approach, water quality criteria are derived from data collected at least disturbed sites, and an upper percentile of the data is taken to establish the numeric criteria. The flaw in this approach is that it does not provide a definite link between nutrient concentrations and impairment. But rather, it presents statistically-derived values for causal and response variables from sites that are known to be least impacted. It says nothing about the water body's capacity to assimilate nutrient inputs. Additionally, by definition, a portion of the water bodies will not attain the water quality standard, even if their designated uses are being fully attained. However, it has been portrayed by EPA to be an acceptable and scientifically defensible approach, and some states have used it to derive their criteria.

An effects-based approach is undoubtedly the preferred means to arrive at values that are neither over- nor under-protective; however, due to limitations in time, data, and resources the reference condition approach may be used in certain water body types. MDEQ will look for cause/effect relationships between nutrient concentration and biological impacts. However, if those relationships cannot be found, then our "fallback" positions may be to set reference-based or designated uses-based criteria.

A. Classification Schemes

Mississippi is covered by EPA's aggregate ecoregions IX, X, and XII. Data will be examined on the basis of Level III and Level IV sub-ecoregions. Where significant differences exist between sub-ecoregions, the nutrient criteria may be established at the sub-ecoregion level. Where no significant difference is found between sub-ecoregions, the data will be aggregated back to the ecoregion level. It is also possible that Omernick's ecoregion boundaries may be modified, or that further delineation within a Level IV sub-ecoregion may result based on analysis of the data. MDEQ may develop additional classification schemes as appropriate to characterize and classify Mississippi's waters for assessment and criteria development efforts.

B. Reference Conditions

Candidate water body reference conditions will be determined from compiled data and information along with the help of the technical experts who are familiar with the water body resources of Mississippi.

C. Protection of Designated Uses

Mississippi's use classifications include public water supply, shellfish harvesting, fish and wildlife, recreational, and ephemeral streams. Additional designated uses may also be created to further refine the description of Mississippi waters. The EPA technical guidance manuals will be used to gain additional understanding of ways to ensure that the nutrient levels we establish are protective of the designated uses that comprise the use classifications.

D. Data Screening

MDEQ screened existing STORET, USGS, USDA, USACE and other databases for information on water bodies with respect to nutrient-related parameters and information. This information will be used to establish a perspective on the condition of a given water body and to help establish trends in trophic conditions and, when possible, to inform the nutrient criteria development process.

E. Data Collection – Existing and Future Efforts

MDEQ has incorporated aggressive monitoring and data gathering initiatives into existing programs in order to provide nutrient data to support nutrient criteria development. MDEQ is leveraging resources and funding from existing monitoring programs such as the Ambient Station Network, the Ambient Lakes Network, the Beach Monitoring Network, the Mississippi Coastal Assessment, and special projects funded under §104(b)(3), 106, 604(b), 319, and EPA's Gulf of Mexico Program Office.

i. Mississippi Benthic Index of Stream Quality (M-BISQ)

In 2001, MDEQ updated the biological monitoring methodology. This initiative led to the development of a Mississippi-calibrated Index of Biological Integrity (IBI) *Development and Application of the Mississippi Benthic Index of Stream Quality (M-BISQ)* for use in assessment of wadeable streams in Mississippi. This initiative has resulted in monitoring efforts that have greatly increased the number of biological assessments conducted on state waters. The M-BISQ and the established sampling and analytical methodology contained therein now serves as the foundation for routine biological monitoring in MDEQ's statewide Ambient Monitoring Network. In 2008, the M-BISQ was recalibrated using data and information collected 2001-2006.

ii. Other DEQ Monitoring Programs

Numerous on-going water quality monitoring programs have been modified to include the collection of nutrient data. MDEQ's surface water monitoring program includes the following monitoring networks and special studies:

- **Ambient Station Network.** The ambient station network includes water bodies throughout the entire state. In this monitoring network, 30 stations are sampled monthly,

- **Beach Monitoring Network.** Twenty-two coastal water quality stations are sampled on a routine basis during the year. Nutrient data are collected along with bacteria data.

- **Special Monitoring Studies**. Special monitoring is provided by funding from the §104(b), 106, 604(b), 319, EPA's NCA program, and the EPA Gulf of Mexico Program Office.

iii. Mississippi Alluvial Plain.

MDEQ is gathering nutrient data from all ecoregions statewide. However, the Mississippi Alluvial Plain (Ecoregion X) is the most data-limited area of the state. MDEQ is participating in special studies in rivers and streams within this ecoregion to support nutrient criteria development. MDEQ's data collection efforts include monitoring of nutrient concentrations, dissolved oxygen levels, benthic macroinvertebrate communities, and fish communities within Ecoregion X.

III. APPROACH FOR EACH WATER BODY TYPE

A. LAKES AND RESERVOIRS

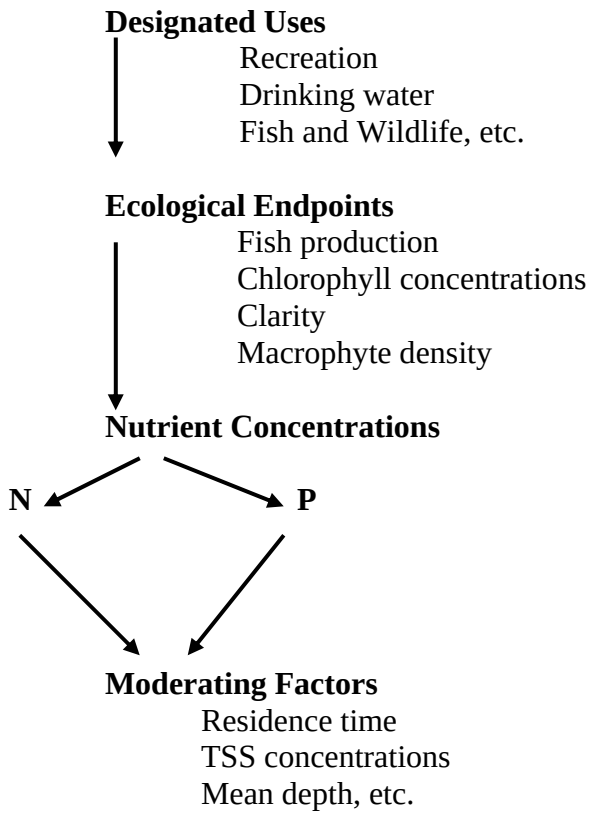
***i. Goal*:** Adopt scientifically defensible water quality nutrient criteria to protect the designated uses of Mississippi's lakes and reservoirs from the adverse effects of nutrient over-enrichment.

Objective 1: Determine the highest attainable designated use for the natural regions and subregions of Mississippi's lakes and reservoirs.

Objective 2: Develop scientifically defensible numeric nutrient criteria that will protect this designated use from adverse effects of nutrient over-enrichment in each region and subregion.

