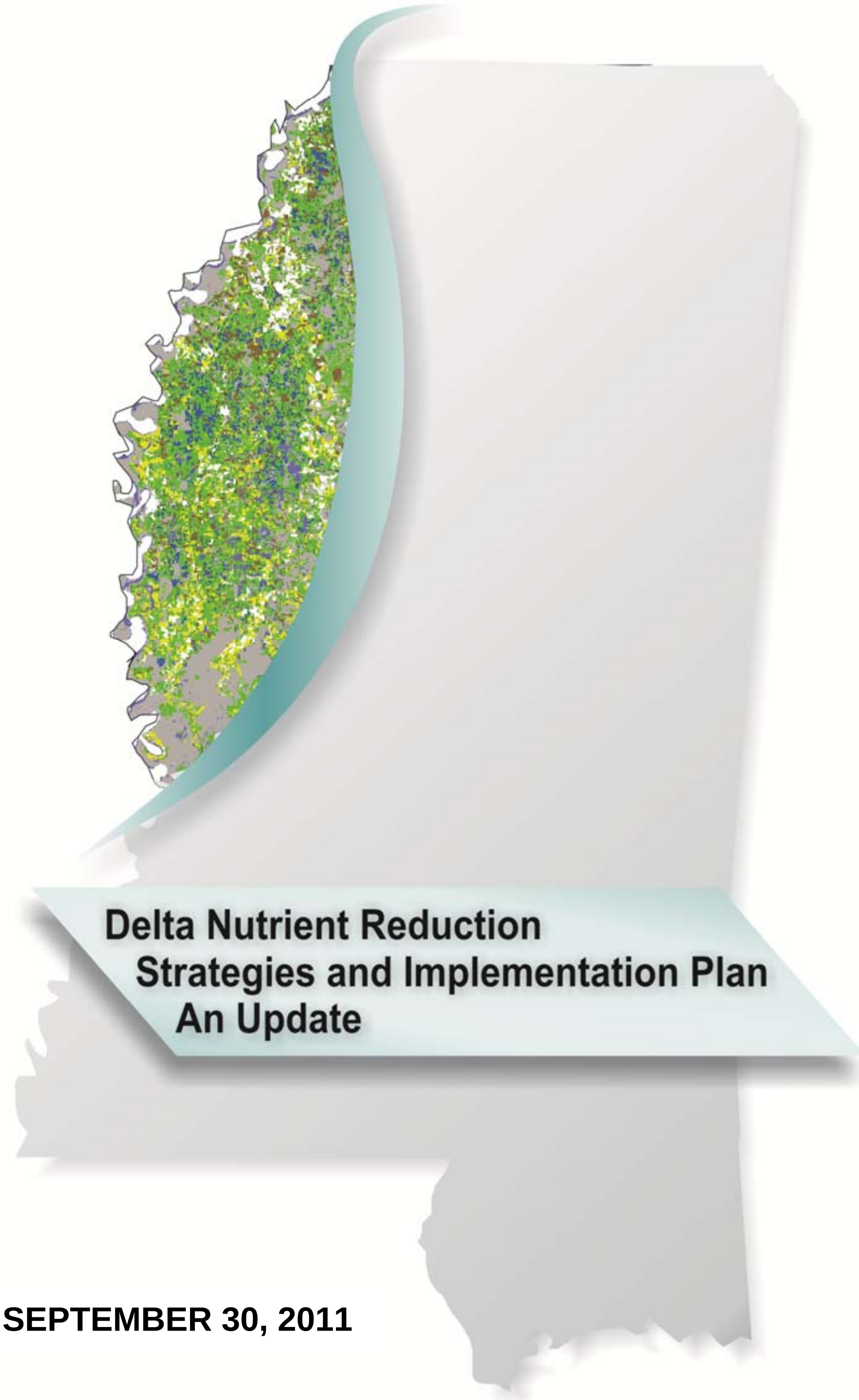

Delta Nutrient Reduction Strategies and Implementation Plan An Update

SEPTEMBER 30, 2011

DELTA NUTRIENT REDUCTION STRATEGIES
AND IMPLEMENTATION PLAN:
AN UPDATE

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EXECUTIVE SUMMARY

Mississippi was the first Hypoxia Task Force and the Gulf of Mexico Alliance state to develop a State Nutrient Reduction Strategy, as recommended in the Action Plans of both of these organizations. The Delta Nutrient Reduction Strategies and Implementation Plan was the first regional strategy developed in Mississippi. The Mississippi Strategies are all designed to answer four questions:

1. What levels of nutrient reductions are achievable and by when?
2. What will they cost?
3. What is the value to each stakeholder from these nutrient reductions?
4. What levels of nutrient reductions will protect Delta waterbodies and benefit the Gulf of Mexico?

The Mississippi Delta Nutrient Reduction Strategies and Implementation Plan was completed and implemented in December 2009. The current project illustrates the progress that can be made to reduce nutrients when stakeholders work together to achieve shared goals of an improved environment, sustained economy, and enhanced quality of life.

All 11 strategic elements have been implemented and progress has been made on each, through the collaborative efforts of federal and state agencies, nonprofit organizations, producers, and the private sector.

- Promote Stakeholder Awareness, Outreach and Education – A stakeholder survey is being designed to determine what stakeholders believe, perceive and value related to the environmental effects of excess nutrients.
- Characterize Watersheds – Two watersheds within the Mississippi River Basin Initiative (MRBI) focus area were characterized and targeted, and management practices are being implemented. The Mississippi Watershed Characterization and Ranking Tool is being revised and improved.
- Determine Current Status and Historical Trends – Historical data was used to document pollutant reductions in Steele Bayou that have occurred since the early 1990's through the use of water and sediment control practices. The reductions were: 42-60% for TSS, 18-25% for TN, and 8-35% for TP.
- Identify Water Management Practices – Tailwater recovery/on-site storage systems are being implemented through MDEQ and YMD. Water conservation practices may provide the best opportunity for nutrient reduction. In addition, reuse of treated municipal wastewater is being considered for agricultural irrigation.

- Promote Input Management – Farmers are working to find new ways to reduce fertilizer application through precision agriculture. There is also collaboration with the private sector to analyze historical and current soil testing records to document TP input to watersheds.

- Identify Sediment and Nutrient Management Practices –Innovative two-staged, low-head weirs are being used to reduce TN in agricultural ditches through denitrification.

- Control Point Sources – NPDES permit renewals have TN and TP limits to reduce nutrients. These activities are being leveraged with water management practices (See above).

- Design Monitoring Networks – Three-tier monitoring networks were implemented to support the MRBI projects and document nutrient reductions occurring through management practices. Budget reductions, however, have eliminated some of these sites.

- Provide Economic Incentives and Funding – A consortium of agricultural and environmental groups helped bring $48 million in funding to the Delta for environmental improvements and research. Incentives are being evaluated for reuse of treated municipal wastewater for agricultural irrigation.

- Manage Information and Communicate Results – MDEQ, USGS, and COE developed a Water Quality Data Compendium, which increases public transparency of the Mississippi approach to reducing nutrients and can be used to access data throughout Mississippi. [1]

Continued progress on the implementation of the Delta nutrient reduction strategies will be reported on a bi-annual basis.

[1] http://www.deq.state.ms.us/MDEQ.nsf/page/WMB_MWQDCompendium?OpenDocument

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INTRODUCTION

The Mississippi River/Gulf of Mexico Hypoxia Task Force released the *Gulf Hypoxia Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico and Improving Water Quality in the Mississippi River Basin* (*Gulf Hypoxia Action Plan*) in June 2008. The Task Force is co-led by the U.S. Environmental Protection Agency (EPA), and the Mississippi Department of Environmental Quality (MDEQ), and includes environmental and agricultural agencies from 12 states within the Mississippi River Basin, as well as federal agencies whose mission deals with agriculture and water quality-related issues. A key component of the *Gulf Hypoxia Action Plan* is the development and implementation of state nutrient reduction strategies. Mississippi is also a member of the Gulf of Mexico Alliance (GOMA) and leads the Nutrient Priority Issue Team. In June 2009, GOMA released its *Governors' Action Plan II for Healthy and Resilient Coasts (Governors' Action Plan II)*. A key component of this plan also includes the development and implementation of state nutrient reduction strategies. As a first step towards achieving the goal of both action plans, MDEQ co-led an effort with Delta Farmers Advocating Resource Management (Delta F.A.R.M.) to develop a nutrient reduction strategy for the Delta region of Mississippi, Mississippi's primary row-crop agricultural area.

The Mississippi Delta covers the western half of the Yazoo River Basin (Figure 1), the largest river basin in the state. Designated stream, lake, and reservoir uses are not being attained in a number of Delta waterbodies. Under a Federal Consent Decree, MDEQ developed 48 nutrient Total Maximum Daily Load (TMDLs) studies for evaluated, non-attaining waterbodies in the Yazoo River Basin during 2008. With limited monitoring data upon which to model assimilative capacities, a mass balance approach was used for most of the TMDLs. This approach did not consider nutrient fate or transport. Based on this approach, the TMDLs call for nutrient load reductions of around 80% for nitrogen and over 90% for phosphorus. There is general agreement that reductions of this magnitude are not feasible. This situation has created the need for focused nutrient reduction strategies, watershed management projects and studies to answer four questions:

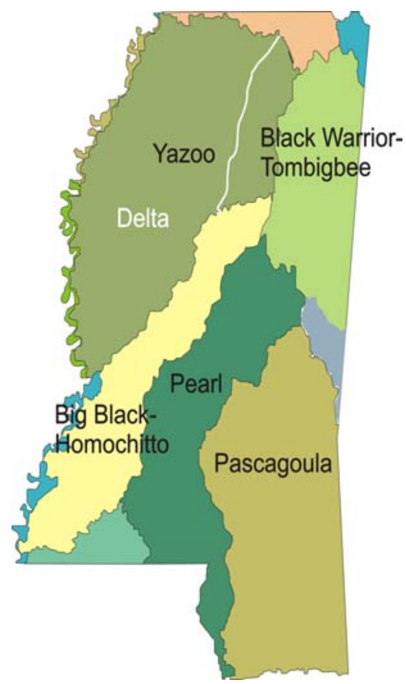

Figure 1. Major river basins of Mississippi.

1. What levels of nutrient reductions are achievable and by when?
2. What will they cost?
3. What is the value to each stakeholder from these nutrient reductions?
4. What levels of nutrient reductions will protect Delta waterbodies and benefit the Gulf of Mexico?

DELTA NUTRIENT REDUCTION STRATEGIES

The Delta Nutrient Reduction Strategies and Implementation Plan (Plan) was completed in December 2009 and is in the process of being implemented. The Plan can be found at http://www.deq.state.ms.us/mdeq.nsf/pdf/WMB_MississippiDeltaNutrientReductionStrategies/$File/Delta%20Nutrient%20Reduction%20Strategy_12-15-2009.pdf?OpenElement.
A Planning Team, whose members represented stakeholders from throughout the Delta, guided eleven Work Groups in developing a set of comprehensive strategies for reducing excess nutrients. Members of the Planning Team and Work Groups are listed in Appendix A. The eleven strategies resulting from this process were:

1. Promote Stakeholder Awareness, Outreach and Education;
2. Characterize Watersheds;
3. Determine Current Status and Historical Trends;
4. Select Analytical Tools;
5. Identify Water Management Practices;
6. Promote Input Management;
7. Identify Best Management Practices;
8. Control Point Sources;
9. Design Monitoring Networks;
10. Provide Economic Incentives and Funding; and
11. Manage Information and Communicate Results.

UPDATE

The purpose of this document is to provide an update on the progress that has been made in implementing each of these strategies and reducing excess nutrients in the Delta.

