IOWA NUTRIENT REDUCTION STRATEGY

A science and technology-based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico

Prepared by:
Iowa Department of Agriculture and Land Stewardship
Iowa Department of Natural Resources
Iowa State University College of Agriculture and Life Sciences

Updated December 2017

December 2017
IOWA NUTRIENT REDUCTION STRATEGY UPDATES

In December 2017, the Iowa Department of Agriculture and Land Stewardship, Iowa State University College of Agriculture and Life Sciences, and the Iowa Department of Natural Resources identified needed updates to the Iowa Nutrient Reduction Strategy. Updates were necessary to keep the text of the strategy up-to-date based on current information and status of efforts related to the strategy.

Below is a summary of the updates that have been made to the September 2016 strategy document.

Nonpoint Source Updates:

- Incorporated the addition of blind inlets as an erosion control practice that reduces phosphorus loss

Point Source Updates:

- Added three facilities to the NPDES required permits list: City of LeClaire STP, City of Hampton STP, and City of Wapello STP.
- Removed one facility from the NPDES required permits list: University of Iowa Power Plant.

May 2013
Preparation and Presentation of the
IOWA NUTRIENT REDUCTION STRATEGY

On November 19, 2012, Iowa Gov. Terry Branstad, Iowa Secretary of Agriculture Bill Northey, Director Chuck Gipp from the Iowa Department of Natural Resources and Dr. John Lawrence of Iowa State University announced the release of the Iowa Nutrient Reduction Strategy for public comment.

A two-month public comment period and several informational meetings allowed the public to provide feedback on the draft strategy. Updates and improvements were made to the draft based on the public comments. The final version of the strategy was released May 29, 2013.

The Iowa Nutrient Reduction Strategy is a science and technology-based approach to assess and reduce nutrients delivered to Iowa waterways and the Gulf of Mexico. The strategy outlines voluntary efforts to reduce nutrients in surface water from both point sources, such as wastewater treatment plants and industrial facilities, and nonpoint sources, including farm fields and urban areas, in a scientific, reasonable and cost effective manner.

The development of the strategy reflects more than two years of work led by the Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources and Iowa State University. The scientific assessment to evaluate and model the effects of practices was developed through the efforts of 23 individuals representing five agencies or organizations, including scientists from ISU, IDALS, DNR, USDA Agricultural Research Service and USDA Natural Resources Conservation Service.

The strategy was developed in response to the 2008 Gulf Hypoxia Action Plan that calls for the 12 states along the Mississippi River to develop strategies to reduce nutrient loading to the Gulf of Mexico. The Iowa strategy follows the recommended framework provided by EPA in 2011 and is only the second state to complete a statewide nutrient reduction strategy.

This strategy is the beginning. Operational plans are being developed and work is underway. This is a dynamic document that will evolve over time, and is a key step towards improving Iowa's water quality.

IOWA NUTRIENT REDUCTION STRATEGY

A science and technology-based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico

EXECUTIVE SUMMARY

The Iowa Nutrient Reduction Strategy is a science and technology-based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico. It is designed to direct efforts to reduce nutrients in surface water from both point and nonpoint sources in a scientific, reasonable and cost-effective manner.

Its development was prompted by the 2008 Gulf Hypoxia Action Plan that calls for Iowa and states along the Mississippi River to develop strategies to reduce nutrient loadings to the Gulf of Mexico. The Gulf Hypoxia Action Plan establishes a goal of at least a 45% reduction in total nitrogen and total phosphorus loads. The strategy will also intensify efforts to address nutrient related water quality problems in Iowa's waters that negatively impact beneficial water uses enjoyed and required by all Iowans.

The Environmental Protection Agency (EPA) embraced a practical approach to meet these goals in the March 16, 2011 memorandum titled, "Recommended Elements of a State Framework for Managing Nitrogen and Phosphorus Pollution" (Stoner 2011).

The memo outlines eight strategy elements that emphasize state implementation of new and existing nutrient reduction practices and technologies for point and nonpoint nutrient sources. The Iowa strategy, which was developed over a two-year period as a result of the Gulf Hypoxia Action Plan, follows the recommended framework provided by the EPA in the 2011 memo.

The Iowa strategy proposes a pragmatic, strategic and coordinated approach for reducing nutrient loads discharged from the state's largest wastewater treatment plants, in combination with targeted practices designed to reduce loads from nonpoint sources now while evaluating the need for nutrient water quality standards long-term.

In this document, steps are outlined to prioritize watersheds and limited resources, improve the effectiveness of current state programs, and increase voluntary efforts to reduce nutrient loading.

Iowa's many successes can be duplicated using the tools known to work, such as targeted, voluntary conservation measures, in conjunction with research, development and demonstration of new approaches.

This strategy recognizes the continued need to work with farmers, industry and cities to optimize nutrient management and lessen impacts to streams and lakes. It also recognizes success is highly dependent on many complicated factors, and new technologies will also need to be developed, tested and implemented.