Nutrient concentrations, *per se*, (with the exception of unionized ammonia toxicity and human health nitrate criteria of 10 mg/L-N) convey little information about the condition of aquatic ecosystems or their capacity to support designated uses. It is the response to nutrient concentrations that are relevant in aquatic ecosystems. Therefore, effects-based criteria represent the preferred approach for the development of numeric nutrient criteria. These numeric nutrient criteria should reflect local conditions and protect specific designated uses as described in the EPA Technical Guidance Manuals (EPA 2000, 2001). In addition to an effects-based approach, other scientifically defensible methods and appropriate water quality data may be considered.

Because water quality standards are comprised of designated uses, water quality criteria, and an anti-degradation requirement, an alternative approach to reference systems is to start with the designated uses, identify ecological endpoints that can be associated with these designated uses and then develop a conceptual model showing the linkage among designated uses, ecological endpoints, nutrient concentrations, and factors affecting the expression or response of the endpoint to nutrient concentrations:



Some of the ecological endpoints that were associated with designated uses are shown in Table 1. Some of the factors that might moderate the effects or response to nutrient parameters are shown in Table 2.

Table 1. Example ecological endpoints associated with designated uses.

Ecological Endpoint	Designated Use(s)
Biodiversity (Sustainability)	Aquatic Life Use
Fish Production	Aquatic Life Use
Chlorophyll Concentrations	Drinking Water Aquatic Life Use
Water Clarity	Recreation Drinking Water Aquatic Life Use
Macrophytes	Recreation Aquatic Life Use
TOC	Drinking Water
Harmful Algal Blooms	Aquatic Life Use Drinking Water
Algal Blooms	Aquatic Life Use Drinking Water

Table 2. Example factors that may moderate nutrient effects.

Category	Factors
Physical	Different classification perspective (e.g. ecoregions, watersheds) Residence time Land use/land cover Morphometric attributes (mean depth, surface area) Geology Clarity Watershed physiography Water temperature Climate (precipitation)
Chemical	Alkalinity PH DO TOC/DOC TSS

While there are additional variables that might be considered, these factors represent an initial starting point in the analyses. The successional stage of the lake or reservoir might be important in establishing different categories for nutrients. Similar information can be used to identify clusters of lakes or reservoirs through multivariate or exploratory statistical analyses.

A reference condition approach to the development of nutrient criteria being considered is comparing the §303(d) list of impaired lakes with those that are being analyzed to determine if any of these water bodies are on the §303(d) list, and the reason for listing. This comparison can be used to determine if any water bodies are listed because of nuisance algal blooms or low dissolved oxygen (DO). Lakes and reservoirs listed for these parameters can be used to establish nutrient concentrations associated with these nutrient-related impairments, thus allowing reference condition values to be discerned, which, if exceeded, indicate lakes and reservoirs in poor condition.

The lakes currently under analysis should also be compared with those lakes that are part of the ambient monitoring network. In addition, ambient monitoring lakes should have a time series of nutrient concentrations, which might permit trend analysis to determine if nutrient concentrations have changed over time. Finally, the conceptual model shown above can be used to assess the relationships among listed lakes and non-listed lakes to see if the relationships follow a predictable continuum of response. Other procedures for developing numerical nutrient criteria for lakes that are being considered include the model prediction and extrapolation method mentioned in the EPA Nutrient Criteria Guidance (EPA 2000), and setting numeric nutrient criteria to existing concentrations in lakes currently supporting designated uses.

Other key factors that must be addressed in defining and developing nutrient criteria include: geographic region, water body types, seasonality, and designated uses.

Geographic regions. Lakes in different areas in the State may have different nutrient concentrations depending on native soil types, surface and groundwater hydrology, land use, ecoregions, physiographic areas, and watersheds and basins. Different criteria may be required in these different geographic regions.

Lake types. Different water body types (e.g., oxbows, large reservoirs, etc.) can have different critical conditions at which nutrient concentrations impair designated uses. If the nutrients and critical conditions vary greatly between water body type, each category will require different criteria.

Seasonality. Many ecological endpoints such as chlorophyll concentrations, fish production, recreation, etc. have definite seasonal components that might require different nutrient criteria for these seasons.

Designated uses. The Clean Water Act requires that States designate a use for each water body and develop criteria that will protect and support the highest attainable designated use. The designated uses for lakes and reservoirs will be considered as the foundation for the development of numeric nutrient criteria.

ii. Form

The form of the nutrient criteria for lake and reservoir water bodies will be effects-based rather than EPA's default §304(a) criteria for nutrients. These effects-based nutrient criteria will, wherever possible, reflect local conditions and protect specific designated uses.

iii. Regionalization

Water quality data will be evaluated to determine if water quality in lakes differs by regions. The region designations that will be evaluated are ecoregions, river basins, and physiographic regions. Statistical analyses including ANOVA and cluster analysis will be used to determine if water quality in lakes differs by region.

iv. Classification

The initial classification of Mississippi lakes was to determine which lakes are Waters of the U.S. or Waters of the State, and thus subject to the Clean Water Act. Mississippi lakes that are subject to the Clean Water Act have been put into classes based on size (surface area greater than 500 acres, between 500 and 100 acres, and less than 100 acres), type [large reservoir (>4000 acres), reservoir, oxbow], successional stage, whether or not they are fertilized, and whether or not they are on Mississippi's §303(d) list. Other classes might be identified as data analysis continues.

v. Prioritization and Coverage

Information from USGS's Geographic Names Information System and various other sources indicated there were 938 named lakes/reservoirs/ponds in Mississippi. One hundred thirteen lakes comprise over 90 % of the total surface area of lentic water bodies in Mississippi. In addition, 84% of the total surface area of Mississippi lentic water bodies was represented by the 40 largest lakes and reservoirs (i.e., >500 ac), as depicted in Figure 1 below.

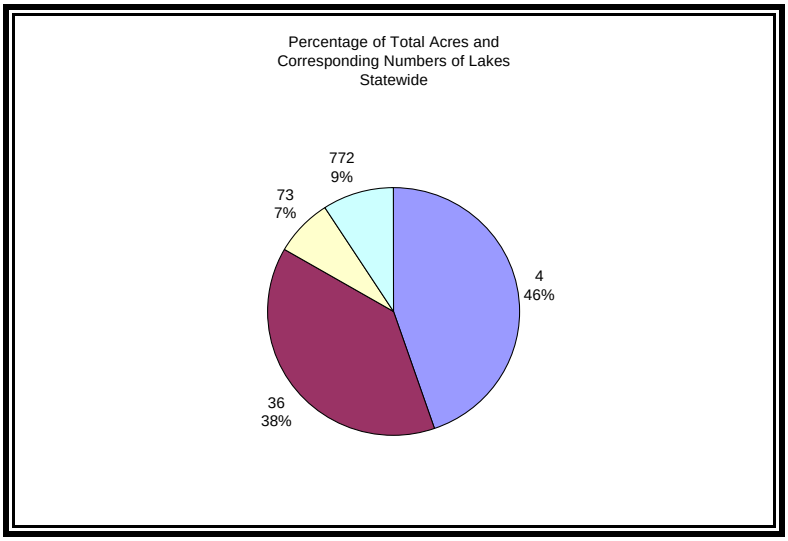


Figure 1. Surface Area of Mississippi Lakes

The first priority, therefore, is to develop criteria on the largest water bodies (i.e., >500 acres). Following the development of criteria for these water bodies, the applicability of these criteria for lakes between 100 and 500 acres will be assessed. Additional criteria will be developed, if needed for these intermediate sized water bodies. Narrative criteria will likely be applied to all other lake and reservoir water bodies below this intermediate size because these water bodies comprise less than 10% of the lentic surface area in the State. MDEQ is also considering the use of narrative criteria for fertilized lakes. Narrative criteria may be applied to fertilized lakes where numeric criteria cannot provide meaningful guidance due to variation in management procedures.

vi. Inventory of Existing Data

One of the first tasks completed was the development of a database of lakes and reservoirs in the State. A number of external sources were consulted to compile the database. The database includes lake name, size, type, mean depth (where known), management status, and location information such as county, watershed, basin, ecoregion, etc. Some of the information obtained as part of this inventory included measurements of chlorophyll *a*, total phosphorus, total nitrogen, turbidity, secci depth, and total suspended solids.