PROMOTE STAKEHOLDER AWARENESS, OUTREACH AND EDUCATION

Involving and engaging stakeholders early in the planning process is critical. Early involvement of stakeholders provides transparency of the process, allows time for trust to develop, incorporates local knowledge, and makes it possible to deal most effectively with misperceptions and to manage expectations. All of this helps gain buy-in and stakeholder cooperation, and increases the likelihood of moving toward sustainable solutions.

Objective: Identify target audiences and perceptions of the nutrient issue in Delta waterbodies, and formulate effective awareness, outreach, and education programs to address these perceptions.

Current Status:
Mississippi State University received a grant in December 2010 from the Mississippi Department of Marine Resources, part of which will be used to develop and implement instruments to survey target audiences in the Mississippi Delta on their awareness, beliefs, and perceptions about excess nutrients, nutrient runoff and reducing nutrient loads. The survey target audiences identified in January 2011 are:

- Farmers and producers;
- Conservation delivery agencies (e.g., US Department of Agriculture Natural Resources Conservation Service and Farm Services Agency, Delta F.A.R.M.);
- Regulatory agencies (e.g., MDEQ, EPA, Yazoo Mississippi Delta Joint Water Management District);
- Agricultural consultants;
- Allied agricultural industries such as fertilizer chemical companies;
- Environmental organizations (e.g., Mississippi Wildlife Federation, The Nature Conservancy, Delta Wildlife, Sierra Club);
- Science/research organizations (e.g., US Geological Survey, US Department of Agriculture Agricultural Research Service and National Sedimentation Laboratory, and US Army Engineering Research and Development Center);
- Educational community (e.g., Mississippi Cooperative Extension Service, MDEQ Nonpoint Source Branch Education/Public Outreach);
- Elected and appointed officials (e.g., State legislators, mayors, county supervisors); and
- The general public.

A list of contacts for each of these audiences was compiled during January and February 2011. A few of these individuals were selected to assist in preparing a preliminary set of questions for the survey instruments.

From June through September 2011, focus group meetings with selected individuals from each of the target audiences were conducted to vet and refine the preliminary set of survey questions and elicit qualitative information on general values, beliefs, and perceptions of these target audiences. Between 10 and 12 individuals were invited to participate in each focus group.

During the 2011 fall and early winter, two survey instruments will be developed – one for the general public and one for professionals from the other target populations. The survey instrument, as currently envisioned, will have 60 to 70 questions, including 10 demographic questions (i.e., gender, race, age, educational background, etc.). The survey will be administered during January and February 2012. The general public survey will be administered as a randomized telephone survey of the entire state, with an oversampling in the Delta so that stakeholder responses from the Delta can be compared with state-wide responses. Some surveys will represent a census of the target audience (e.g., regulatory agencies in Mississippi), while others will be a random selection from the list of contacts.

The survey results will be used to design, test, and implement stakeholder outreach and education programs to increase awareness of nutrient enrichment, where needed; reinforce factual beliefs; and revise perceptions that are not factually based, given our current scientific and technical understanding of nutrient enrichment, its effects, and the benefits of nutrient reduction.

CHARACTERIZE WATERSHEDS

This strategy includes delineating and characterizing the watersheds that will be addressed by the strategy. Watershed characteristics include geography, ecology, socioeconomics, and stakeholder interest and willingness to participate. Characterizing current conditions provides a baseline against which the effects of restoration and protection activities can be assessed.

Objective: Characterize, prioritize, and target (select) watersheds in which to implement nutrient management practices.

Current Status:
In 2008, 48 nutrient TMDLs were completed for watersheds in the Delta where waterbodies were evaluated as not attaining designated uses because of excess nutrients. Because waterbodies within these 48 watersheds were not attaining designated uses, these watersheds became candidates for the development of watershed management plans. These 48 watersheds were ranked by:

- Water body type (bayou, creek, lake) as an indicator of flow;
- Available water quality data, both current and historical;
- Point source nutrient contributions;
- Geographic location;
- Drainage area size; and
- Channel modification.

The 48 watersheds were reduced to 11 priority watersheds based on the screening criteria listed above. These 11 watersheds were further screened based on the following criteria:

- Stakeholder interest (most important criteria),
- Local topography (e.g., ridge and swales),
- Soil types (i.e., presence of erodible soils),
- Cropping practices (e.g., corn, cotton),
- Existing drainage (e.g., primary swales, ditches, secondary drains and streams), and
- Hydraulic connectivity (i.e., connected to a downstream system).

Based on the watershed characterization approach and the screening criteria, two watersheds were selected for the development of watershed management plans: Harris Bayou and Porter Bayou (Figure 2), both of which are in the Big Sunflower River watershed.

The US Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) Mississippi River Basin Healthy Watersheds Initiative (MRBI) recently identified priority hydrologic unit code (HUC) 8 watersheds in each of the 12 Mississippi River Basin states for funding of nutrient reduction management practices. The MRBI watersheds in Mississippi are the Big Sunflower River, Deer-Steele Bayou, and Upper Yazoo River (Figure 3). Over the next three years, these major drainage basins will have priority for the implementation of watershed management plans. In addition, EPA Section 319 funds will also be targeted for these priority watersheds. As noted above, both Harris Bayou and Porter Bayou are in the Big Sunflower River basin, a priority MRBI HUC (Figure 3).

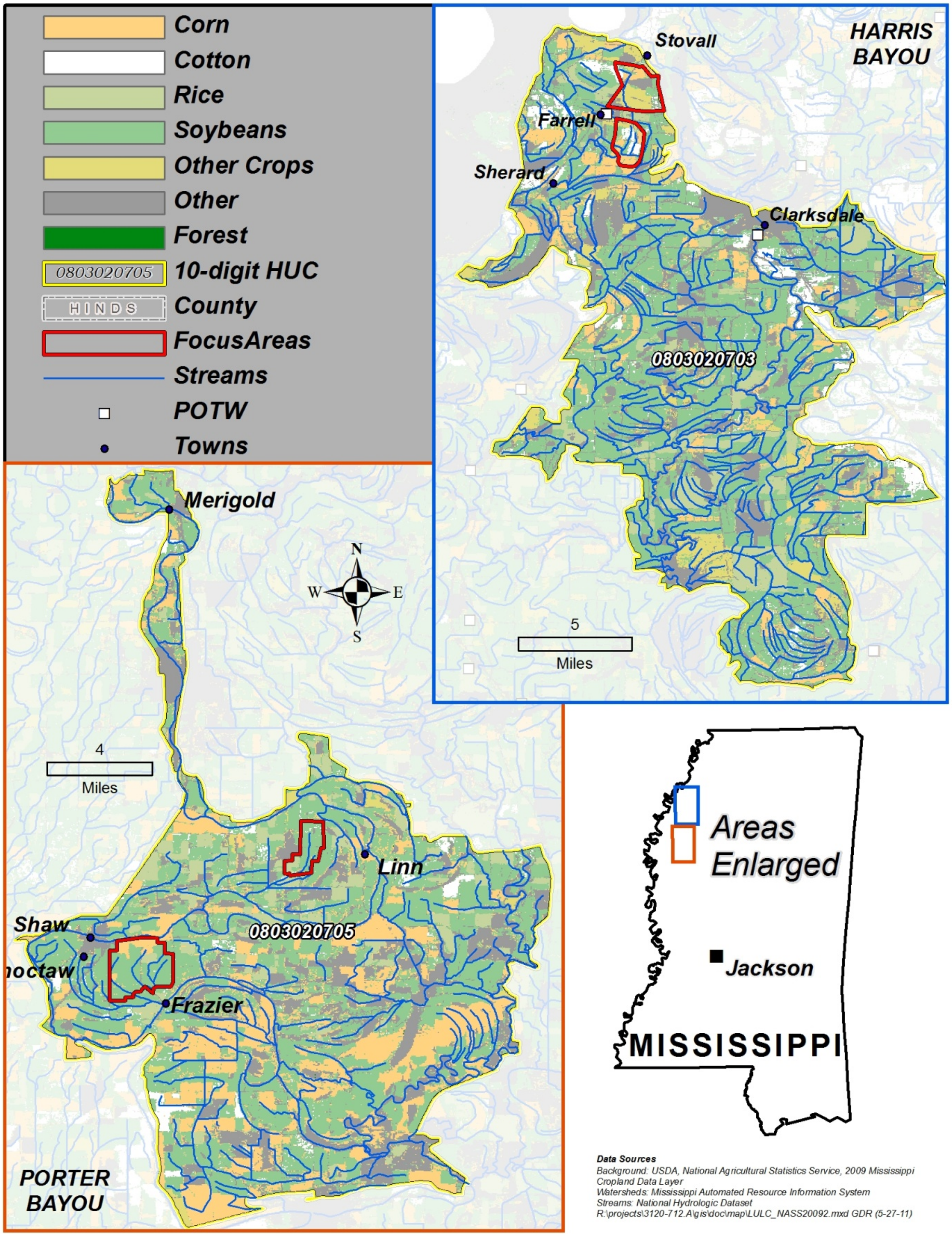

Figure 2. Land use/land cover as one of the criteria characterized in the Harris Bayou and Porter Bayou watersheds. Catchments selected for initial study in each watershed are shown in red.

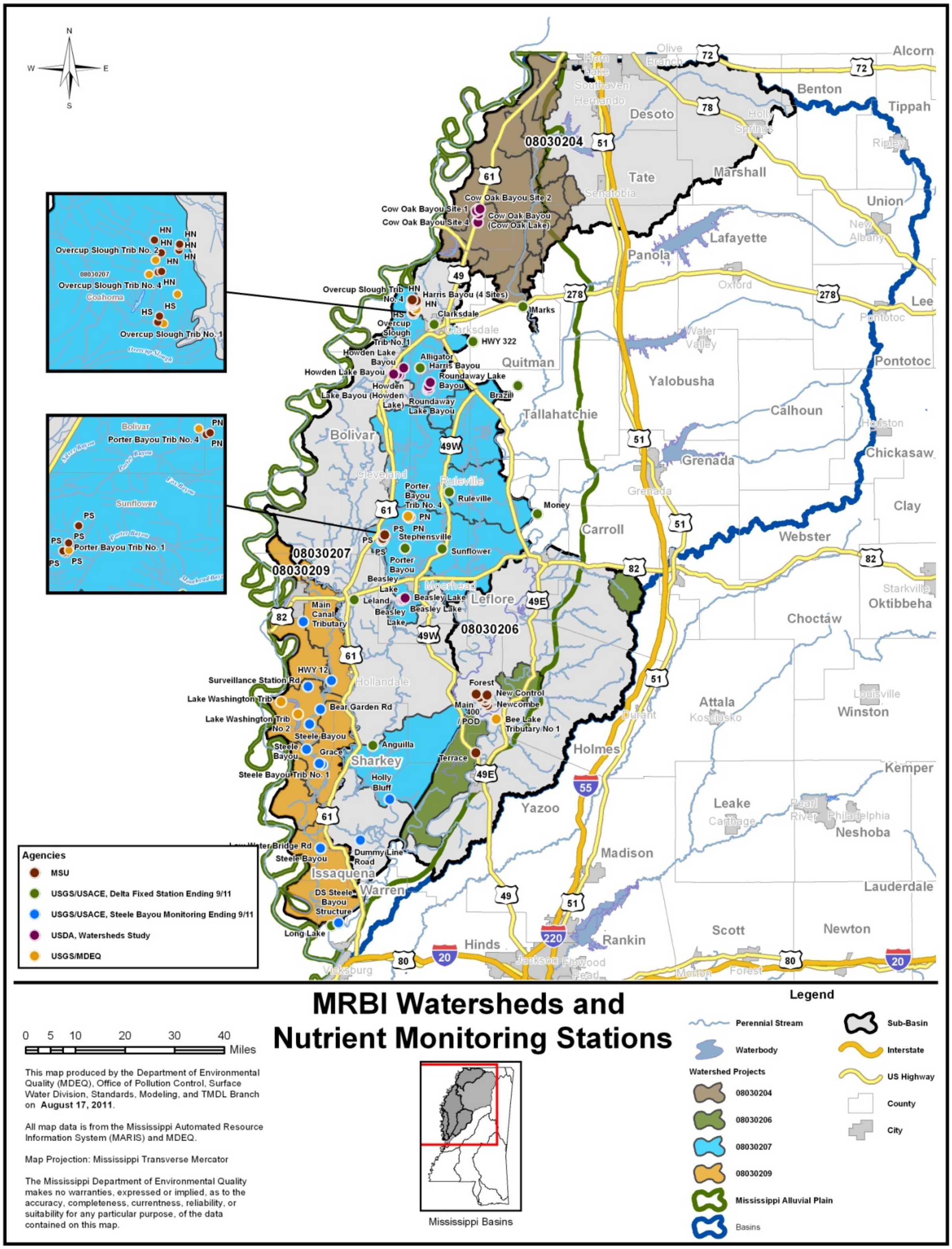

Figure 3. MRBI Priority Watersheds- Big Sunflower River, Deer-Steele, and Upper Yazoo River watersheds. Monitoring sites and Harris Bayou and Porter Bayou watersheds are shown on the map.