All Iowans have an impact on nutrients in surface water and can play a role in reducing those impacts over time. This strategy emphasizes Iowans working together in small watersheds, using existing and new frameworks, to make an impact.

What's New

- The Iowa Nutrient Reduction Strategy is a new beginning in the state's efforts to assess and reduce nutrient loading to Iowa waters. Iowa leaders representing nonpoint sources (agriculture) and point sources (municipalities and industries) are working together through the Water Resources Coordinating Council to develop and implement an integrated strategy to enhance Iowa's and downstream waters, including the Gulf of Mexico.
- An Iowa Science Assessment of Nonpoint Source Practices to Reduce Nitrogen and Phosphorus Transport to the Mississippi River Basin has been completed to enhance the implementation of conservation practices to improve Iowa's waters.
- An Iowa Point Source Nutrient Reduction Technology Assessment has been completed, to guide the implementation of wastewater treatment technologies to reduce nutrient discharges to Iowa waters.

- The strategy harnesses the collective initiative and capacity of Iowa agricultural organizations, ag businesses and farmers towards implementation of nonpoint source management practices to improve Iowa water and soil quality.
- Iowa's major municipalities and industries will evaluate and implement process changes and biological nutrient removal wastewater treatment processes to reduce nutrient discharge to Iowa's and downstream waters.
- Coordination, oversight and implementation of this strategy including identification of high priority watersheds within one year is underway and will continue through the Water Resources Coordinating Council, which consists of 19 state and federal agencies, in consultation with the nongovernmental organizational membership of the Watershed Planning Advisory Council.

Point Source and Nonpoint Source Collaboration

Point source pollution is characterized by relatively constant discharges from stationary locations or fixed facilities from which discrete discharges originate, such as municipal wastewater treatment plants and major industries.

As defined by EPA, nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. Unlike pollution from industrial and sewage treatment plants, nonpoint source (NPS) pollution comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters.

With an integrated strategy to address both point source and nonpoint source nutrient loads, it is important to understand the different roles that each part plays on an annual and seasonal basis in achieving nutrient load reductions to water resources that will enhance water resources within Iowa as well as receiving waters beyond our state.

While it is true the largest percentage of nutrient loads in Iowa comes from nonpoint sources on an annual basis, this should not be interpreted to mean that point source contributions are insignificant. In fact, point sources can be the primary source of nutrient contributions during the most critical conditions for protecting stream aquatic life when stream flows are low and/or when a point source comprises the majority of flow to a stream. These types of low flow conditions commonly develop during summer months as well as during drought conditions. Both nonpoint source and point source loads play critical roles in Iowa and Gulf of Mexico waters.

A concerted, cooperative and sustained effort by both point and nonpoint sources will be needed to meet the ambitious goals defined in this strategy, since neither source can meet the goals on its own. We must continue to recognize that both sources play critical roles in regards to nutrient loads on a seasonal and annual basis.

The approach to addressing the diverse and weather-driven nutrient transport from Iowa nonpoint sources involving Iowa's 92,000 farmers will be different from the approach to address the controlled and relatively constant nutrient discharge from Iowa's major point sources. But both approaches share a common goal of reducing nutrient loads to the water resources of our state and receiving waterbodies beyond our border.

Point Source Policy

The nutrient strategy outlines steps to achieve significant reductions in the amounts of nitrogen and phosphorus discharged to Iowa's rivers and streams by point sources. The portions of this strategy related to point sources are built on a technology assessment of practices that offer the most "bang for the buck" at reducing loading of nitrogen (N) and phosphorus (P) to Iowa surface waters from Iowa's major

wastewater treatment plants and industrial facilities that discharge N and P to Iowa waters. The assessment also takes into account related costs of these practices.

A total of 102 major municipal facilities serve the wastewater treatment needs of 55-60% of Iowa's population and treat more than 80% of the volume of all wastewater handled by Iowa cities. Among permitted industrial facilities, there are 28 that discharge significant amounts of nitrogen and phosphorus to Iowa waters.

For the first time, discharge permits issued to these 130 facilities will require implementation of technically and economically feasible process changes for nutrient removal. These changes are designed to achieve targeted reductions of at least two-thirds in the amount of nitrogen and a three-fourths reduction in the amount of phosphorus from levels currently discharged by these facilities.

If successful, this strategy will reduce by at least 11,000 tons per year the amount of nitrogen and 2,170 tons per year the amount of phosphorus discharged annually by municipal facilities alone. These figures represent a 4% reduction in nitrogen and a 16% reduction in phosphorus in the estimated statewide amounts of nitrogen and phosphorus discharged to Iowa waters from both point and nonpoint sources.

This approach is estimated to have a total present worth cost (includes capital costs and operation and maintenance cost over a 20-year period) of approximately $1.5 billion if implemented in full. The annual cost of this approach is approximately $114 million.