Existing data from the 1974 NES and the 1984 Clean Lakes Studies were added to the database to provide a historical perspective and possible trends in nutrient and endpoint concentrations or values.

vii. Data Collection

MDEQ conducted a review of nutrient criteria from EPA and southern states, along with a literature review of studies relating nutrient concentrations to biological and designated use attainment endpoints. From this we gained an understanding of what water quality parameters and relationships would be the most useful to examine in developing nutrient criteria.

MDEQ initially developed a phased approach for data collection and analysis on 132 lakes and reservoirs for which we plan to develop nutrient criteria. In Phase I, data collection and analyses were performed on the 40 largest unfertilized lakes. These lakes account for approximately 84% of the lake surface area in Mississippi. In addition, 10 fertilized lakes were sampled and data will be analyzed to test the hypothesis that unfertilized lakes and fertilized lakes should be regulated as different classes of lakes.

Phase II focused on those lakes/reservoirs with surface areas between 100 and 500 acres. Characteristics of this subgroup of lakes are being examined to determine if numerical criteria are appropriate for the entire subgroup, or if there is a logical size break point within this range below which narrative criteria would be appropriate.

In 2009, MDEQ re-established the Ambient Lakes Monitoring Program as part of the Statewide Ambient Network. MDEQ collects samples from approximately 20 public lakes (greater than 100 acres in size) annually. Lakes are monitored for traditional physical, chemical, and biological water quality parameters using the protocol that was developed for nutrient criteria development.

viii. Assessing Progress

MDEQ completed a two year data collection effort targeting 50 of the Mississippi lakes larger than 500 acres. Monitoring is ongoing for lakes between 100 and 500 acres in size. Parameters being measured in this sampling program are conductivity, pH, temperature, dissolved oxygen (mg/l), dissolved oxygen percent saturation, turbidity, chlorophyll-*a*, total organic carbon, turbidity, alkalinity, total Kjeldahl nitrogen, nitrate+nitrite, ammonia, total phosphorus, Secchi depth, total dissolved solids, total suspended solids, carbonaceous oxygen demand, and hardness. Table 3 is a listing of the lakes included in the Phase I sampling program indicating the sample collection that has occurred at each one.

Table 1. Summary of lakes sampled October and November 2002 (Fall), March and April, 2003 (Spring), and June through August 2003 (Summer).

Water Body Name	Sampling Period			Type	Fertilized?
	Fall 2002	Spring 2003	Summer 2003		
Aberdeen Lake	X	X	X	LR	
Arkabutla Reservoir	X	X	X	LR	
Bay Springs Lake	X	X	X	LR	
Lake Bogue Homa	X	X	X	R	
Bee Lake	X	X	X	O	
Lake Beulah	X	X	X	O	
Bluff Lake	X	X	X	R	
Lake Bolivar	X	X	X	O	
Lake Chotard	X	X	X	O	
Columbus Lake	X	X	X	LR	
Dalewood Shore Lake	X	X	X	R	
Desoto Lake	X	X	X	O	
Eagle Lake	X	X	X	O	
Elvis Presley Lake	X	X	X	R	Y
Enid Reservoir	X	X	X	LR	
Lake Ferguson	X	X	X	O	
Flint Creek Reservoir	X	X	X	R	
Geiger Lake	X	X	X	R	Y
Grenada Reservoir	X	X	X	LR	
Hard Cash Lake	X	X	X	O	
Horseshoe Lake	X	X	X	O	
Horn Lake	X	X	X	O	
Kemper County Lake	X	X	X	R	Y
Lake Lamar Bruce	X	X	X	R	Y
Little Black Creek Reservoir	X	X	X	R	
Lake Lee	X	X	X	O	
Lake Lincoln	X	X	X	R	Y
Lake Mary	X	X	X	O	
Lake Whittington	X	X	X	O	
Moon Lake	X	X	X	O	
Natchez St. Park Lake	X	X	X	R	Y
Okatibbee Reservoir	X	X	X	LR	
Pickwick Lake	X	X	X	LR	
Tenn-Tom Pools	X	X	X	R	
Ross Barnett Reservoir	X	X	X	LR	
Roebuck Lake	X	X		O	
Sardis Reservoir	X	X	X	LR	
Lake Tangipahoa	X	X	X	R	Y
Tchula Lake			X	O	
Tunica Cutoff	X	X	X	O	
Trace State Park Lake	X	X	X	R	Y
Turkey Fork Creek Reservoir	X	X	X	R	Y
Wolf Broad Lake	X	X	X	O	
Lake Washington	X	X	X	O	
Wasp Lake	X	X	X	O	

"X" in cells indicates that sampling was performed for the period indicated
O = oxbow, LR = large reservoir, R = reservoir; Y = yes