DETERMINE CURRENT STATUS AND HISTORICAL TRENDS

To assess the effectiveness of reduction strategies, the current level of nutrient loads and impacts must be documented as a reference for comparison. Analyzing the historical trends provides insight into the current trajectory of nutrient loadings to aquatic ecosystems. In addition, past conditions can indicate areas where legacy sediment and nutrient sources might be expected.

This strategic element can also include identifying any case studies that could help direct the implementation of nutrient management practices.

Information from this element also contributes to the Watershed Characterization process, because both current status and historical trends are part of targeting priority HUC10 watersheds. The management practices selected and implemented will likely be different if the trend in nutrient loadings is decreasing versus increasing. Sustaining current management practices might be warranted if there is a decreasing trend in nutrient loads compared to implementing new management practices if there is an increasing nutrient loading trend. These trends could also be cross-referenced with future land use projections identified as part of the Watershed Characterization element to provide insight into emerging nutrient load sources.

Objective: Document historical trends and establish current baseline of nutrient concentrations and loads in Delta waterbodies.

MDEQ previously compiled historic water quality data collected in the Delta. The Yazoo River Basin Compendium of Water Quality Information (2003) included an inventory of water quality data collected in the Delta through 2001. Historical monitoring sites with nitrogen or phosphorus data have been categorized by the duration of the historical record and the age of the information (Figures 4 and 5). Many of the historical monitoring sites have data that were collected over 15 years ago. Improved analytical technology and lower detection levels can confound comparisons of older data with more recent information. However, these data might also provide a reference for comparison with current nitrogen and phosphorus concentrations. This compendium is currently being updated through 2010.

Historic and current crops and cropping practices and best management practices (BMPs) information for the Delta is also being compiled from the Census of Agriculture, Yazoo Mississippi Delta Joint Water Management District (YMD) and USDA NRCS records to evaluate historical trends in the implementation of conservation practices in the Delta. Future efforts will consider not only the acres affected by conservation practices, but also the suites of conservation practices that have been implemented.

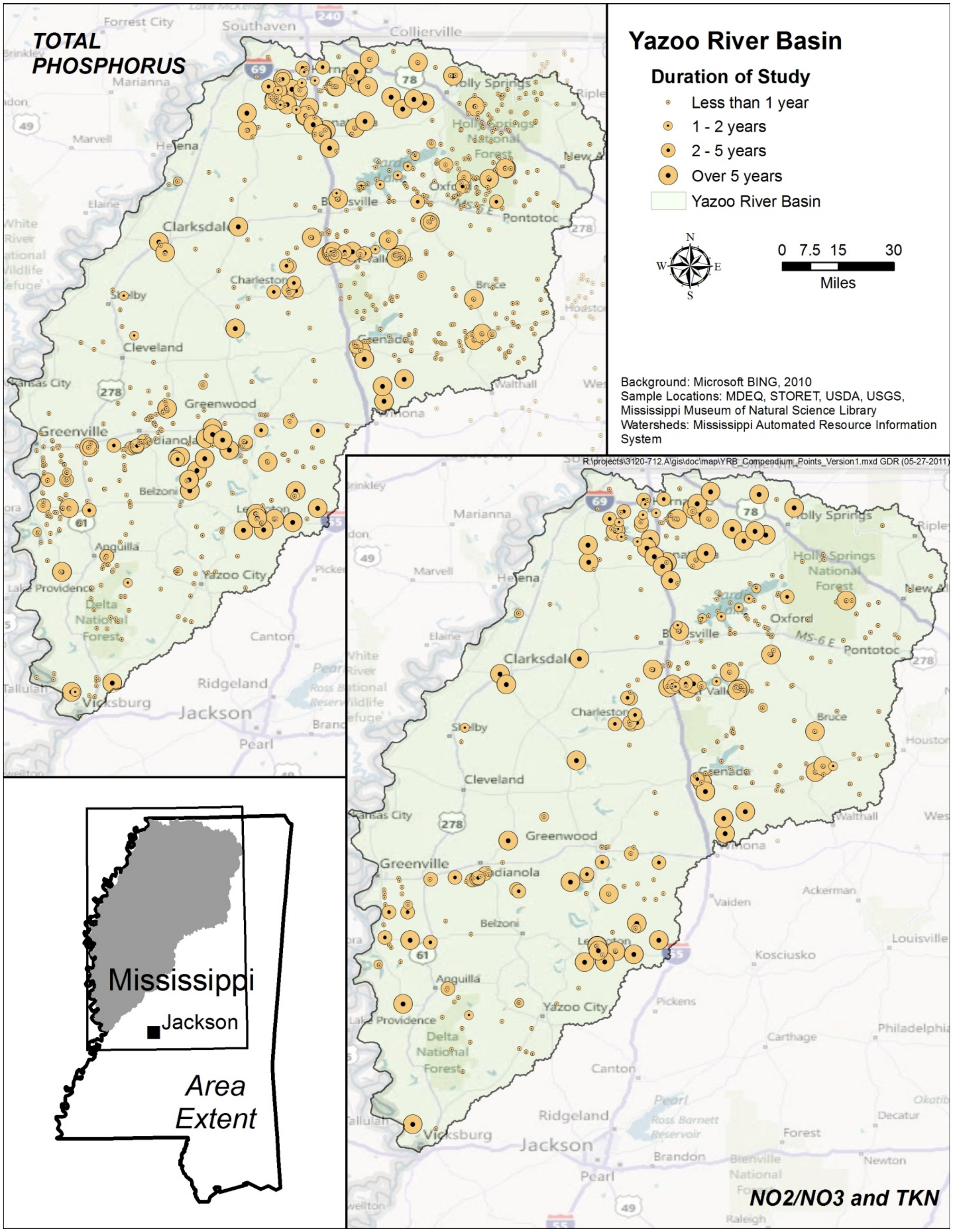

Figure 4. Locations and duration of nutrients monitored at sites in the Yazoo River Basin through 2001.

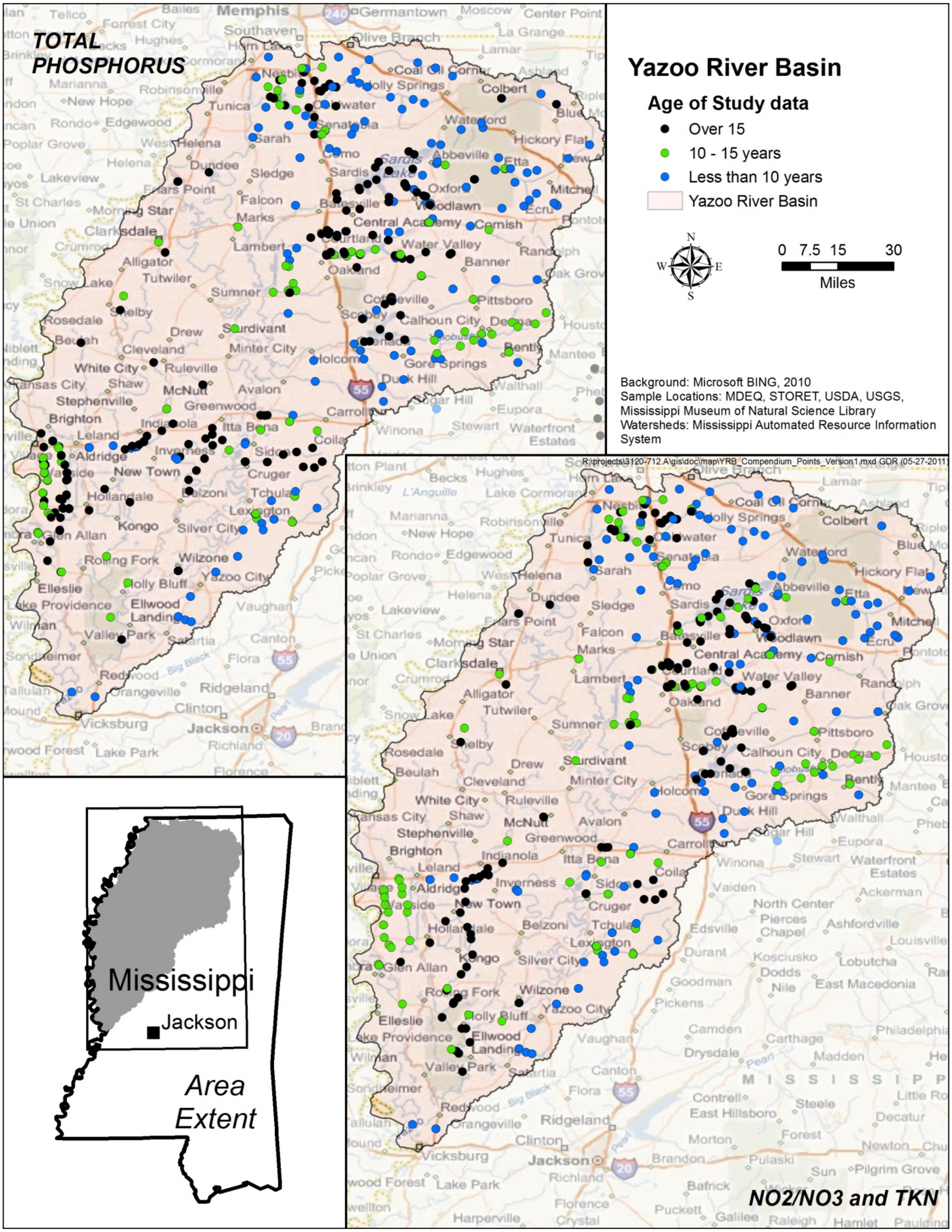

Figure 5. Age of nutrient data from sites monitored in the Yazoo River Basin through 2001.

One of the explicit goals of the Delta Nutrient Reduction Strategies is to determine what nutrient reductions can be achieved and by when. Several recent studies have addressed this specific goal. D. Johnson (personal communication) has estimated that land leveling and pads and pipes implemented in the Black Bayou and Main Canal watersheds and the Steele Bayou watershed over the past 15 years have reduced sediment (TSS) concentrations by 42 to 60%, total nitrogen (TN) concentrations by 18 to 25% and, TP concentrations by 8 to 35% (Figure 6). These practices were targeted at sediment reduction, but there also was collateral nutrient reduction.