Nonpoint Source Policy

The approach to addressing the diverse and weather-driven nutrient transport from Iowa nonpoint sources involving Iowa's 90,000 farmers must be different from the approach to address the controlled and relatively constant nutrient discharge from Iowa's 130 major cities and industries.

Accounting for the potential reduction from point sources, the target load reductions for nonpoint sources is 41% of the statewide total nitrogen and 29% of the total phosphorus to meet the Gulf Hypoxia Action Plan goal. Iowa has nutrient-rich landscapes and significant progress towards these large nutrient reduction targets will take considerable time, effort and funding sources.

Iowa is a national and global leader in the production of food and renewable fuels, so a goal of this strategy is to make Iowa an equal national and global leader in addressing the environmental and conservation needs associated with food and renewable fuels production.

The policy of this strategy related to nonpoint sources is built on a scientific assessment of practices and associated costs to reduce loading of nitrogen (N) and phosphorus (P) to Iowa surface waters.

Nonpoint Source Policy Actions

The strategy identifies multiple action items within five categories. Highlights of the action items (detailed in Section 1.4(4)) include:

Setting Priorities

- Focus conservation programs
- Combination of in-field and off-field practices
- Small watershed pilot projects
- Nutrient trading and innovative approaches

Documenting Progress

- New and expanded frameworks to document farm best management practices
- Collaboration with the science assessment team to measure success

Research and Technology

- New technologies and creative solutions
- Private and public funding for science and technology

- Gulf hypoxia zone research

Strengthen Outreach, Education, Collaboration

- New, enhanced private and public sector roles
- Assist local watershed groups with coordination of local nutrient reduction projects
- Expanded agribusiness consulting and advisory services to farmers
- Broaden awareness and provide relevant information to farmers
- Achieve market-driven solutions
- Collaborate and share information with other states
- Increased public awareness and recognition
- Farmer recognition program
- Statewide marketing and education campaign

Funding

- Make most effective use of funding resources including maximizing benefits per amount expended

Nonpoint Source Science Assessment

To develop the strategy, the Iowa Department of Agriculture and Land Stewardship and the College of Agriculture and Life Sciences at Iowa State University partnered in October 2010 to conduct a scientific assessment. The team consisted of 23 individuals representing five agencies or organizations.

The objective of the Iowa Nonpoint Source Nutrient Reduction Science Assessment was to identify and model the effectiveness of specific practices at reducing N and P from reaching the Gulf of Mexico, plus estimating the total cost and per unit cost of nutrient removed when implementing each practice.

The assessment involved establishing baseline conditions, reviewing scientific literature to assess potential performance of practices, estimating potential load reductions of implementing various scenarios involving nutrient reduction practices, and estimating implementation costs.

Possible nutrient reduction practices identified fall into three categories — nitrogen and phosphorus management, erosion control and land use, and edge-of-field. Management practices involve such things as application rate, timing, and method, plus the use of cover crops and living mulches.

Land use practices include such things as perennial energy crops, extended rotations, tillage methods, grazed pastures, land retirement and terraces. Edge-of-field practices involve drainage water management, wetlands, bioreactors, buffers and sediment control.

The scientific assessment demonstrated that a combination of practices will be needed to reach desired load reductions. To that end, the science team developed scenarios of practice combinations that could potentially achieve the goals. The practice combinations are examples, not recommendations.

After considering all possible practices, three example scenarios were developed that meet both the N and P reduction objective. Initial investment costs of the three scenarios range from $1.2 billion to $4 billion. Alternatively, annual costs, including initial investment and operating cost, range from $77 million per year to $1.2 billion per year.

To carry these action items forward, operational plans will be developed and work teams formed. Where appropriate, the science assessment and outcomes of the science assessment will be integrated into the operational plans.

Moving Forward

While the positive effects of any individual nutrient control practice may not be noticed immediately, the cumulative impact of these actions will result in long-term water quality improvements in Iowa, plus downstream waters from Iowa to the Gulf of Mexico.

This strategy is the beginning. From this, operational plans will be developed through the Water Resources Coordinating Council. This work is already underway. This is a dynamic strategy document that will evolve over time as new information, data and science is discovered and adopted.

There still is a need for development of additional practices, testing of new practices, further testing of existing practices, and verifying practice performance at implementation scales. This strategy encourages the development of new science, new technologies, new opportunities, and the further engagement and collaboration of both the public and private sectors.

The path forward to reducing nutrient impacts will not be easy, but this strategy is a key step towards improving Iowa's water quality while ensuring the state's continued, reasonable economic growth and prosperity.

Section 1 — Policy Considerations and Strategy

1.1 Introduction

The 2008 Gulf Hypoxia Action Plan calls for states along the Mississippi River to develop strategies to reduce nutrient loadings to the Gulf of Mexico. The plan establishes targets of at least a 45% reduction in riverine total nitrogen load and in riverine total phosphorus load.