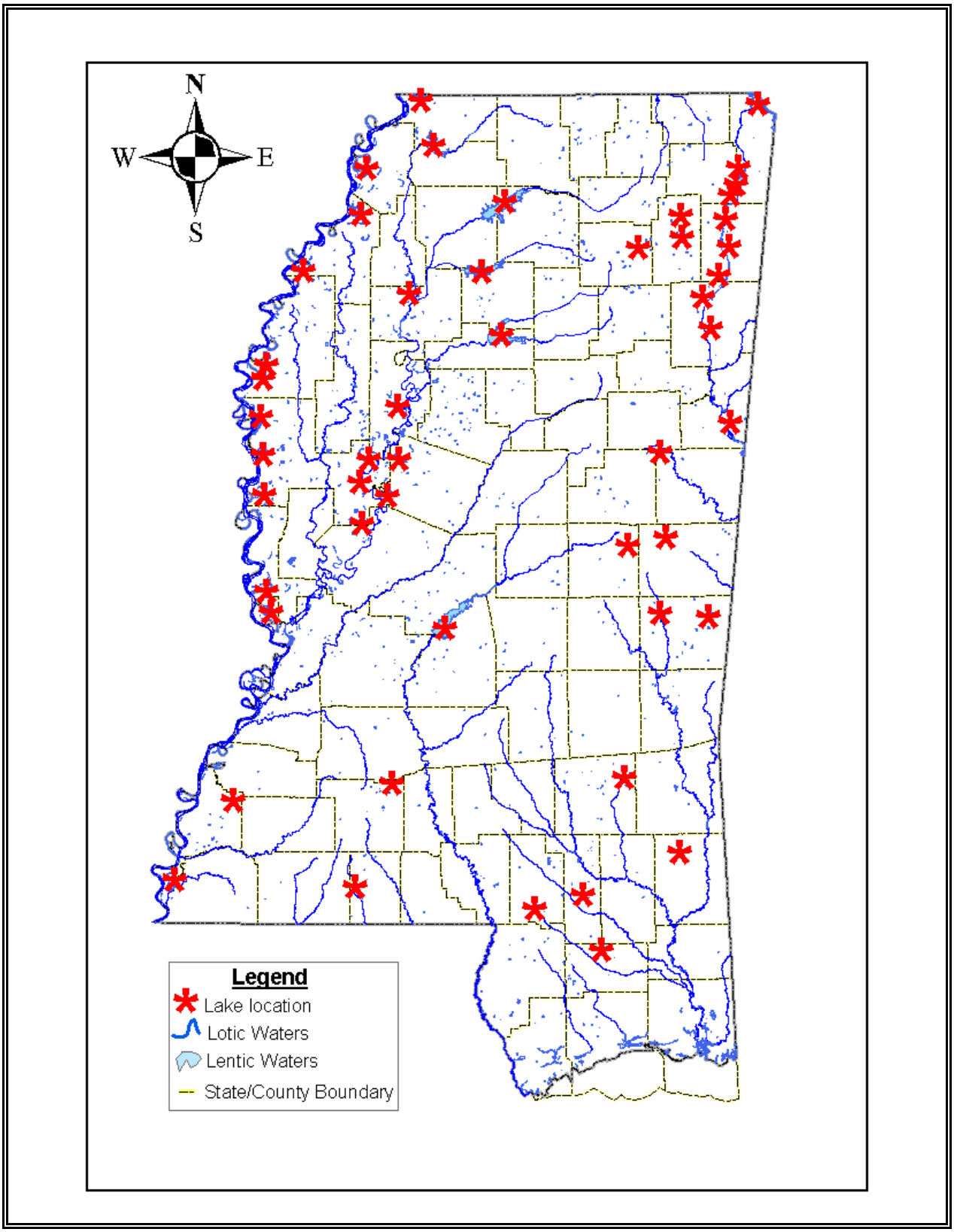


Figure 3. Locations of Sampled Lakes and Reservoirs

ix. Preliminary Data Analyses

Using SYSTAT statistical analysis software, preliminary data analyses were performed on water quality data from lakes and reservoirs sampled during October and November, 2002 (Fall data), March and April, 2003 (Spring data), and June, 2003 (June data). The purpose of the analyses was to examine the data for general patterns in relationships among variables and among for the ultimate purpose of refining classifications of reservoirs, large reservoirs, and oxbows. The statistical analyses performed were, in general, exploratory analyses rather than tests of specific hypotheses.

x. Schedule and Milestones

The schedule for development of nutrient criteria for lakes and reservoirs is:

Year	Milestone	Task Complete?
2003	Inventory of All Existing Lake Data	yes
	Design and Implementation of Additional Data Collection	yes
	Phase I Lake Sampling Initiated	yes
2004	Phase I Lake Sampling Completed	yes
	Initiated Analysis of Phase I Lake Sampling and Historical Data	yes
2005	Initiated Analysis of Combined 2003-2004 Lake Sampling and Historical Data	yes
	Phase II Lake Sampling Initiated	yes
2006	Continued Data Analyses	yes
	Initiate Development of Phase I Lake/Reservoir Nutrient Criteria Targets	yes
	Phase II Sampling Completed	yes
	Initiate Development of Phase II Lake/Reservoir Nutrient Criteria Targets	yes
2007	Complete Data Analyses for Phase II	yes
	Complete Development of Phase I and Phase II Lake and Reservoir Nutrient Criteria Targets	yes
2008	Continue Criteria Development Activities	yes
2009	Coordinate Draft Lake/Reservoir Nutrient Targets with Draft Nutrient Targets for Coastal and Estuarine Waters	yes
	Coordinate Draft Lake/Reservoir Nutrient Targets with Draft Nutrient Targets for Wadeable Streams	yes
	Coordinate Draft Lake/Reservoir Nutrient Targets with Draft Nutrient Targets for Non-Wadeable Streams	yes
2010	Mississippi's Nutrient Technical Advisory Group (TAG) is Established	
	Development of Trophic State Index (TSI) is Initiated	
	TAG Meeting on Lakes and Reservoirs	
2011	TSI Completed and Incorporated into Nutrient Criteria Development Activities	
	Continue Criteria Development Activities	
	TAG Meeting on Lakes and Reservoirs	
	Continue Coordination of Criteria Development Activities among Lakes and Reservoirs, Wadeable Streams and Non-Wadeable Streams	
	Initiate Stakeholder Outreach and Education on Nutrient Criteria Development	

2012	TAG Meeting for Final Technical Comments on Lakes and Reservoirs	
	Complete Technical Work on Lakes and Reservoirs, Wadeable Streams, Non-Wadeable Streams, and Coastal and Estuarine Waters	
	Continue Coordination of Criteria Development Activities among Lakes and Reservoirs, Wadeable Streams and Non-Wadeable Streams	
	Continue Stakeholder Outreach and Education on Nutrient Criteria Development Activities	
2013	Final Draft Criteria for Lakes and Reservoirs are Submitted for MDEQ Management/Agency Review	
	MDEQ Management/Agency Review is Completed	
	Numeric Nutrient Criteria for Mississippi's Lakes and Reservoirs are Public Noticed by June 30, 2013 and the Public Comment Period Begins	

B. Streams and Rivers

i. Goal Initially, MDEQ will attempt to establish effects-based numeric nutrient criteria tied to specific designated uses. We will also attempt to collect sufficient data so that we may "fall back" to reference-based or designated uses-based criteria if data do not allow the establishment of effects-based criteria.

ii. Form

Initially, MDEQ will evaluate historical data from streams and rivers in Mississippi. Parameters to be evaluated in the historical database will include:

- Field parameters
  - pH, D.O. (instantaneous), temperature, turbidity, and specific conductance
- Phosphorus
  - Total
- Nitrogen
  - Total
  - Dissolved inorganic (alternates: nitrate+nitrite, ammonia, TKN)
- Suspended solids
  - Total
- Habitat assessment
- Benthic macroinvertebrate assemblages

Additional data collection efforts will evaluate the following parameters:

- Field parameters
  - pH, D.O. (instantaneous and diurnal), temperature, turbidity, and specific conductance
- Phosphorus
  - Total
  - Dissolved inorganic (alternate: orthophosphorus)
- Nitrogen
  - Total
  - Dissolved inorganic (alternates: nitrate+nitrite, ammonia, TKN)
- Suspended solids
  - Total
  - Fixed (alternate: volatile)
- Algal-related response variables
  - Chlorophyll *a* and Pheophytin (water column)
  - Chlorophyll *a* (stream bottom)—wadeable streams only
  - Rapid periphyton survey—selected wadeable streams only
  - Laboratory identification of algal taxa—selected stations/sample only
- Habitat assessment
- Benthic macroinvertebrates
- Fish communities