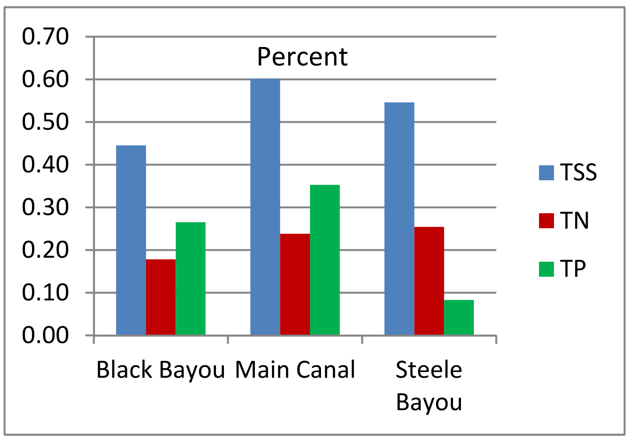

Figure 6 Percent reduction in TSS, TN, and TP concentrations in Steele Bayou tributaries (D. Johnson USACE).

The US Army Corps of Engineers (USACE) determined that the percent reduction in TSS, TN, and TP in the Steele Bayou watershed corresponded with the proportion of the watershed with implemented water control and soil erosion/sediment management practices (D. Johnson, USACE personal communication). YMD provided annual records of permitted irrigated agricultural acres treated through water control or sediment control management practices from the early 1990's through 2010 for the Yazoo River Basin. These records were cumulatively aggregated by acreage in 5-year intervals: pre-1995; 1996- 2000; 2001- 2005; and 2006-2010 by HUC10 watersheds throughout the Delta. The 2008 National Agricultural Statistics Service agricultural census information was used as the reference frame for calculating the proportion of each watershed in conservation practices (using irrigated area as a surrogate for all areas treated through management practices) for each of the 5-year periods. Long-term water quality information was available for three watersheds in the Delta – Steele Bayou, Quiver River, and Bogue Phalia. The primary conservation practices in these watersheds, and other areas in the north Delta region, have been pads and pipes and land leveling for greater water use efficiency and reduced soil erosion, so the assumption of using irrigation as a surrogate for all agricultural management practices is not unreasonable. This estimate is being refined by obtaining the NRCS contract information on various conservation management practices throughout the State.

The change in the proportion of the watershed in management practices in these three watersheds from pre-1995 through 2010 is shown in Table 1. For Steele Bayou, in general, the 35% increase in treated acres was associated with about a 35% decrease in TP concentrations, or about a 1% decrease in TP concentration for a 1% increase in conservation management practice acreage. Whether this percentage is applicable for other watersheds is not currently known.

Table 1. Increase in implementation of BMPs in three Delta watersheds.

Watershed	Pre-1995 Treated Acres (%)	2010 Treated Acres (%)
Steele Bayou	15	50
Quiver River	50	75-80
Bogue Phalia River	50	84

Similar reductions in TSS, TN, and TP were also determined for the Quiver River and Bogue Phalia River watersheds, although the decreases were not as dramatic as in Steele Bayou. The primary difference among the three watersheds might be that USACE structural controls including channel cleanout, in addition to NRCS practices, were implemented in Steele Bayou watershed, but not in the Quiver River or Bogue Phalia River watersheds. Additional analyses are being conducted in all three watersheds.

Soil phosphorus concentrations in the Delta and Bluff Hills regions of Mississippi were evaluated through a literature search of studies in which soil phosphorus was measured in these two areas (Evans, in preparation). A literature search was conducted because soil phosphorus data is not included in the USDA NRCS National Soil Information Systems for either the Mississippi Alluvial Floodplain (i.e., Delta) or for the Loess Bluff Hills. The literature review results indicated that phosphorus concentrations in soil samples from these two areas were consistently ranked at the "high" P level, and fertilizer application of phosphorus was not recommended for Delta soils. The literature indicated that Delta soils are naturally rich in phosphorus. However, Sharpley et al., (1996) cautions that soil-test phosphorus content is not a good predictor of phosphorus loss from soils. High or low soil phosphorus concentrations in soils do not necessarily correlate with high or low phosphorus loss (loading) to receiving waters.

Nutrients are found in groundwater as well as surface water in the Delta. A recent study (Welch et al., in preparation) sampled 46 wells throughout the Mississippi River Valley alluvial aquifer in the Delta for dissolved phosphorus and other water quality constituent concentrations from June to October 2010. Welch et al., (in preparation) found that dissolved phosphorus concentrations in the aquifer ranged from 0.12 to 1.7 mg/L, with a median concentration of 0.6 mg/L. Dissolved phosphorus concentrations were higher in the Holocene alluvium than in the Pleistocene valley, and generally higher in wells located near the Mississippi River (Figure 7). Higher dissolved phosphorus concentrations were generally associated with higher dissolved iron concentrations, which indicates reducing conditions in the aquifer contribute to the mobilization of phosphorus.

Both studies indicate that, in the Delta, the high dissolved phosphorus in groundwater and high soil phosphorus concentrations in soils might be of geologic origin.

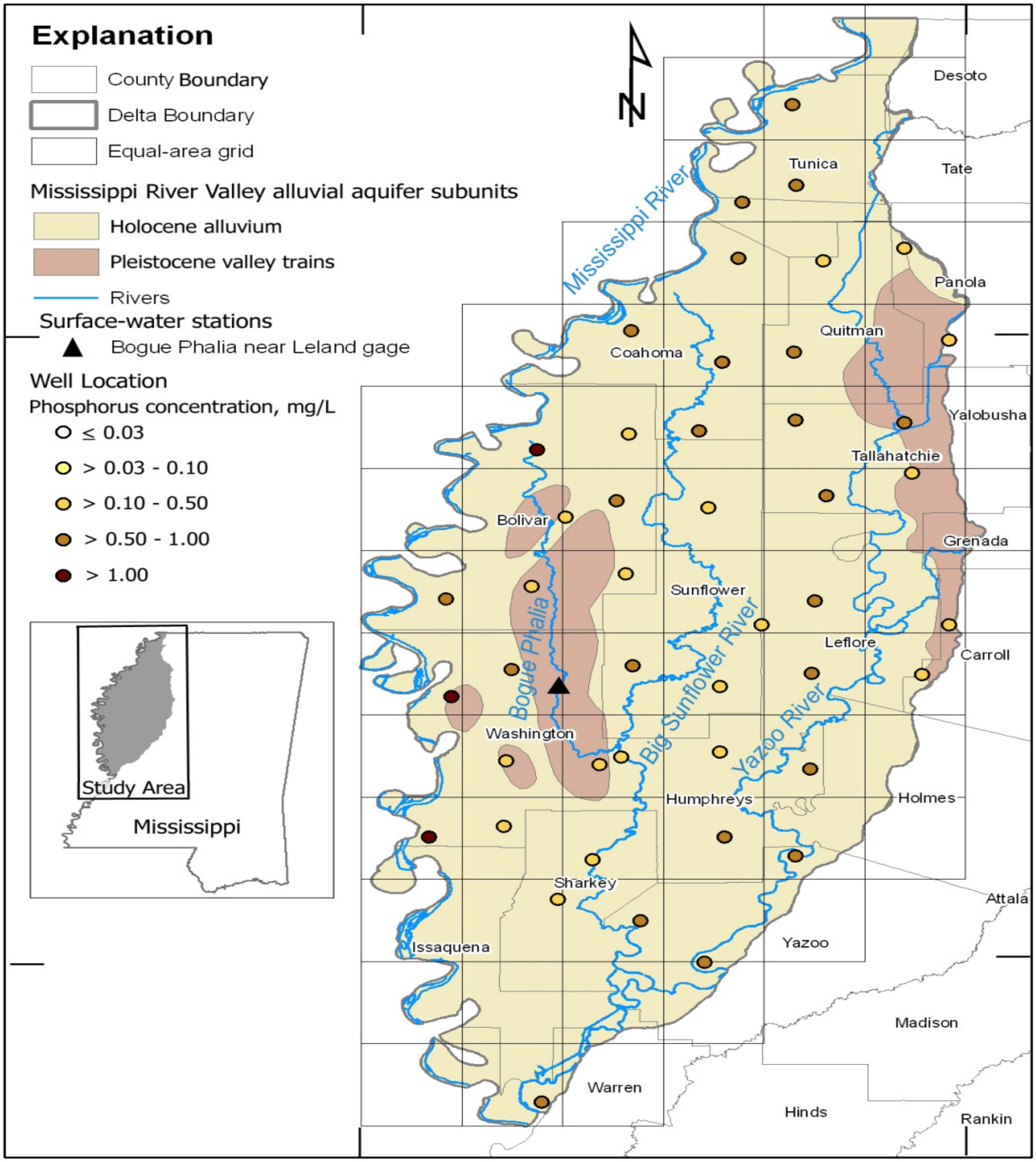

Figure 7. Map showing the equal-area grid for site selection and phosphorus concentrations at the sampled wells in northwestern Mississippi (from Welch et al. in preparation).

SELECT ANALYTICAL TOOLS

Numerous tools are available for estimating and assessing potential nutrient reductions from different management practices, and the associated benefits of attaining designated uses. It is important to identify which tools are applicable for aquatic ecosystems in the Delta, and document the associated assumptions, inputs, and output results. It is also important to have a suite of tools that spans the range from simple, back of the envelope procedures, to steady-state models through time-varying dynamic process watershed models, which span a range of spatial scales from individual agricultural fields or stream reaches to an entire basin.

Objective: Guide the application of tools in order to develop the most efficient and effective action plans for the selected watersheds.

Current Status:
A number of analytical tools have been developed for application to agricultural systems, from field scale applications (AnnAGNPS - Yuan et al. 2001, 2008), to stream reach applications (mass balance TMDL models-MDEQ 2008), through three-dimensional water quality models for oxbows (Chao et al. 2004). These tools, and others potentially applicable for Delta systems, are incorporated into a nutrient decision support toolbox, which can be found on the GOMA website (See last paragraph below).

Three analytical tools are currently under development for application to the Delta:

1. Mississippi Watershed Characterization and Ranking Tool (MWCRT) – MDEQ developed the MWCRT to help with prioritizing Mississippi watersheds for protection and restoration activities. The guiding principles in developing the MWCRT were:

   - Simplicity of use,
   - GIS-based,
   - Use of data that is readily available statewide, and
   - Transferability across watersheds/basins in Mississippi.

   Recently, several meetings were held to discuss updating and revising the MWCRT. Suggested revisions include incorporating new GIS layers that are now available statewide. Additional information is now available for factors such as source water protection areas and shellfish harvesting areas. Revised weights are also being developed for some of the factors such as extent of impervious area. This tool is in the process of being revised for application in the Delta.

2. Watershed Assessment Tool – Mississippi State University (MSU) is developing a watershed model based on the EPA SUSTAIN framework (urban stormwater modeling framework, EPA 2009) for application in a specific catchment in Harris

Bayou watershed to evaluate nutrient reductions associated with different agricultural management practices. The model will be calibrated and verified using the monitoring information being collected in Harris Bayou.

3. Regional SPARROW – The US Geological Survey (USGS) recently released regional versions of the SPARROW (Spatially Referenced Regressions on Watershed Attributes) model for application in the southern US that includes the Mississippi Delta. The regional versions of the model, and a decision support interface, have been developed and can be found at http://water.usgs.gov/nawqa/sparrow/.

A Decision Support Toolbox was developed as a resource for managers in GOMA states to locate and select tools to assist with developing management decisions and action plans. The toolbox is a simple compendium of tools and information, which are categorized by the eleven nutrient reduction strategies. The toolbox was developed by a work group of the GOMA Nutrient Priority Issue Team. A beta version of the toolbox was released on April 7, 2011 and was evaluated over the summer. The toolbox is available at http://www.gulfofmexicoalliance.org/toolbox/toolbox.html.