Iowa has been working for decades to protect and improve water quality, with positive small watershed results. Progress measured at the Gulf of Mexico towards these larger reduction targets, however, has been challenging, and many complex nutrient-related impacts in Iowa's lakes, reservoirs and streams remain to be addressed.

The Iowa Nutrient Reduction Strategy outlines efforts to reduce nutrients in surface water from both point and nonpoint sources in a scientific, reasonable and cost effective manner.

The Environmental Protection Agency (EPA) embraced a practical approach in the March 16, 2011 memorandum titled, *"Recommended Elements of a State Framework for Managing Nitrogen and Phosphorus Pollution"* (Stoner 2011). The framework includes eight strategy elements that emphasize implementation of existing nutrient reduction practices and technologies for point and nonpoint nutrient sources.

Consistent with EPA's framework, the Iowa strategy proposes a pragmatic approach for reducing nutrient loads discharged from the state's largest wastewater treatment plants in combination with targeted practices designed to reduce loads from nonpoint sources.

Iowa's many successes in protecting the state's water quality can be duplicated using the tools known to work, such as targeted, voluntary conservation measures, in conjunction with research, development and demonstration of new approaches.

Current investments will continue to pay dividends, and the policies proposed within this strategy will accelerate progress towards reducing nutrient loads to local and Gulf waters.

This is a dynamic strategy and science/technology assessment document that will change over time as new information, data and science is discovered and adopted. The Water Resources Coordinating Council (WRCC) shall annually evaluate whether the Iowa Nutrient Reduction Strategy needs to be reviewed and updated. This evaluation shall be included in the annual report of implementation activities and progress.

1.2 Background

Nutrients are chemical elements that are necessary to sustain all life forms. Nitrogen and phosphorus are two nutrients that allow for healthy aquatic ecosystems. However, at excessive levels these nutrients can lead to water quality problems and interfere with beneficial water uses.

Iowa is not alone in facing nutrient-related water quality problems. To some degree, every state faces problems associated with nutrient over-enrichment caused primarily by too much nitrogen and phosphorus in waters. Nutrient enrichment can originate from many types of sources including from the landscape or within the stream itself. Complex biological systems demand an adaptive management approach to address the variability and uncertainties of addressing the related water quality problems.

The Gulf Hypoxia Task Force Report attributes the hypoxic zone – an area containing little or no oxygen – in part to excessive algae growth stimulated by nutrients. Targets of 45% total nitrogen and 45% total phosphorus riverine load reductions have been called for in order to achieve the goal for hypoxic zone size and to facilitate water quality improvements in the basin (Gulf Hypoxia Action Plan 2008).

Reducing excess nutrients in Iowa's surface waters can a) improve water clarity and minimize objectionable algal growths affecting water-based recreation; b) reduce dissolved oxygen deficiencies which can lead to fish kills and reduce aquatic biological diversity; and c) minimize occurrence of taste and odor chemical compounds that impact potable drinking water supplies. Reducing nitrogen in ground water aquifers and surface water withdrawals also protects private and public drinking water sources.

Numeric Nutrient Criteria

Based on its 1998 Nutrient Strategy, EPA (1998) developed a plan to adopt numeric nutrient criteria to protect surface waters against the negative effects of nutrient enrichment. However, for most states, including Iowa, the adoption of numeric nutrient criteria has proven to be difficult for a variety of reasons. In 2000, EPA issued nutrient criteria recommendations derived from statistical distributions of nutrient data from the nation's lakes and rivers (EPA 2000). These recommendations were developed with the available water quality data for each of the 14 "nutrient ecoregions" nationwide. Ecoregions are defined as areas of relative homogeneity in ecological systems and their components. The recommendations have been characterized as a starting point for the development of more refined, local and waterbody-specific nutrient criteria.

Concerns with EPA's initial statistical approach have been raised by the U.S. Geological Survey (USGS) and several states. For example, the USGS estimated natural background concentrations for total phosphorus can vary by an order of magnitude within an ecoregion and would exceed EPA recommended numeric criteria in 52% of stream reaches nationwide (Smith et al., 2003). In other words, more than half of all streams in the country might not be able to meet the EPA recommended numeric criteria for phosphorus due to naturally occurring background conditions.

Iowa and many other states have been evaluating alternative approaches for establishing numeric water quality standards or strategies in order to reduce nutrients in surface water. EPA has recommended regional criteria or averages and ranges for nutrients in lakes and reservoirs and streams and rivers for states to consider when setting standards. State nutrient criteria based on the EPA recommendations would establish the maximum acceptable concentrations of nutrients in surface waters that would allow those waters to support designated uses, such as drinking water supplies, fishing and swimming.

There is debate on how to establish the appropriate nutrient criteria for protecting these designated stream and lake uses. Unlike most pollutants that currently have criteria established, no single criterion value appears to be appropriate for every water body. Therefore, numeric criteria may not be the best approach for achieving reductions in nutrient loads.