Upon evaluation of all parameters listed above, MDEQ will determine those indicators that are believed to be scientifically credible in establishing numeric nutrient criteria. Data evaluation to determine parameter applicability will include various statistical analyses to identify causal parameters that accurately represent the nutrient characteristics of the given water bodies and response variables that clearly respond to the dynamics of the causal variables. We have initiated exploratory analyses of linkages between historical nutrient concentration trends and low IBI scores. MDEQ is currently looking at this relationship to see if it is possible to conclude that the stressed sites are that way because of nutrient concentrations. This will provide a much more defensible connection between nutrients and impairment than a simple percentile of all "least disturbed" concentrations. If cause-response relationships cannot be established with confidence, however, a statistical approach which characterizes the percentile distributions of causal parameters from reference conditions may be used.

iii. Regionalization

MDEQ will use statistical analyses to evaluate all data to determine if natural variability exists in nutrient values and responses in rivers and streams in Mississippi. Frameworks to be evaluated as potential regional strata include ecoregions, bioregions, basins, various longitudinal and latitudinal geographic regions, system types, physiographic regions, and land use and cover characteristics. The results of data analyses will determine if nutrient criteria will be applied by specific strata and/or substrata, or if stratification is not necessary, and therefore will be applied statewide.

iv. Classification

Through statistical analyses of historical and current data being collected through ongoing data collection efforts, MDEQ will evaluate stream size and season as potential classes for nutrient criteria for rivers and streams, based on the presence of natural variation in these factors. Streams will be evaluated in a minimum of three groups: (1) Wadeable streams, (2) Non-Wadeable Streams, and (3) Delta Waters.

v. Inventory of Existing Data

MDEQ has a historical database for use as a basis to derive numeric nutrient criteria or more likely to provide direction and guidance for future data collection needs. This database is primarily composed of multiple data points collected from ambient monitoring stations and single data points collected during MDEQ's §303(d) assessment project. The ambient monitoring data is composed of different amounts of data from each station, collected at varying frequencies and for varying duration. In addition, data from the ambient stations are either new (post 1997), old (prior to 1997) or a combination of new and old data.

vi. Data Collection

MDEQ's Nutrient Task Force recommended the following data needs in order to more thoroughly document nutrient conditions and characteristics to be able to derive scientifically defensible nutrient criteria:

- Increase the amount and forms of data to complement MDEQ's existing database by collecting various physical, chemical, biological and land use data from historical stations as well as new stations, representing a gradient of nutrient conditions. This gradient will include streams thought to be very healthy, in poor health due to nutrients and streams of moderate impairment or thought to be at risk for nutrient impairment. Sampling locations will be determined through a combination of a target-based sampling design and a stratified random sampling design.
    - Targeted stations will be selected based on their having been sampled historically and based on an *a priori* selection process that identifies streams that will potentially reflect healthy conditions, conditions that are at risk of nutrient impairment based on land-use and conditions that will potentially reflect severe nutrient impaired conditions.
    - Stratified random sampling stations will be selected using strata that represent ecoregions, stream size and major watersheds or basins, and by determining the proportional amount of streams and rivers represented by each strata. Total available state-wide samples will be divided by proportional allocation within each strata based on its number of river and stream miles so that collected data will be "self-weighting".
- Collect sufficient data within each major basin to be able to account for downstream effects, and ensure that criteria development in streams complement criteria developed in lakes, reservoirs, estuaries, and wetlands, and are not mutually exclusive and/or conflicting.

MDEQ plans to address the lack of data concerns by incorporating a basin-wide sampling plan to collect sufficient data to be able to model nutrient loadings throughout the basin and be able to potentially model the predicted effects of these loadings. This would serve to verify autonomous data collection efforts and criteria development by water body type (i.e. lake, stream, and estuary) and to modify criteria where necessary, based on a whole watershed framework.

vii. Schedule and Milestones

Year	Milestone	Task Complete?
2003	Sampling of Wadeable Streams Initiated	yes
	Wadeable Streams Historical Data Analyses	yes
2004	Analyses of 2003 Wadeable Streams Data	yes
	Continued Sampling of Wadeable Streams	yes
	Design Sampling Plan for Non-Wadeable Streams	yes

2005	Initiated Analyses of Combined 2003-2004 Data for Wadeable Streams	yes
	Completed Sampling for Wadeable Streams	yes
	Evaluation of Other Stream Classes	yes
2006	Continue Sampling of Wadeable Streams	yes
	Continue Analyses of Wadeable Streams Data	yes
	Initiated Sampling of Non-Wadeable Streams	yes
2007	Continue Sampling of Wadeable Streams	yes
	Continue Analyses of Wadeable Streams Data	yes
	Continue Sampling for Non-Wadeable Streams	yes
	Initiate Sampling of Delta Streams	yes
2008	Continue Sampling of Wadeable Streams, Non-Wadeable Streams, and Delta Waters	yes
	Continue Analyses of Wadeable Streams Data	yes
	Initiate Data Analyses for Non-Wadeable Streams	yes
	Initiate Development of Draft Nutrient Targets for Wadeable Streams and Non-Wadeable Streams	yes
2009	Continue Sampling of Wadeable Streams, Non-Wadeable Streams, and Delta Waters	yes
	Complete Draft Nutrient Targets for Wadeable Streams and Non-Wadeable Streams	yes
	Coordinate Draft Nutrient Targets for Wadeable Streams with Draft Nutrient Targets for Lakes and Reservoirs	yes
	Coordinate Draft Nutrient Targets for Wadeable Streams with Draft Nutrient Targets for Non-Wadeable Streams	yes
	Coordinate Draft Nutrient Targets for Wadeable Streams with Draft Nutrient Targets for Coastal and Estuarine Waters	yes
	Coordinate Draft Nutrient Targets for Non-Wadeable Streams with Draft Nutrient Targets for Lakes and Reservoirs	yes
	Coordinate Draft Nutrient Targets for Non-Wadeable Streams with Draft Nutrient Targets for Coastal and Estuarine Waters	yes
	Initiate Data Analyses for Delta Streams	yes
2010	Continue Sampling and Data Analyses of Wadeable Streams, Non-Wadeable Streams, and Delta Waters	
	Mississippi's Nutrient Technical Advisory Group (TAG) is Established	
	TAG Meeting on Wadeable Streams	
	Continue Criteria Development Activities	
2011	Continue Sampling and Data Analyses of Wadeable Streams, Non-Wadeable Streams, and Delta Waters	
	TAG Meetings on Wadeable Streams, Non-Wadeable Streams, and Delta Waters	
	Continue Coordination of Criteria Development Activities among Lakes and Reservoirs, Wadeable Streams and Non-Wadeable Streams	
	Initiate Stakeholder Outreach and Education on Nutrient Criteria Development Activities	