IDENTIFY WATER MANAGEMENT PRACTICES

Nutrient reduction management practices typically focus on traditional point and nonpoint source controls, such as alum or ferric chloride additions to remove phosphorus from wastewater or grassed waterways and riparian buffers to capture or trap phosphorus and nitrogen in runoff. Water management practices, particularly water reuse and recycling, however, can be effective in reducing nutrient loading to waterbodies. Water that never enters a waterbody will never contribute to nutrient loadings in these waterbodies.

Declining groundwater tables and water quantity are important issues in the Delta. Fortunately, many water management practices that reduce dependence on groundwater for irrigation also reduce nutrient loadings.

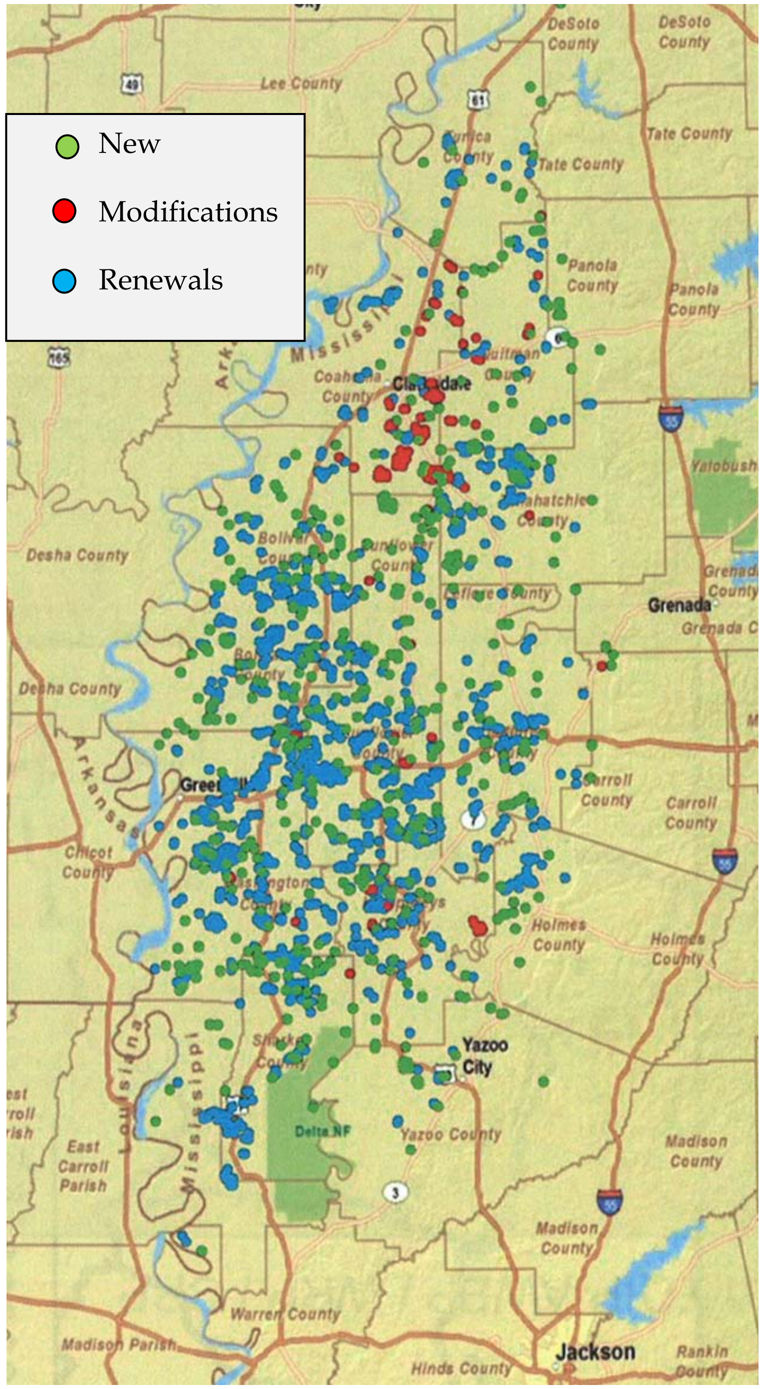

Figure 8. Groundwater use permits in the Yazoo River Basin (From D. Pennington, YMD).

Objective: Integrate sustainable water management practices with nutrient reduction management practices to reduce nutrient loadings to Delta waterbodies.

Current Status:
Water use permits are required in the Delta for groundwater pumping and surface water diversions for irrigation (Figure 8). Groundwater withdrawal permits are issued by the YMD for five years. Modifications were made to the water use permitting process by MDEQ in late 2010 and in January 2011. One of the modifications is that groundwater withdrawal permits can be cancelled after three years if permittees do not install minimum

water conservation practices, or install a water meter on the permitted well. Water use quantities recorded by water meters are to be reported to MDEQ.

Because of groundwater depletion throughout the Delta, applications for tailwater recovery systems and on-farm storage units have increased significantly throughout the Delta (Figure 9). These systems are also highly ranked for financial assistance through USDA NRCS programs such as the Agricultural Water Enhancement Program. These systems increase irrigation efficiency, reduce irrigation costs (i.e., less energy is needed to pump surface water than to lift groundwater), and increase the land value of those farms with these systems. In addition, once these systems are constructed, there is greater emphasis on erosion control to keep these systems from filling with sediment. Greater reuse of irrigation return flows, however, could result in lower stream flows.

Integrated water management practices, including flow meters, timers, and underground lines, are being implemented by many producers. More farm operators in the Delta are also interested in the USDA NRCS PHAUCET software to size the holes in polypipe irrigation lines based on well flow rate, slope, and length of the row for greater irrigation efficiency. YMD is working with NRCS to implement use of the NRCS PHAUCET software for furrow irrigation in the Delta.

YMD has committed to reducing groundwater use rates from the Mississippi River Alluvial Aquifer to equal the average aquifer recharge rate, and stopping the decline of aquifer water levels in the central Delta. The two approaches being used by YMD to achieve these goals are water conservation practices, and development of new surface water supplies. YMD has several projects in the Delta to install weirs in stream channels and oxbow lake outlets to store surface water for irrigation. In addition, YMD is developing water transfer projects to increase surface water availability.

Several water management BMPs are being utilized in the targeted Section 319 Harris Bayou and Porter Bayou watershed management projects. Monitoring stations have been sited in both watersheds to assess the effectiveness of these management practices in reducing excess nutrients. The management practices include on-farm storage reservoirs (Figure 9), irrigation tailwater recovery systems, flow meters and timers, and underground irrigation lines. Land leveling, and pads and pipes are continuing to increase the efficiency of moving and using water for irrigation. The possibility of using treated municipal wastewater effluent for agricultural irrigation is also being explored. This option could reduce dependence on groundwater withdrawals for irrigation in some watersheds.

Low flows in the Sunflower River are a concern in the Delta. In 2005 and 2006, YMD installed 11 wells near the Mississippi River in northwest Coahoma County. Water from these wells is used to augment flow in the Sunflower River to maintain a minimum flow of 35 to 50 cubic feet per second (cfs).

Figure 9. Aerial View of on-farm storage reservoir being constructed in the Delta.

PROMOTE INPUT MANAGEMENT

Nutrients that are not applied in the watershed cannot enter the water systems. Input management, therefore, is a critical strategic component of nutrient management. Input management is not only environmentally beneficial, but also economically beneficial for the producer. Fertilizer costs have increased substantially, as have fuel costs. Applying fertilizer only where it is needed to sustain yield with fewer passes through the field decreases production costs. Documenting the costs and benefits associated with management practices is an integral part of the nutrient reduction strategies.

Objective:
Review and enhance input management to reduce the application of fertilizers to Delta Farms, while sustaining agricultural productivity and yield.

Current Status:
Delta F.A.R.M. conducted an informal survey of producers on the use of variable rate fertilizer application in the Delta. Variable rate fertilizer application is used primarily for potash (K) and phosphorus, with limited application for nitrogen in the Delta. If tractors already have GPS capability, adding the variable rate application technology represented a $3K to $5K expenditure. Without GPS capability, the cost increased to about $20K per tractor. On those farms using variable rate fertilizer application, soil testing was conducted on a 2.5 to 5 acre grid, with a three-year rotation on a 5-acre grid being the most common practice. The cost for soil testing ranged from about $7.50 to $9.50/acre. Prescription application of fertilizer based on soil testing typically cost an additional $0.75/acre, with many consultants providing these prescriptions at no charge if the producer purchased the fertilizer through the consultant. Producers surveyed indicated that variable rate fertilizer application was cost-effective and saved them anywhere from $15 to $25/acre. Yield was sustained or increased even though less fertilizer was applied. Some of the barriers to variable rate fertilizer application identified in the survey were: 1) confusing technology; 2) impractical on small land parcels (200 to 300 acres); and 3) not currently applicable for nitrogen.

Variable rate application of nitrogen is currently limited for several reasons. First, six inch soil cores can be collected mechanically (e.g., Autoprobe, Figure 10) and analyzed for potash and phosphorus. Soil tests for nitrogen require a 24 to 30″ core, which cannot be collected mechanically, so soil sample collection for nitrogen analyses are more labor intensive. Second, on-the-fly applications of nitrogen using spectroradiometer technology is not yet fully developed, and the temporal lag associated with the use of satellite or aerial imagery currently is too long. On-the-fly technologies are in development, and several are near commercial application for some crops, such as cotton (Yabaji et al., 2009). These technologies will make a significant contribution to variable rate nitrogen application when they become available.

Figure 10. Autoprobe soil sampler used for soil sampling in the Delta.

Jimmy Sanders (OptiGro) and Helena Chemical both have extensive historical records of soil nutrient test results and variable rate fertilizer applications on millions of acres throughout the Lower Mississippi River Valley. Discussions are on-going with both these businesses regarding analyses that might be performed on aggregated data for soil phosphorus and potassium (potash) concentrations throughout the Delta. Elevated dissolved phosphorus concentrations in groundwater in the Delta were measured by Welch et al. (in preparation) and discussed in the Status and Trends Section. In addition, a literature review by Evans (in preparation) indicated soil phosphorus concentrations are high in Delta soils. Both of these studies suggested these elevated phosphorus concentrations might be of natural or geological origin. The Jimmy Sanders and Helena Chemical soil tests for phosphorus would provide greater, systematic, spatial coverage of soil phosphorus concentrations throughout the Delta. While these data would not necessarily indicate phosphorus loss in runoff and loading to aquatic systems, they could provide insight into background phosphorus concentrations for the development of numeric phosphorus criteria for surface waters.

IDENTIFY BEST MANAGEMENT PRACTICES

Traditionally best management practices (BMPs) were implemented to reduce soil erosion and control sedimentation. Published effectiveness and efficiency estimates for BMPs typically relate to sediment reduction, but, in some instances, they have been developed for nutrient reduction. While sorbed nutrients, such as particulate phosphorus, will be reduced through the implementation of many traditional BMPs, the reduction efficiencies for nutrients has not been extensively documented, particularly for southern agronomic practices (R. Kröger, MSU, personal communication). Determining reduction efficiencies for excess nutrients remains an active research area and one that is being addressed through the Delta Nutrient Reduction Strategies.

A critical part of this strategy is also the estimation of costs and benefits associated with management practices. Costs include not only the capital costs for implementation, but also operation and maintenance costs. Several case studies have identified maintenance after installation as the necessary ingredient for effective nonpoint source management practices that is often lacking. Benefits can be monetary and non-monetary, direct and indirect. Direct, indirect, and non-monetary costs associated with not implementing management practices (i.e., no action alternative) also need to be estimated. Benefits that are not marketable can be more difficult to quantify. Non-market valuation approaches are improving (e.g., ecosystem services valuation techniques), but other valuation procedures are needed.