Because of the difficulties involved in deriving and implementing numeric nutrient criteria for streams, as well as the complexity and widespread occurrence of nutrient pollution, states that have made only small strides in reducing nutrient pollution have focused their efforts to reduce nutrient losses on activities other than establishing numeric criteria. Concern over states uneven progress in establishing and implementing numeric nutrient criteria according to the timeframe set by EPA was raised in a 2007 memorandum from Benjamin Grumbles, Assistant Administrator, U.S. EPA, Office of Water. Grumbles called upon EPA and its partners to take steps to accelerate the pace. In its response letter (July 18, 2007), the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA) pointed to a number of factors confounding the nutrient criteria development process including variability of nutrient responses in aquatic ecosystems, and the lack of strong linkages and clear thresholds between nutrient causal and response variables.

The primary impact of numeric nutrient criteria would be felt almost exclusively by point source wastewater dischargers - primarily municipal wastewater treatment plants. Federal regulations require wastewater treatment plant permits contain limitations for pollutants that "contribute to an excursion above any State water quality standard." If a state adopts numeric water quality standards for nutrients, wastewater treatment plants would be required to remove nutrients to the degree their discharge to surface waters would not cause the water quality standard to be exceeded. Nonpoint sources do not have this requirement, but rather use voluntary state and federal conservation programs.

Discharges from wastewater treatment plants contribute approximately 8% of the total nitrogen (TN) and 20% of the total phosphorus (TP) entering Iowa's streams and rivers annually. Wastewater treatment facilities contribute relatively minor percentages of the total annual nutrient loads to Iowa streams as compared with nonpoint sources. However, the impacts of nutrient discharges by wastewater treatment facilities on water quality in small streams during low streamflow conditions can be significant.

Nonpoint sources account for 92% of the total nitrogen (TN) and 80% of the total phosphorus (TP) entering Iowa streams annually. However, only 5% of all nitrogen inputs and 4% of all phosphorus inputs in watersheds are lost to Iowa streams. The rest is removed by harvest, grazing, volatilization, denitrification or is immobilized in soil (Libra et al., 2004).

For Iowa streams, EPA's recommended criteria range from 0.712 to 3.26 mg/L for TN and from 0.070 to 0.118 mg/L for TP. The best performance expected for municipal wastewater treatment facilities utilizing biological, physical, and chemical treatment methods is around 3.0 mg/L TN and 0.1 mg/L TP. Wastewater discharges that comprise a large portion of the flow in a receiving stream could be required to treat to levels that are impossible to achieve even with today's state-of-the-art treatment technologies.

In addition to the issues with treatment efficacy for nutrient removal, the treatment technology is typically beyond the financial and technical capabilities of the many small towns in Iowa. Based on cost data developed by Foess et al. (1998), the cost per household for new treatment facilities including biological nutrient removal (BNR) ranges from approximately $60/month for a population of 1,000 to more than $200/month for a population of 100. These rates are approximately three to 10 times higher than the typical Iowa sewer rate.

An economy of scale is also apparent in IDNR's estimation of costs[1] associated with BNR improvements for Iowa's current 102 major municipal wastewater treatment facilities. User rates resulting from construction of nutrient removal facilities will depend on a number of factors such as the existing treatment facility type

[1] Cost estimates were developed by categorizing each facility by treatment type and design average wet weather flow. Capital and operational costs on a treatment type/unit design flow basis for target effluent nitrogen and phosphorus concentrations of 10 mg/L and 1 mg/L, respectively, were derived from the Utah POTW Nutrient Removal Cost Impact Study (CH2MHILL). These unit costs then were applied to the Iowa facilities based on treatment type and design flow.

and configuration, ease of BNR modifications in specific plant configurations and available funding sources. In general, the larger the population served, the lower the cost per user.

If the EPA nutrient criteria recommendations were adopted as Iowa water quality standards, cities would be required to pay for expensive wastewater treatment plant upgrades that would address only a fraction of the overall amount of nutrients discharged to Iowa's streams while leaving wastewater treatment facilities unable to comply with permit limits. A summary of estimated treatment costs is included in Section 3.2.

If compliance with stringent numeric effluent limits on point source discharges did not eliminate an existing impairment, the receiving stream would continue to exceed the water quality standard and would require development of a total maximum daily load (TMDL). At that point, any further reduction required by a TMDL would need to be accomplished through voluntary controls placed only on nonpoint sources. Nonpoint sources face another set of equally challenging technological and financial limitations.

Recently EPA has been exploring water quality standards and permitting implementation flexibilities with states that have stringent numeric criteria in place to help resolve implementation issues. These flexibilities include site-specific criteria, revisions to designated uses, permit compliance schedules, water quality standards variances, and trading. While the increased interest from EPA on these possible flexibilities is encouraging, each one has pros and cons and may or may not be possible depending on case-specific circumstances.