2012	TAG Meeting for Final Technical Comments on Wadeable Streams and Non-Wadeable Streams	
	TAG Meeting on Delta Waters	
	Complete Technical Work on Lakes and Reservoirs, Wadeable Streams, Non-Wadeable Streams, and Coastal and Estuarine Waters	
	Continue Coordination of Criteria Development Activities among Lakes and Reservoirs, Wadeable Streams and Non-Wadeable Streams	
	Continue Stakeholder Outreach and Education on Nutrient Criteria Development Activities	
2013	Final Draft Criteria for Wadeable Streams and Non-Wadeable Streams are Submitted for MDEQ Management/Agency Review	
	MDEQ Management/Agency Review is Completed	
	Numeric Nutrient Criteria for Mississippi's Wadeable Streams and Non-Wadeable Streams are Public Noticed by June 30, 2013 and the Public Comment Period Begins	
	TAG Meeting(s) on Delta Waters	
	Continue Stakeholder Outreach and Education on Nutrient Criteria Development Activities	
2014	Complete Technical Work on Delta Waters	
	Final Draft Criteria for Delta Waters are Submitted to MDEQ Management/Agency Review	
	MDEQ Management/Agency Review is Completed	
	Numeric Nutrient Criteria for Delta Waters are Public Noticed by November 30, 2014 and the Public Comment Period Begins	

This schedule represents MDEQ's best projected approach to developing numeric nutrient criteria for streams and rivers. However, the approach and schedule may be changed because of the uncertainties in the following areas:

- The state of the science supporting criteria development; and
- Difficulty in linking nutrient concentrations to use impacts on streams.

Information gained from discussions with other states and EPA at RTAG, and others, during regional EPA Sponsored meetings may lead to changes in schedules and approaches.

C. COASTS AND ESTUARIES

The President's U.S. Ocean Action Plan released in December 2004 highlighted the Gulf of Mexico Alliance, a partnership formed by the five Gulf State Governors. The Plan called for increased integration of resources, knowledge and expertise to make the collaboration of the Gulf Alliance a success. Thirteen federal agencies formed a Federal Workgroup, with EPA and the National Oceanic and Atmospheric Administration (NOAA) as co-leads, committed to supporting the Alliance. The Gulf of Mexico Program (GMPO) is the lead for EPA. The Gulf Alliance released an action plan in 2006 as a starting point for effective regional collaboration and addresses specific issues and projects which will result in a healthier Gulf of Mexico ecosystem and economy with a vision toward healthy and resilient coasts and communities in the Gulf of Mexico. An objective of the Gulf Alliance Action Plan is to reduce nutrient inputs to sustain productive Gulf aquatic ecosystems. MDEQ actively supports the GMPO and the Gulf Alliance in achieving the goals of the Action Plan. The nutrient criteria development work by MDEQ will be coordinated with the Gulf Alliance Partnership to ensure MDEQ's criteria development work is fully coordinated with the other coastal states.

Data collection began during the summer of 2004 and provides information that can be used in determining causes, effects, and extent of water quality impairment from nutrient enrichment in Mississippi coastal waters. MDEQ was awarded a grant from the EPA Gulf of Mexico Program to Develop Pilot Nutrient Criteria for a Mississippi Estuary. MDEQ selected the St. Louis Bay watershed for this intensive study. The study will include intensive and comprehensive data collection including physical, chemical, and biological monitoring efforts. A modeling component is also included in the project. This project was awarded in 2009 and is anticipated to be complete by December 31, 2013. If MDEQ is unable to establish linkages between nutrient concentrations and biological responses, then as with other water body types, one fall-back position may be to establish reference condition thresholds using a percentile of concentrations at least disturbed sites.

MDEQ believes that it is of utmost importance that criteria for these coastal water bodies be related to a measurable impairment of a designated use. Estuaries and coasts are the most downstream of all state waters, and are therefore the ultimate nutrient "sink". Criteria needed to protect these waters can be translated, or modeled, upland to determine allowable loadings from freshwater inputs. MDEQ is considering this approach as an alternative to establishing reference condition-based criteria in upland freshwaters, as discussed previously in the Rivers and Streams section of this document.

The general approach will be:

- Review historical data from Mississippi coasts and estuaries to assess status and trends in nutrient concentrations and associated biotic effects;
- Determine what additional data are needed to develop effects-based nutrient criteria for coasts and estuaries;
- Participate in Gulf Alliance Partnership workshops and meetings to coordinate nutrient criteria development activities; and
- Formulate analytical approaches for using historical and additional data to develop nutrient criteria for coastal and estuarine water bodies.

Designated uses for coastal and estuarine water bodies include shellfish harvesting, recreation, fish consumption, and aquatic life support. Effects-based indicators linking nutrients with these designated uses will be included in additional data collection efforts. The approaches being considered for linking nutrients with effect-based indicators include empirical approaches/relationships, loading models, and cause-effect studies.

The Coasts and Estuaries Subcommittee of the Nutrient Task Force was instrumental in the development of nutrient criteria for Mississippi's coastal and estuarine ecosystems. In addition, the Mississippi Nutrient Technical Advisory Group will be coordinating the efforts for criteria development in upstream water body systems to be protective of the highest attainable coastal and estuarine designated use.

Other key factors that must be addressed in defining and developing numeric nutrient criteria include: geographic region, water body types, seasonality, and designated uses.

Geographic regions. Different areas of the States coastal waters have different nutrient concentrations depending on native soil types, surface and groundwater hydrology, land use, tidal regime, and coast-estuarine hydrodynamics and interactions. Different criteria might be required in these different geographic regions.

Water body types. Different water body types (e.g., small bays, riverine estuaries, etc.) can have different critical conditions at which nutrient concentrations impair designated uses. Because the nutrients and critical conditions vary greatly between water body type, each category may require different criteria.

Seasonality. Many ecological endpoints such as chlorophyll concentrations, shell fish and fin fish production and harvesting, recreation, etc. have definite seasonal components that might require different nutrient criteria for these seasons.

Designated uses. The Clean Water Act requires that States designate a use for each water body and develop criteria that will protect and support the highest attainable designated use. The designated uses for coasts and estuaries were stated above.

i. Form

The form of the nutrient criteria for coastal and estuarine water bodies will be effects-based rather than EPA's default 304(a) criteria for nutrients. These effects-based nutrient criteria will, wherever possible, reflect localized conditions and protect specific designated uses.

ii. Regionalization

Because estuarine systems are continuous and not discrete water bodies, the development of nutrient criteria will be coordinated with the Gulf of Mexico Program and adjacent states of Louisiana and Alabama. The Gulf of Mexico Program is spearheading an effort to compile and analyze existing nutrient data from all States bordering the Northern Gulf. The "Northern Gulf Pilot Project" is a product of EPA's efforts to demonstrate the methodology described in their Coasts/Estuaries Guidance Document. We have provided a considerable amount of data to

GMPO's contractor, and we will rely heavily on the findings to ensure consistency with other Gulf States.

iii. Classification

Within regions, coastal and estuarine systems will be classified according to various factors such as size (e.g., small bays), hydrologic and/or salinity regime, seasonal responses, and other factors that might affect the response of coastal and estuarine systems to nutrient loading and concentration and attainment of designated uses. Classifications will become more apparent upon analysis of the data.