Objective: Determine which Best Management Practices are most effective and applicable in reducing nutrient concentrations/loads from non-point sources to, and in, surface waters in the Mississippi Delta region.

Current Status:
Nutrient reduction management practices are a priority for the Hypoxia Task Force. However, the effectiveness of nutrient reduction for many southern management practices has not been established. R. Kröger (Mississippi State University) and S. Sharpley (University of Arkansas), working with the World Resources Institute, conducted a literature review of management practices used in the Mississippi River Alluvial Valley to determine which management practices had documented nutrient reduction efficiencies based on field measurements. They found there were no more than 15 studies for this region that reported nutrient reduction efficiencies based on field measurements (Kröger, et al. In review).

While specific nutrient reduction efficiencies have not been widely documented for neither individual nor suites of management practices, there is general agreement that sediment reduction practices and water control management practices can contribute to nutrient reduction. Some estimates attribute from 60 to 75% of the total phosphorus (TP) load entering surface waters to particulate phosphorus sorbed on sediment particles (Beckert et al. 2011, Carpenter et al. 1998). Reducing sediment loading to aquatic ecosystems, therefore, would be expected to reduce phosphorus loads. Water management practices such as tailwater recovery systems and on-farm storage that capture runoff and prevent associated nutrient loads from entering aquatic ecosystems will also contribute to reduced nutrient loading. In informal surveys, selected producers identified land leveling (Figure 11) and pads and pipes as the management practices that provided the greatest return on their investment.

Figure 11. Land leveling to improve irrigation efficiency in the Delta.

Management practices implemented in the Wolf Lake watershed specifically for nutrient reduction illustrate the percent reductions in nitrogen that might be attained (R. Kröger, Final Report in revision). Wolf Lake was monitored from 2008 to 2010 through the EPA Section 319 Program and monitoring is currently being continued through Gulf of Mexico Program funding (R. Kröger, personal communication). Over 200 BMPs were implemented in the Wolf Lake watershed including land leveling, pads and pipes, grassed waterways, and low head weirs (Figure 12). The low head weirs were implemented in series in the channel of the main tributary to Wolf Lake. Downstream of the first weir, in-stream nitrate, nitrite, and ammonia concentrations were reduced by 38%, 80% and 28%, respectively relative to inflow concentrations. Downstream of the second weir, nitrate, nitrite, and ammonia concentrations were reduced by 78%, 80% and 61%, respectively relative to the upstream concentrations. The overall reduction of nitrate, nitrite, and ammonia from the inflow to downstream of the second weir was 80%, 90%, and 63%, respectively.

Watershed Implementation Plans, which include nutrient reduction strategies and practices, are being developed for Harris Bayou and Porter Bayou HUC10s. Drafts have been reviewed by the Watershed Implementation Teams. Monitoring networks are in place to collect pre-BMP and post-BMP water quality (See Monitoring Section). These data will be used to determine the effectiveness of the BMPs implemented.

Figure 12. Low head weir implemented in the Delta for sediment retention and dentrification.

Contracts are in place, or in process, for a significant number of agricultural nutrient and sediment reduction and water management practices in the Delta. Specific BMPs have been identified as eligible for funding through the MRBI in selected Delta watersheds. Tailwater recovery systems, on-farm storage, flow meters, and timers represent the next suite of management practices that will make a significant return on economic and environmental investment.

As noted in the Status and Trends discussion, soil phosphorus concentrations in the Delta are high, and data collection associated with precision agriculture indicates that Delta farmers do not apply phosphorus to their fields. In freshwater systems, phosphorus is generally assumed to be the limiting nutrient for primary productivity and the major contributor to eutrophication. Therefore, for Delta waterbodies classified as impaired due to high nutrients and/or organic enrichment and low DO, the standard recommendation would be to reduce phosphorus inputs in the watershed. Since phosphorus is not entering the watershed via fertilizer applications, the options for reducing phosphorus loads to impaired waterbodies are limited to reducing sediment loads and runoff quantity. Whether phosphorus load reduction is needed will depend on the final nutrient criteria that are promulgated and estimates of natural background phosphorus concentrations.

CONTROL POINT SOURCES

Municipal and industrial sources can also contribute nutrient loading to Delta water bodies. These sources, known as point sources, are regulated under the Clean Water Act National Pollutant Discharge Elimination System (NPDES) through permits that limit the quantity of pollutants that can be discharged into water bodies. Regulations have also been promulgated to reduce nutrient and other pollutant loadings from stormwater runoff of municipal and industrial sites.

Objective: Reduce nutrient loadings (nitrogen and phosphorus) from point source discharges into Delta waterbodies.

Current Status:
Most of the current NPDES permit limits do not have restrictions for nitrogen, other than ammonia (for aquatic life toxicity), nor phosphorus. NPDES permits are typically renewed every 5 years, and through the permit renewal process, publically owned treatment works (POTWs) NPDES permits are being changed to limit the TN and TP load/concentration that can be discharged into receiving waters (M. Freeman, MDEQ, personal communication). Most of the POTWs in the Delta are small to medium sized facilities. These facilities treat wastewater from communities that do not have the resources to install or operate the types of treatment systems that are currently being used at large facilities to remove nitrogen and phosphorus from their effluents. There are, however, less expensive, alternative treatment options that might be applicable for small to medium sized POTW facilities. A workshop is being planned for winter 2012 to provide small to medium sized POTW facilities throughout Mississippi with treatment options and alternatives to reduce nutrients in their effluent.

In addition to the workshop, the feasibility of reuse and recycling of treated effluent from POTWs for agricultural irrigation in the Delta is being evaluated. Small to medium sized POTWs in the Delta typically discharge into ditches or streams that are surrounded by agricultural fields. The possibility of using POTW discharges for agricultural crop irrigation is being explored initially in the Harris and Porter Bayou watersheds. Reuse and recycling of this treated effluent could:

- Reduce the need or cost of additional treatment upgrades for POTWs through providing water, with nutrients, for agricultural irrigation;
- Reduce the dependence on groundwater for irrigation and reduce groundwater depletion within the Delta; and
- Decrease costs of treatment for the municipalities and irrigation for the producers while providing significant environmental and economic benefits.

DESIGN MONITORING NETWORKS

Effective monitoring programs can contribute to the nutrient reduction effort in a variety of ways. Monitoring data can be used to:

- Characterize current conditions;
- Establish baseline or reference conditions;
- Track changes in both nutrient levels and biological responses;
- Estimate nutrient loads, and apportion loads among sources; and
- Develop relationships among nutrients and biological responses.

Providing information to develop empirical relationships between nutrients and biological responses would significantly enhance the ability to assess the potential for improved ecological condition resulting from nutrient reductions associated with management practices. Monitoring data can also be used to document and track water quality changes resulting from management, and characterize the effectiveness of these nutrient management practices. Both pre-and post-implementation monitoring are needed to document the success of management practices.

Monitoring networks need to account for anticipated lags in system responses in larger watersheds as well as be sited to demonstrate early successes in smaller catchments.

Objective: Provide quality assured data to scientifically assess success of nutrient reduction efforts in Mississippi Delta streams, and to plan future nutrient reduction activities.

Current Status:
Reduction in sediment, nitrogen (N) and phosphorus (P) will be documented through a tiered monitoring approach in the Big Sunflower River watershed. Tier 1 and 2 monitoring sites are active in the Harris and Porter Bayou watersheds within the Big Sunflower River watershed (Figure 3). MDEQ, USACE, USGS, MSU, and Delta Wildlife are monitoring flow, sediment, N and P, and other constituents during both base flow and storm flow, prior to, and after, construction and implementation of conservation management practices to determine the resulting percent reduction in sediment, N, and P. Edge of field sites (Tier 1) with pads and pipes and sites above and below in-ditch low head weirs (Tier 1) have been established to monitor discharge and constituent concentration, so both concentration and loads can be estimated. Stream gages are also established at downstream water quality monitoring sites (Tier 2 and 3) so the cumulative effectiveness of management practices in reducing sediment, N and P concentrations and loads can be estimated.

The USDA Agricultural Research Service National Sedimentation Laboratory (ARS-NSL) is also monitoring Tier 1 and Tier 2 sites at Beasley Lake, which is a USDA NRCS Conservation Effects Assessment Project (CEAP) study area in the Indian Bayou- Big Sunflower River watershed (Figure 3). The Delta Fixed Network of monitoring sites also includes Tier 2 sites, one on the headwaters of the Big Sunflower River and another on the Quiver River, and a Tier 3 site on the Bogue Phalia. However, because of federal budget reductions, many of these fixed network sites, and other monitoring sites in the Delta have been discontinued (see Table 2). Without these sites, it will be difficult to document nutrient reductions anticipated from implemented management practices, or answer the first question posed in the Delta nutrient reduction strategies plan, "What levels of nutrient reduction are achievable and by when?"

Table 2. Tiered monitoring sites in the Delta and sites discontinued because of federal budget reductions (shown in red).

USGS/MDEQ PROJECTS	USGS/COE PROJECTS
HARRIS BAYOU PROJECT (TIER 1 AND 2 SITES)	**STEELE BAYOU PROJECT (TIER 1, 2, AND 3 SITES)**
Overcup Slough Tributary No 1 Near Farrell, Mississippi	Steele Bayou Tributary No 28 Near Fitler, Mississippi
Overcup Slough Tributary No 2 Near Farrell, Mississippi	Steele Bayou Trib No 1 Near Grace, Mississippi
Overcup Slough Trib No 3 Nr Farrell, Mississippi	Steele Bayou nNr Glen Allan, Mississippi
Overcup Slough Trib No 4 Nr Farrell, Mississippi	Steele Bayou at Grace Road at Hopedale, Mississippi
PORTER BAYOU PROJECT (TIER 1 SITES)	Steele Bayou Below Onward, Mississippi
Porter Bayou Trib No 1 NW Of Frazier, Mississippi	Main Canal Tributary East of Swiftwater, Mississippi
Porter Bayou Trib No 4 Off Fox Road Nr Shaw, Mississippi	**DELTA FIXED NETWORK PROJECT (TIER 2 AND 3 SITES)**
LAKE WASHINGTON PROJECT (TIER 1 SITES)	Big Sunflower River at Clarksdale, Mississippi
Lk Washington Trib No 2 Nr Marathon, Mississippi	Harris Bayou at Palmer Rd East of Alligator, Mississippi
Lk Washington Trib at Stein Rd Nr Chatham, Mississippi	Big Sunflower River at Sunflower, Mississippi
BEE LAKE PROJECT (TIER 1 SITE)	Porter Bayou at Stephensville, Mississippi
Bee Lake Tributary No 1 Nr Thornton, Mississippi	Quiver River Southeast Ruleville, Mississippi
	Bogue Phalia Nr Leland, Mississippi
	Big Sunflower River Nr Anguilla, Mississippi
	Tallahatchie River at Money, Mississippi
	Coldwater River at Marks, Mississippi
	Cassidy Bayou at Highway 322 Near Clarksdale, Mississippi
	Opossum Bayou at Brazil, Mississippi
	Yazoo River Bl Steele Bayou Nr Long Lake, Mississippi

Tiered monitoring is also occurring in the Upper Yazoo River watershed in the Whittington Channel (Wolf Lake) and Lower Tchula Lake (Bee Lake) watersheds to evaluate sediment and nutrient reductions associated with vegetated drainage ditches and other practices. In the Deer-Steele Watershed, pre and post-management practice monitoring will be used to determine the sediment, N, and P reductions occurring in the Washington Bayou (Lake Washington) and other sub-watersheds. A Tier 3 site is also shown in Figure 3 on the Yazoo River downstream of the confluence of the Big Sunflower River and Steele Bayou with the Yazoo River to capture overall trends of the entire Yazoo River Basin.