Because of the lack of confidence in EPA's (2000) statistically derived criteria recommendations and the substantial financial costs associated with implementing nutrient removal technologies, legitimate concerns about the value of numeric nutrient criteria have been raised. Other criteria derivation approaches such as nutrient stressor-response analysis and reference condition modeling are better alternatives that Iowa will continue assessing as a basis for appropriate nutrient standards for implementation within an adaptive watershed management framework.

Challenges of Best Management Practice Adoption to Address Nonpoint Sources

The current understanding is that in tile-drained landscapes, N losses are greater due mostly to subsurface drainage and dominated by nitrates[2]. The largest losses can occur with sustained flows that usually occur in the spring and at a time with little evapotranspiration and nutrient uptake.

In "rolling" or more hilly landscapes with good surface drainage, the phosphorus losses can be greater. Surface runoff water and sediment are the predominant carriers. The largest losses can occur with "flashy"rainfall-runoff events, such as in spring when there is less vegetative cover.

According to Baker and Helmers, emerging science suggests that current nutrient impairment problems are not mainly due to mismanagement of fertilizers and manures, but more to historic changes in land use and hydrology that came with the conversion of prairie and wetlands to cropland. Often it is written that nutrients in water resources are the result of the loss of "excess nutrients" present in the soil (implying if there were no "excess nutrients," losses would not occur). However, for optimum crop production, significant amounts of N and P must be present in the soil. Precipitation that results in excess water (thus surface runoff and/or subsurface drainage) can and does come at any time. When that happens some nutrients are certain to be lost.

Despite what some believe, there are few "win-win" situations, and those associated with rate of nutrient inputs will not get Iowa to currently targeted water quality goals. Reaching those goals will come at considerable effort and costs, and therefore, it is imperative to be sure that the practices promoted will

[2] Hypoxia –Improving the system in Iowa: Costs and Needs. Heartland Regional Water Resources Workshop, June 10, 2009 Jim Baker and Matt Helmers, Department of Agricultural and Biosystems Engineering, Iowa State University.

secure those goals; and furthermore, that reaching those goals will result in the anticipated environmental benefits. But it will be difficult given the variable nature of weather and Iowa's modified landscape, major reasons why many say a regulatory approach on nonpoint sources is not likely to achieve aggressive water quality outcomes.

In addition, Iowa has developed and adopted a Phosphorus Index, which also is utilized to address this resource concern for regulated livestock operations. The Natural Resources Conservation Service (NRCS) and the Iowa Department of Agriculture and Land Stewardship (IDALS) also use the P-Index as part of voluntary soil and water conservation programs on farms.

Ongoing research at Iowa State University and other institutions also indicates in-channel scouring and streambank erosion contributes a previously unrecognized higher contribution to the phosphorus loading of streams. While this strategy calls for continued in-field erosion reduction and soil sustainability, thereby reducing sediment and phosphorus loading to streams, it is unlikely that in-stream phosphorus mass loading water quality goals will be achieved from only in-field phosphorus loading reductions to streams, given in-channel bed and bank sediment, and phosphorus loads. This should not discourage continuing efforts to reduce sediment and phosphorus loads from fields to streams, but should be recognized as an area of critical research need to better evaluate, understand and address in-channel bed and bank sources of sediment and phosphorus.

Mississippi River/Gulf of Mexico Watershed Nutrient Task Force

The EPA co-chairs the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force. The task force has set a goal of establishing state nutrient strategies by 2013 that will coordinate the basin efforts to reduce nitrogen and phosphorus delivery to the Gulf by 45 percent. The task force consists of five federal agencies, 12 state agencies (including Iowa) and the tribes within the Mississippi/Atchafalaya River Basin.

Iowa is well-positioned to work with the federal task force to document past success and make additional progress on nutrient reductions in surface water. The task force was established in the fall of 1997 to understand the causes and effects of eutrophication in the Gulf of Mexico; coordinate activities to reduce the size, severity, and duration; and reduce the effects of hypoxia.

In 2001, the task force released the 2001 Action Plan, a national strategy to reduce Gulf hypoxia. While there was an initial federal commitment to funding state actions under the plan, no federal funding was ever received. Iowa has developed a variety of creative state actions (e.g., the Iowa Conservation Reserve Enhancement Program, the Iowa Wetland Landscape Systems Initiative, and various Iowa watershed protection projects) and continues to work to make progress with available resources.

The task force embarked on a four-year reassessment of the science surrounding Gulf hypoxia since the release of the 2001 Action Plan. The 2008 Action Plan currently is being implemented by member states and agencies, including Iowa. The revised action plan includes five annual operating plans, one for each year through the next reassessment, that provide short-term roadmaps to maintaining forward progress towards the goals of the Action Plan.

Iowa Secretary of Agriculture Bill Northey is the state co-chair of the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (EPA is the federal co-chair with states). The Iowa Department of Agriculture and Land Stewardship (IDALS) is the designated lead Iowa agency for hypoxia issues and participation in the hypoxia task force, its subcommittees, and related working groups.