iv. Prioritization and Coverage

Because the large estuaries comprise most of the surface area of coastal and estuarine water bodies, the first priority of nutrient criteria will be for the large estuarine water bodies. The next priority will be to determine if numeric criteria are needed for all coastal and estuarine water bodies, or if there is a size category below which narrative criteria should be retained. If a size category is determined, the applicability of the numeric criteria developed for the large estuaries will be assessed for this intermediate category of estuarine water bodies. Additional numeric nutrient criteria will be developed if the large estuarine nutrient criteria are not considered adequate in protecting and supporting the highest attainable use for these intermediate water bodies.

v. Inventory of Existing Data

The data inventory consists of a number of special studies conducted on the Mississippi Gulf Coast since 1990, ambient monitoring data, beach monitoring data, and National Coastal Assessment data.

vi Data Collection

A data collection program was developed based on guidance used in designing the EPA National Coastal Assessment Program. The stations are given in Table 4 below along with the reason that each station was targeted. The design considered the parameters to be sampled, which included: Dissolved Oxygen, at least one diurnal event, pH, Temperature, Salinity, Turbidity, Total Dissolved Solids, Ammonia Nitrogen, Nitrite plus Nitrate Nitrogen, Total Kjeldahl Nitrogen, Total Phosphate, Chlorophyll *a*, and Benthic Macrofauna. However, because of potential funding limitations, benthics were not included during the first year of sampling. The sampling interval was quarterly, beginning in April 2003. The sampling and analytical methods followed the US Environmental Protection Agency National Coastal Assessment Program Guidance. Diel sampling for DO and nutrients will also occur once during the spring high flow period (e.g., May) and once during the summer low flow period (e.g., August) at all stations. Data collection locations are shown in Figure 4. Data were lost as a result of Hurricane Katrina. Based on this and other factors, data analyses conducted in 2007 indicated the need for additional collection of Chlorophyll *a* data. Additional data collection efforts continue across the Mississippi coastal region.

Detailed analysis of all data and production of reference conditions for estuarine water bodies will be performed using Excel worksheets and SYSTAT statistical analysis software. The results can be made available to other Gulf Coast states and EPA for use in establishing recommendations for nutrient criteria in the Northern Gulf.