Significant N and P monitoring has occurred at other sites in the Big Sunflower watershed in the past that can also provide useful information. The USGS had two National Quality Assessment Agricultural Chemicals Sources, Transport, and Fate ACT sites in the watershed. The USGS and USACE also had an active monitoring program in the Big Sunflower-Silver Creek watershed to determine the percent reduction in sediment, N, and P from reforestation, including restoration of bottomland hardwood wetlands. Many partners collaborated on the Mississippi Delta Management Systems Evaluation Area project that included extensive monitoring of practice effectiveness and effects on receiving lakes. Two of the lakes are in the Big Sunflower River watershed.

The Harris Bayou target catchments are being monitored as a paired system, with BMPs installed in the north catchment in 2010, and the south catchment representing a control watershed, with no BMPs implemented for 3 years (Figure 13). Before and after comparisons will occur in the Porter Bayou catchments to assess BMP efficiencies (Figure 14). Pre-implementation monitoring has been occurring for a year.

All current and recent nutrient monitoring data collected in the Delta are quality assured by the agency or group responsible for the monitoring. A Quality Assurance Project Plan (QAPP) has been prepared for nutrient monitoring being funded by Section 319 in the Harris Bayou and Porter Bayou target catchments, and for nutrient monitoring in the Lake Washington, Bee Lake, Wolf Lake, and Steele Bayou watersheds.

Tracking input management, cropping practices, water management, and BMP implementation will also be important for evaluating cumulative BMP effectiveness at large scales. Delta F.A.R.M., YMD, and the USDA NRCS and NASS routinely collect information from farmers on crops and farming practices, including BMPs. Tracking water, input, sediment, and nutrient management practices has been initiated.

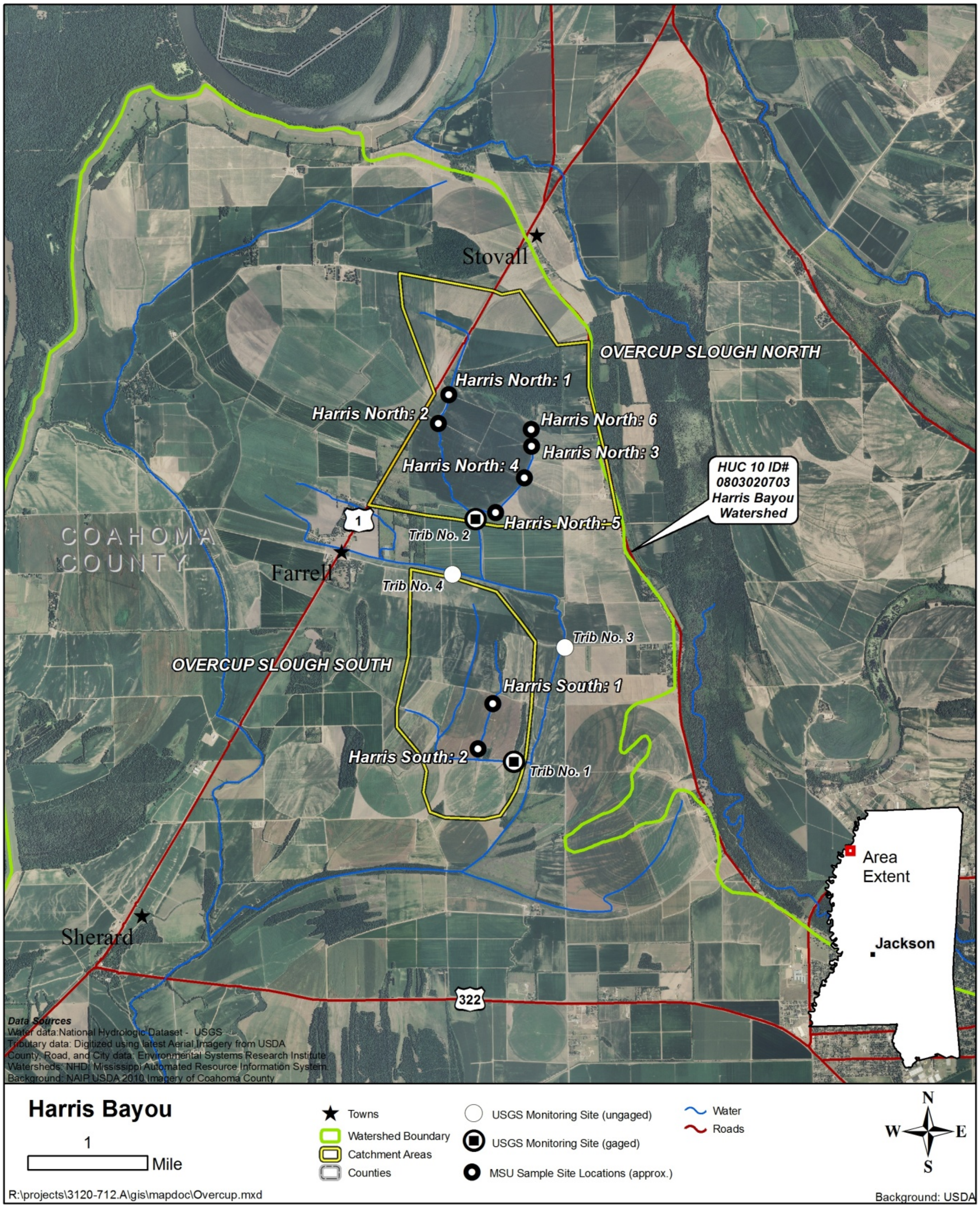

Figure 13. Monitoring locations on Overcup Slough in Harris Bayou watershed.

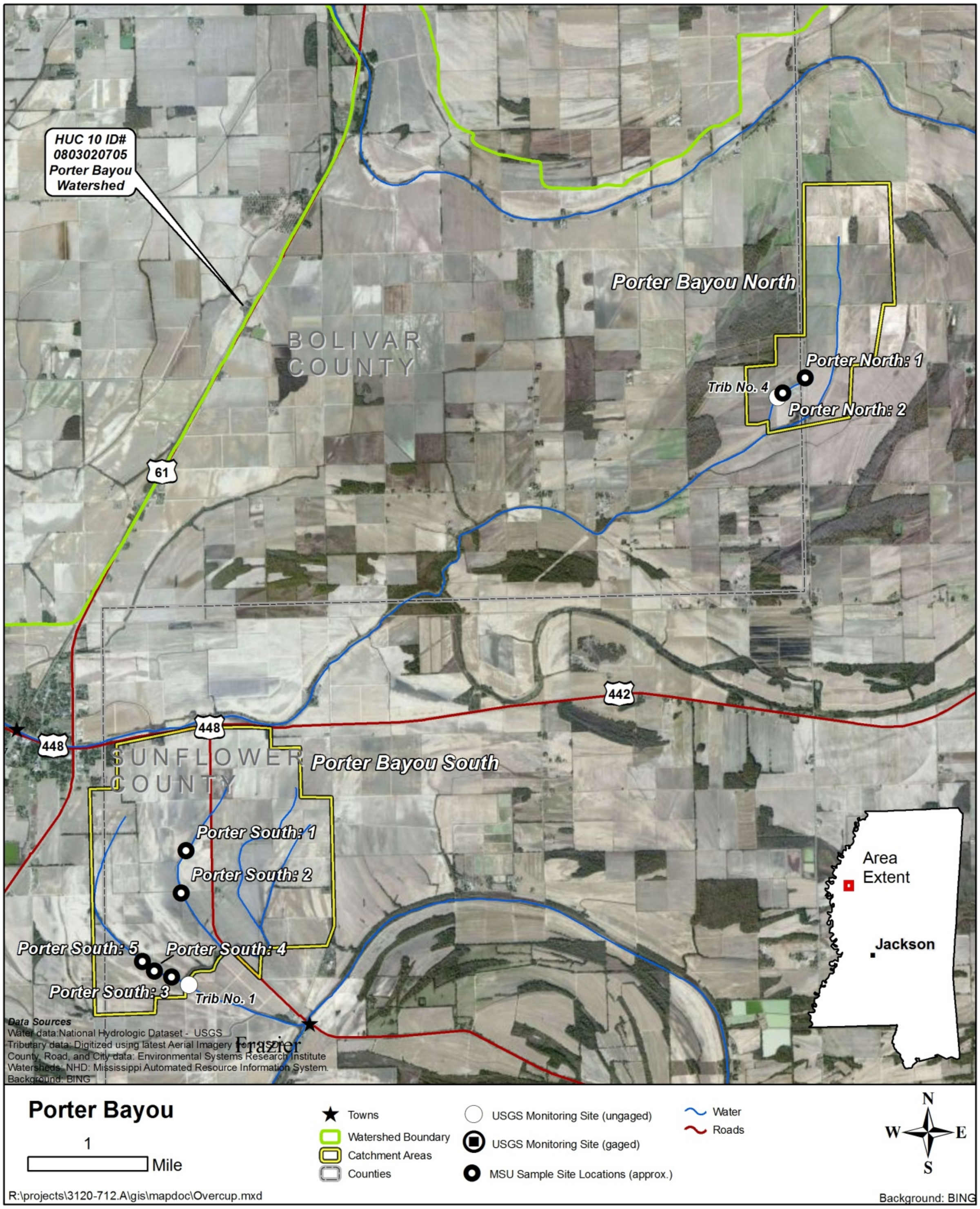

Figure 14. Monitoring locations in Porter Bayou.

PROVIDE ECONOMIC INCENTIVES AND FUNDING

Leveraging funds from multiple sources should be a key component in implementing nutrient reduction strategies. One of the guiding principles of the *Governors' Action Plan II* is the use of innovative, market-based solutions for nutrient reductions. Economic incentives need to be created and identified to encourage voluntary implementation. Economic incentives are particularly important for the private sector, although recognition of performance and contributions to nutrient reductions are also important incentives for this sector. Economic incentives might include watershed- or basin-scale water quality or nutrient trading programs, wetland credits for treatment or marsh creation, and conservation easements.

Objective: Synthesize information on existing monetary sources available to fund the implementation of various elements of nutrient reduction strategies for Delta waterbodies and investigate alternative economic incentives to promote nutrient reduction.

Current Status:
Program funding sources for management practices directly or indirectly related to reducing nutrient loading to aquatic ecosystems are listed below with the amount, time frame and practices funded.

Table 3. Potential funding sources, amounts, and practices available over the next several years.

Funding Source	Funded Program	Amount	Time Frame	Practices Funded
Mississippi River Basin Healthy Watersheds Initiative	NRCS EQIP	$17.8 million	2010 – 2013	Nutrient and erosion management
Mississippi River Basin Healthy Watersheds Initiative	NRCS Wetland Reserve Enhancement Program	$3 million	2010 – 2013	Wetland restoration
Agricultural Water Enhancement Program	NRCS EQIP	$14 million	2009 – 2013	Water enhancement and management
USDA NRCS Migratory Bird Habitat Initiative	NRCS WRP, EQIP, WHIP	$2.2 million		Waterfowl habitat

Table 3. Continued.