Iowa Nutrient Reduction Strategy Development

The Secretary of Agriculture and the Iowa Department of Natural Resources (IDNR) are working cooperatively to develop the state nutrient reduction strategy, with the support of EPA Region 7. IDALS is leading work with the affected nonpoint source industries, while IDNR is working with permitted facilities and industries to focus on point source impacts.

The initial step to developing a statewide strategy to reduce nutrients to streams and the Gulf of Mexico was a scientific assessment of the practices with potential to achieve the desired environmental goals. Iowa has voluntarily moved forward to complete the science assessment and strategy development using existing state funds, much of which comes from fertilizer fees paid by Iowa farm families.

IDALS and the Iowa State University College of Agriculture and Life Sciences (CALS) led the nonpoint source science assessment. The Iowa Nonpoint Source Nutrient Reduction Science Assessment is based on the peer-reviewed science studies of in-field, edge-of-field and watershed scale practices and treatments to determine the potential reductions in total nitrogen and total phosphorous leaving agricultural landscapes. A team of 23 research and extension faculty from ISU CALS, IDALS, USDA-ARS, NRCS, EPA, and IDNR, as well as scientists from nearby states worked on the science assessment.

The coefficient of potential nutrient reductions for each practice and treatment is based on peer-reviewed literature and best professional judgment of the team. The initial level of use of each practice is based on values estimated by the team using published literature and information publicly available from the USDA. Scenarios of combinations of the practices and treatments were developed to estimate the expected reduction in nutrients and the resulting cost.

For each scenario, the coefficient of potential nutrient reduction was multiplied by adoption rate and potential acreage to determine the potential nutrient reduction for the practice. Next, the reductions from the practices were aggregated to a total potential reduction for the scenario over the state. The cost in investment, operating expenses and lost production also were taken into consideration, as were potential trade-offs with other environmental concerns. For instance, a practice that reduces nitrates in groundwater may increase phosphorus in surface water. The cost and supply impacts of each scenario were used to estimate the local economic impact.

The science assessment is particularly useful in demonstrating the relative effectiveness of various practices in achieving N and P reductions. For example, ranking the 15 nitrate-N reduction practices suggests that cover crops (28% reduction), wetlands (22%), bioreactors (18%) and perennial crops (18%) offer the greatest potential for N reductions. In contrast, a commonly highlighted practice such as moving fall fertilizer applications to spring only resulted in a nitrate-N reduction of 0.1%. However, the science assessment goes beyond simply listing practice effectiveness by including the number of acres that a practice can impact and estimating the cost of N reduction per pound. So, while perennial crops are associated with higher N reductions, the practice is also the most expensive practice ($21.46 per pound of N reduced). Hence, the science assessment can be used by the NPS community to identify appropriate N and P practices that align with specific watershed goals in terms of nutrient reductions, area impacted by a practice and potential practice cost. Details provided in the science assessment can form the basis for developing specific nutrient reduction plans in watersheds.

The science assessment demonstrates a combination of in-field and edge-of-field practices will be needed to reach desired load reductions from nonpoint sources. To that end, the science team developed scenarios of practice combinations that could potentially achieve the goals. **The practice combinations are examples, not specific recommendations.**

Nitrogen reduction practices considered in the assessment included in-field N management practices such as timing, source, application rate, nitrification inhibitor, cover crops and living mulches; land use changes such as the addition of perennials, extended rotations and grazed pastures; and edge-of-field practices such as drainage water management, shallow drainage, wetlands, bioreactors and buffers.

Phosphorus reduction practices studied included in-field P management practices such as application, source and placement; erosion control and land use change practices such as tillage, crop choice, perennials and terraces; and edge-of-field practices such as wetlands, buffers and sediment control.

After considering all possible practices, three example scenarios were developed that meet both the N and P reduction objective. Initial investment costs of the three scenarios range from $1.2 billion to $4 billion. Alternatively, annual costs, including initial investment and operating cost, range from $77 million per year to $1.2 billion per year.

While significant research has been conducted on the potential performance of various nutrient reduction practices, there is a need for development of additional practices, testing of new practices, further testing of existing practices, and verifying practice performance at implementation scales. Additional research also would improve the predictability of practice performance and the understanding of practice uncertainty.

1.3 Regulatory and Administrative Framework

Recent EPA Guidance to States

EPA, in its March 16, 2011 memo, outlined a new path for local-state-federal partnerships to address nutrients. In the memo, Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions, the agency said that states, EPA and stakeholders must make greater progress in accelerating the reduction of nitrogen and phosphorus loadings to the nation's waters. While EPA has a number of regulatory tools at its disposal, its resources can best be employed by catalyzing and supporting action by states to protect their waters.

"Where states are willing to step forward, [the EPA] most effectively encourages progress through on-the-ground technical assistance and dialogue with state officials and stakeholders, coupled with cooperative efforts with agencies like USDA with expertise and financial resources to spur improvement in best practices by agriculture and other important sectors," EPA said in the memo. "States need room to innovate and respond to local water quality needs, so a one-size-fits-all solution to nitrogen and phosphorus pollution is neither desirable nor necessary."