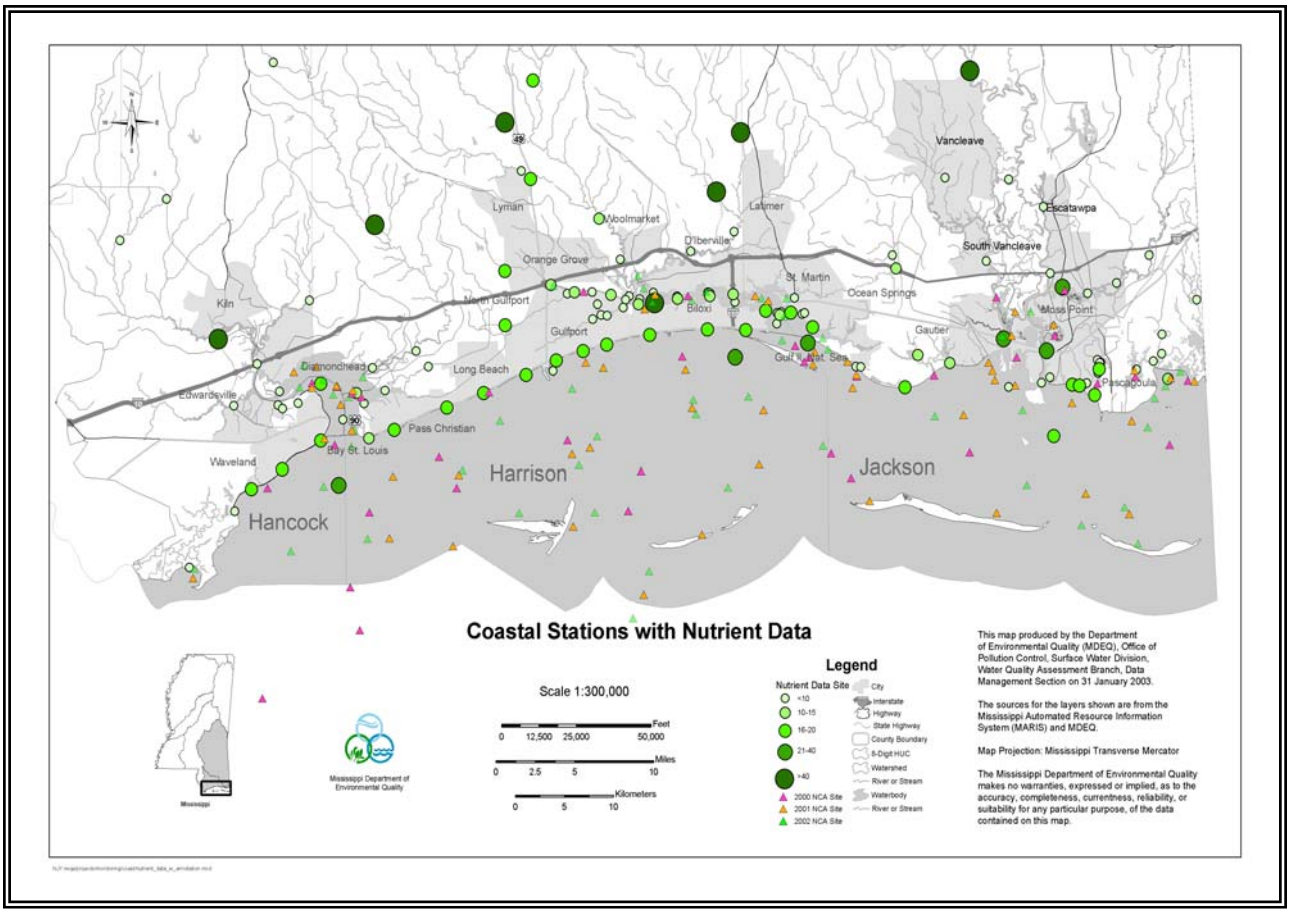


Figure 4. Map of Coastal Sampling Locations

Table 4. Coastal Nutrient Monitoring Stations

Water Body	Recommended Monitoring Sites	Justification for Sampling
Biloxi River	1. One site located near the mouth	1. Increases in TP concentrations, (e.g. 240 to 300ug/L)
Tchoutacabouffa River	1. One site located near the mouth	1. Increases in TP concentrations, (e.g. 130 to 370ug/L)
Confluence of Biloxi and Tchoutacabouffa R.	1. Locate one station at confluence of Biloxi and Tchoutacabouffa Rivers	
Old Fort Bayou	1. Locate site at mouth of Old Fort Bayou at Washington Avenue Bridge	1. Increases in TP concentrations, (e.g. 90ug/L)
Biloxi Bay	1. Site No. 646BBB04 (Ocean Springs) 2. Site No. 02481270 (Biloxi) 3. Site No. BBYB02 (Davis Bayou)	1. 20 previous samples, P spike @1920 ug/l 2. 52 previous samples, P spike @3190 ug/l 3. 18 previous samples, no nutrient spikes
Central Mississippi Sound	1. Site No. MSDB16 (Gautier South)	1. 19 previous samples, nutrient and turbidity spikes
Pearl River	1. Upstream near Highway 90 Overpass	
Industrial Seaway	1. Site No. 02481210	1. Location is common to Bernard Bayou and the Industrial Seaway
Wolf River	1. Site No. 2481527	1. Poor water quality based on TP, TKN, and TN 2. Best water quality based on TP, TKN, and TN
Western Mississippi Sound	1. Site No. 640MSDB02 2. Site No. 640MSDB03 3. Site No. 640MSDB04	1. Poor water quality based on TN 2. Best water quality based on TP 3. Best water quality based on TN, but poor water quality based on TP
Pascagoula River	1. Site No. 02480210	1. Best water quality based on TN during 3 separate seasonal sampling events
East Mississippi Sound	1. Site No. 640MSD03 2. Site No. 640MSDB18 3. Site No. 640MSBD16 4. Site No. 640MSBD17	1. Best water quality based on TN during 3 separate seasonal sampling events, but also had one sampling that would make it a poor water quality station 2. Best water quality based on TN during 2 separate seasonal sampling events, but also had one sampling that would make it a poor water quality station 3. Poor water quality based on TN
Bayou Chicot	1. Site No.CS023	Poor water quality based on TN
Graveline Bayou	1. Site No. 118GRV02	Poor water quality based on TN
Bangs Lake	1. Site No. 109BNG01	Poor water quality based on TN
Point Aux Chenes Bay	1. Site No. 109PAX01	Best water quality based on TN during 2 separate seasonal sampling events
Bayou Casotte	1. Site No. 109CAS01	Poor water quality based on TN during 6 separate seasonal sampling events
St. Louis Bay *	1. Center of the bay 2. Outside the bay in the sound, South of the Intercoastal Waterway * Additional sites to be established during development of monitoring plan.	
Bayou Caddy	Sites to be selected.	The NCA program has a station at the mouth of the bayou.

vii. Schedule and Milestones

Year	Milestone	Task Complete?
2003	Sampling of Large Estuaries	yes
	Historical Data Analysis	yes
2004	Continued Sampling of Large Estuaries	yes
	Analysis of 2003 Data for Large Estuaries	yes
2005	Completed Sampling and Laboratory Analyses	yes
	Evaluation of Other Estuarine Classes	yes
2006	Analysis of Combined 2003-2005 Data	yes
	Coordinate Data Analyses with EPA Northern Gulf Pilot Study Phase II Coastal Nutrient Data Analyses	yes
2007	Suspend Data Analyses and Criteria Development Until New Data Are Collected	yes
	Conduct Additional Water Quality Sampling and Laboratory Analyses for Additional Chlorophyll *a* Data (Late Spring, Summer, and Fall of 2007)	yes
	Initiate Plans for Additional Nutrient and Water Quality Data Collection through Collaboration within Gulf of Mexico Alliance States	yes
2008	Initiate Data Analyses of the 2007 Data	yes
	Participate in Data Collection and Parameter Standardization Efforts with other Gulf States as part of the Gulf of Mexico Alliance	yes
	Development of a Criteria Development Approach that is Consistent Across the Gulf of Mexico Alliance States	yes
2009	Development of Draft Nutrient Criteria for Mississippi's Coastal and Estuarine Waters	yes
	Re-evaluate Other Estuarine Classes and Data Analyses, as needed, in Collaboration with other Gulf of Mexico Alliance States	yes
	Coordinate the Coastal and Estuarine Waters Draft Nutrient Criteria with Lakes/Reservoirs Draft Nutrient Criteria	yes
	Coordinate the Coastal and Estuarine Waters Draft Nutrient Criteria with Draft Nutrient Criteria for Wadeable Streams	yes
	Coordinate the Coastal and Estuarine Waters Draft Nutrient Criteria with Draft Nutrient Criteria for Non-Wadeable Streams	yes
	MDEQ is Awarded EPA Gulf of Mexico Program Grant for Intensive Nutrient Study of St. Louis Bay, Mississippi	yes
	Development of Monitoring Plan for St. Louis Bay Project is Initiated through the Gulf of Mexico Alliance Nutrients Priority Issue Team	yes
2010	Monitoring Plan is Complete for St. Louis Bay Project	
	Data Collection and Modeling are Initiated for St. Louis Bay Project	
	Mississippi's Nutrient Technical Advisory Group is Established	
2011	Continue Sampling and Data Analyses Efforts	
	TAG Meeting on Coastal and Estuarine Waters	
	Continue Coordination of Criteria Development Activities among Coastal and Estuarine Waters, Lakes and Reservoirs, Wadeable Streams, and Non-Wadeable Streams	
	Initiate Stakeholder Outreach and Education on Nutrient Criteria Development Activities	

2012	Continue Data Collection and Modeling Activities Associated with the St. Louis Bay Project	
	Complete St. Louis Bay Monitoring and Modeling Grant	
	Incorporate Results from St. Louis Bay Project and Project to Develop a Macrobenthic Index of Biological Integrity for Gulf of Mexico Waters Completed by Gulf of Mexico Alliance Nutrients Priority Issue Team	
	TAG Meetings on Coastal and Estuarine Waters	
	TAG Meeting for Final Technical Comments on Coastal and Estuarine Waters	
	Complete Technical Work on Lakes and Reservoirs, Wadeable Streams, Non-Wadeable Streams, and Coastal and Estuarine Waters	
	Continue Coordination of Criteria Development Activities among Lakes and Reservoirs, Wadeable Streams and Non-Wadeable Streams	
	Continue Stakeholder Outreach and Education on Nutrient Criteria Development Activities	
2013	Final Draft Criteria for Coastal and Estuarine Waters are Submitted for MDEQ Management/Agency Review	
	MDEQ Management/Agency Review is Completed	
	Numeric Nutrient Criteria for Mississippi's Coastal and Estuarine Waters are Public Noticed by June 30, 2013 and the Public Comment Period Begins	

IV. ADMINISTRATIVE PROCESS

The administrative process for regulatory changes will be as follows:

- Publish a public notice in certain major daily newspapers across the State announcing the intent to modify MDEQ's Water Quality Standards by adopting numeric nutrient criteria.
- Hold a 45 day public comment period.
- During the public comment period, hold a public hearing
- Prepare a responsiveness summary to all comments received.
- Present recommendations to the Mississippi Commission on Environmental Quality.
- Upon approval by the Commission, public notice the standards adoption.
- Submit to EPA for approval.

V. INVOLVEMENT OF DECISION MAKERS, PUBLIC AND STAKEHOLDERS

Upon Commission adoption, the criteria become applicable and will be implemented. Implementation will proceed in conjunction with the rotating basin cycle and with close coordination with the Environmental Permits Division and affected stakeholders. A process will be defined for implementation in TMDL's involving nutrient-related impairments. Presentations will be made at Basin Stakeholders meetings and other coordination/outreach meetings.

VI. CONCLUSION

MDEQ has made a strong commitment of resources and established the TAG to ensure that nutrient criteria development work is carried out in an efficient and productive manner while assuring quality of the final products. Significant in-house and contract resources have been applied to this work, and MDEQ plans to maintain this level of commitment through the entire process. Our greatest challenge, however, is to maintain sufficient funding over the project duration to support the field and laboratory investigations necessary to provide statistically significant data.