Funding Source	Funded Program	Amount	Time Frame	Practices Funded
USDA	NRCS Conservation Reserve Program	2010 national funding was $1.9 billion.	Renewed annually	Remove land from production, vegetative erosion control
USDA	NRCS EQIP	2010 national funding was $873.3 million.	Renewed annually	Nutrient and Erosion and water management practices
USDA & EPA	Sustainable Agriculture Research and Education Program	2010 national funding was $14.5 million.		
US Dept. Interior	USFWS Partners for Fish and Wildlife Program	2010 national funding was $60 million.		Wetland and riparian restoration
USACE	Aquatic Ecosystem Restoration (CAP Section 206)	2010 national funding was $27.126 million.	Renewed annually	Aquatic ecosystem restoration
USEPA	MDEQ Clean Water State Revolving Fund	2010 national funding was $2.1 billion. Monies are also available from loan repayment.	Renewed annually	Point source and nonpoint source pollutant reduction
USEPA	USFWS Five Star Restoration Program	Not funded in 2010. Last funded in 2009 at $300,000.		Wetland and riparian restoration
USACE	Small Flood Damage Reduction Projects (CAP Section 205)	2010 national funding was $37.783 million.	Renewed annually	Construction and improvement of flood control structures

Table 3. Continued.

Funding Source	Funded Program	Amount	Time Frame	Practices Funded
USACE	Snagging and Clearing for Flood Control (CAP Section 208)	Not funded in 2010. Last funded in 2009 at $478,000.	Renewed annually	Channel clearing and excavation
USFWS	State Wildlife Grant Program	2010 national funding was $76 million.	Renewed annually	Wildlife habitat improvement
USDA	Rural Utilities Service Water and Waste Disposal Systems for Rural Communities	2010 national funding was $1.2 billion.	Renewed annually	Installation, repair, improvement, and expansion of rural water facilities
USDA	NRCS Watershed Protection and Flood Prevention Program	2010 national funding was $30 million.	Renewed annually	Planning and installation of conservation practices
USDA	NRCS Wetlands Reserve Program	2010 national funding was $359.8 million.	Renewed annually	Restoration and protection of wetlands
USDA	NRCS Wildlife Habitat Incentives Program	2010 national funding was $42 million.	Renewed annually	Establish and improve wildlife habitat
USEPA	MDEQ Nonpoint Source Implementation Grants	Usually around $37,000 state-wide	Renewed annually	Nutrient and erosion management practices

Grants and loans for drinking water, wastewater, stormwater, and solid waste programs are listed in Table 4 below.

There are few if any direct economic incentives, such as tax credits, for nutrient reduction in the Delta. However, there are ancillary benefits associated with implementing management practices that are not always considered but that are being evaluated through ecosystem service benefits. These benefits, even if not monetary, might be an incentive for implementing nutrient reduction management practices. These ecosystem service benefit analyses are underway.

PDF TABLE

Funding Matrix

MANAGE INFORMATION AND COMMUNICATE RESULTS

Information management involves establishing and managing a repository for data and information. However, managing information is only one element of this strategy. Currently, there are oceans of data, rivers of information, pools of knowledge, and drops of wisdom. Extracting the pools of knowledge and drops of wisdom is the important element of this strategy.

Objective: Develop a user-friendly repository for information related to and applicable for reducing nutrients within the Mississippi Delta, extract knowledge and wisdom, and communicate this information to stakeholders.

Current Status:
MDEQ, USACE, and the USGS Mississippi Water Science Center have completed a joint project to compile a GIS-based compendium of their water quality data for Mississippi. This compendium shows the location of data collection sites and provides a description of the available data, including contact information and/or website links to obtain water quality data. The data compendium was developed to provide information on water quality data in a simple and user-friendly format. Data can be categorized, described, listed and geographically queried using a GIS tookit. Users can use the resulting lists of monitoring sites and available water quality constituents to request the data from the agencies. This data compendium will help MDEQ, USACE, USGS, and other stakeholders access existing Mississippi water quality data and other pertinent information. MDEQ is currently working to add data concerning groundwater and surface water withdrawal permits to this system. The Data Compendium is located at http://opcgis.deq.state.ms.us/MSWQDataCompendium/.

A Decision Support Toolbox, available on the GOMA website, is a resource for managers to locate information related to, and applicable for, reducing nutrients in Gulf coast states. Most of the information in the toolbox related to agricultural land use is applicable in the Delta. The toolbox is a compendium of weblinks to information, classified by nutrient reduction strategy, to provide a place to identify what is available. The toolbox can be found at http://www.gulfofmexicoalliance.org/toolbox/toolbox.html

MDEQ is also working to "Tell the Story" of the success of nutrient reduction efforts in the Delta. This effort will be integrated with the Stakeholder Awareness, Outreach and Education activities to insure the messages are tailored for each target audience. This update is part of "Telling the Story".

SYNTHESIS, GAPs, AND PATH FORWARD

SYNTHESIS

An integrated, interactive, comprehensive set of strategies to reduce excess nutrients are being implemented in the Mississippi Delta to answer four questions:

1. What levels of nutrient reductions are achievable and by when?
2. What will these reductions cost?
3. What is the value to each stakeholder from these nutrient reductions?
4. What levels of nutrient reductions will protect Delta waterbodies and benefit the Gulf of Mexico?

Question 1 – What levels of nutrient reductions are achievable and by when?
High priority basins were identified through the Mississippi River Basin Initiative, and watersheds within these basins have been characterized to identify where this question can be explicitly and effectively answered. The approach for reducing excess nutrients is comprehensive, focusing on:

- Input management, or reducing fertilizer inputs while sustaining agricultural productivity;
- Water management to reuse and recycle not only irrigation return flow, but also treated municipal effluent;
- In-field and in-stream management practices to avoid, control, and trap sediment and excess nutrients; and
- Improved wastewater treatment effectiveness and efficiency, including reuse and recycling of treated effluent.

Tiered monitoring networks have been implemented so that the effectiveness of these management practices can be assessed and documented at the edge of field and in-ditch, in the tributaries draining these ditches, and in the streams at the confluence of HUC10 and HUC8 watersheds. The monitoring strategies include both assessing nutrient loads and concentrations before and after the implementation of management practices, and the comparison of a control watershed with a watershed in which management practices are being implemented. However, discontinuation of monitoring at tiered sites as a result of federal budget reductions could significantly reduce the likelihood of answering this question.

Nutrient reductions, however, have been occurring in the Delta for almost two decades. The USACE has documented reductions in TSS, TN, and TP in Steele Bayou (HUC8) that have occurred since the early 1990's. Similar historical water quality and agricultural management practice records are being sought for other watersheds in the Delta to document reductions in

TSS, TN, and TP that have occurred over the past two decades. Nutrient reduction efforts were on-going long before the Mississippi River Basin Initiative, although this program has provided substantial economic incentives and funding for additional nutrient reductions.

These historical analyses have also documented the lag in system response that occurs from the time management practices are implemented on the landscape until changes in nutrient loading are noted downstream. This is a critical part of the story. Ecosystem responses at the confluence of HUC10 and HUC8 watersheds lag the implementation of the management practices in the watershed. The response of the Gulf of Mexico to nutrient reductions from these management practices are likely to take a minimum of a decade to observe.

Question 2 – What will these nutrient reductions cost?
The cost associated with the management practices being implemented are being documented as these practices are implemented so this question can be answered. However, cost is only one side of the balance ledger. In addition to cost, the benefits associated with these practices are also being documented. For input and water management, these benefits can be expressed directly in dollars. For erosion control and sediment management practices, the benefits are tangible and implicit for the land owner, and can be estimated in dollars. For management practices associated with reducing excess nutrients, benefits will be estimated not only in dollars, but also in additional ecosystem services gained through these management practices, which will be expressed in dollars, where estimates are possible (e.g., duck hunting leases), and documented where dollar estimates are less precise (e.g., increased migratory songbird habitat and bird watching). The costs and benefits of the management practices and ecosystem services are in the early stages of being documented and estimated.

Question 3 – What is the value to each stakeholder from these reductions?
To answer this question first requires an understanding of what is of value to different stakeholders. Stakeholder surveys are being designed to determine not only what stakeholders value, but also what they believe to be true about the effects of excess nutrients, how to manage these excess nutrients, and who should be involved in implementing and paying for these management practices. This information will be used to answer not only this question, but also to develop effective awareness, outreach and education programs.

A critical element of this question also relates to the costs and benefits of implementing nutrient reduction strategies. Reduced fertilizer input costs without reduced yields for producers would be one significant benefit. There are also additional benefits associated with ecosystem services (soil formation, denitrification, etc.) that will be quantified and monetized, where possible, to provide a more complete evaluation of costs and benefits associated with nutrient reduction.

Question 4 – What levels of nutrient reductions are needed to protect Delta waterbodies and the Gulf of Mexico?
Nutrient criteria are being developed not only for Delta waterbodies, but also waterbodies throughout Mississippi. The nutrient criteria development process is using the information being collected through the implementation of these strategies in conjunction with other information and approaches to answer this question. Nutrient criteria for the Mississippi Delta

are scheduled to be promulgated in 2014. If waterbodies are protected through the integrated nutrient reduction management practices that are being implemented in the Mississippi Delta and in other states upstream, the belief is that the Gulf of Mexico will also be protected. The response of the Gulf of Mexico to these changes in nutrient loading, however, may not be recognized for at least a decade.

GAPS

There is missing information within each strategic element, and efforts are on-going to fill these information gaps. For example, adding additional GIS layers and revising the weights in the MWCRT will improve its applicability for watershed characterization not only for the Delta, but also other areas of Mississippi. Additional analytical tools are being developed for predicting water quality improvements from different suites and spatial locations of management practices within the watershed. Precision agriculture and variable rate application of fertilizer are recognized as important and research is on-going to improve the effectiveness of fertilizer application without reducing yield. Similarly, use of the PHAUCET software program can improve water use efficiency for agricultural irrigation. These gaps have been recognized and efforts are underway to fill these gaps.

Two major gaps in the Delta Nutrient Reduction Strategies relate to the input and output of nutrients. While information on the input of TP is being developed, there is less information on the input of TN. Soil sampling for TN is not automated as it is for TP, so the soil N concentrations are relatively unknown. Fertilizer applications of N also vary in form (e.g., urea, ammonium nitrate, nitrification inhibitors) depending on weather, crops, and cropping practice. In addition, soil N is susceptible to leaching as soluble nitrate-N or loss through denitrification as gaseous N. A better understanding of nitrogen inputs and transformations is needed. Determination of the output of nutrients is dependent on the implementation of a comprehensive monitoring network throughout the Delta to document water quality improvements and nutrient reductions. Tiered monitoring sites have been implemented within the Harris and Porter Bayou HUC10 watersheds, but not in other watersheds receiving MRBI funds. This is particularly critical because there are likely to be lags in watershed response to the implementation of management practices, such that responses may not be detected unless Tier 1 and 2 monitoring sites are in place. Steele Bayou represents an excellent example of a delayed, but actual, reduction in sediment, nitrogen, and phosphorus, and improvement in water quality that occurred over a 15 to 20 year period. The emphasis in Steele Bayou was not on nutrient reduction, but nutrient reductions occurred through the implementation of water and sediment control practices. Additional monitoring funds are needed to implement more tier 1 and 2 monitoring sites for earlier detection and documentation of water quality improvements. As noted earlier, discontinuing monitoring sites could significantly decrease the likelihood of documenting and demonstrating the effectiveness of management practices.

PATH FORWARD

The process of implementing the nutrient reduction strategies is not complete, but the path forward is clear and proceeding. Additional management practices are, and will continue to be, implemented in watersheds throughout the Delta. The effectiveness of these management practices will be documented through tiered monitoring approaches and analysis of historical water quality information and associated management practices in the watershed. The costs, and benefits, of these management practices will continue to be documented, and the ecosystem services and their benefits will be estimated. Additional insight into stakeholder beliefs, values, and awareness of effects associated with excess nutrients will be determined, and used to refine the strategies as well as develop and implement effective awareness, outreach and education programs.

Similar updates on the progress of the Delta nutrient reduction strategies will be prepared on a bi-annual basis.

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