This approach was supported by EPA Administrator Lisa Jackson in an April 2011 visit to Iowa. During the visit, Jackson said the EPA is not targeting agriculture. She said EPA has decided not to apply its Chesapeake Bay model for reducing pollution to the Upper Mississippi River Basin. Instead, Jackson indicated the EPA might look at ways to quantify how voluntary conservation methods in the Mississippi River basin are helping reduce hypoxia in the Gulf of Mexico. Further, Jackson "ruled-out" the need to move directly to a regulatory approach when states are working to apply more conservation measures on the ground.

Petition for Federal Rules Denied

On July 29, 2011, the U.S. Environmental Protection Agency denied a petition from environmental organizations in 13 Mississippi River basin states that requested federal rulemaking to establish water quality standards and a basin-wide watershed plan to address nutrients.

The 2008 petition from the Minnesota Center for Environmental Advocacy asked the EPA to develop numeric water quality standards for nutrients (i.e., nitrogen, phosphorus, chlorophyll a and turbidity) for all navigable waters in all 50 states where such criteria do not already exist, or alternatively, promulgate such criteria for the Mississippi River basin and the northern Gulf of Mexico (some 31 states), but at a minimum promulgate numeric water quality standards for nutrients for the 10 states along the main stem of the Mississippi River and the northern Gulf of Mexico.

The petition also asked EPA establish total maximum daily loads (TMDLs) for nitrogen (N) and phosphorus (P) for the main stem and tributaries of the Mississippi River that do not meet the criteria EPA establishes for N or P, the portion of the contiguous zone within the Gulf of Mexico, and the portion of the ocean that is within the coverage of the Clean Water Act (CWA) in the Gulf of Mexico.

EPA denied the petition because it believes "...the most effective and sustainable way to address widespread nitrogen and phosphorus pollution in the Mississippi-Atchafalaya River Basin is to build on existing efforts, including providing technical assistance and collaborating with states to achieve near-term reductions, supporting states on development and implementation of numeric criteria, and working cooperatively with states and tribes to strengthen management programs."

EPA said another reason for its action on the petition was it wants to put its limited resources and efforts into the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force.

In March 2012, the Gulf Restoration Network – and others including the Iowa Environmental Council, the Environmental Law and Policy Center and the Sierra Club – filed a lawsuit that seeks to impose federal numeric nutrient criteria throughout the 31-state Mississippi River Basin and the Northern Gulf of Mexico.

In response, almost 30 agriculture organizations, including two Iowa groups, were granted intervention status in the case. These groups are supportive of addressing nutrient challenges without incurring the costly regulatory burden numeric nutrient criteria would bring. These groups are long-time supporters of conservation programs to improve water quality, but recognize more progress can be made through the Iowa nutrient reduction strategy.

Eleven states in the Mississippi River Basin, including Iowa, also have been granted intervention in the case as party to the lawsuit, in order to protect their state interests to implement water quality programs in ways that make sense for their respective states. The National Association of Clean Water Agencies, representing municipal interests, also has intervened in the case as a party.

The case is expected to be resolved on summary judgment motions. The federal district court for the Eastern District of Louisiana has set a schedule through the spring of 2013 for each side and the intervenors to make their written legal arguments. A decision in the case is expected sometime in 2013.

Roles and Responsibilities of the Iowa Water Resources Coordinating Council

In 2011, the Iowa Secretary of Agriculture was given the responsibility by the Iowa Legislature to chair the Iowa Water Resources Coordinating Council (WRCC), which was created in 2008 to coordinate state and federal efforts to address water quality and flooding issues. The WRCC is comprised of 19 state and federal agencies, and is responsible for engaging in regular coordination of water resource related functions, including protection strategies, planning, assessment, prioritization, review, concurrence, advocacy, and education. The purpose of the council is to preserve and protect Iowa's water resources, and to coordinate the management of those resources in a sustainable and fiscally responsible manner.

The Iowa Watershed Planning Advisory Council, a diverse group of private, non-governmental organizations and stakeholders, is to cooperate with the WRCC, make recommendations, and report annually to the Iowa Legislature on progress.

The Surface Water Protection and Flood Mitigation Act was signed into law in 2010. This law adds several provisions to Iowa Code Chapter 466B. The law:

1. Establishes a Watershed Planning Advisory Council to develop annual recommendations for improving water quality and mitigating floods.
2. Directs several state agencies to seek funding to plan and implement a watershed demonstration pilot.
3. Outlines the process for Watershed Management Authorities to be created using 28E agreements to reduce flood risk and improve water quality, monitor federal flood risk planning and activities, and educate residents of the watershed regarding flood risks and water quality.

Iowa's 100 Soil and Water Conservation Districts provide on-farm technical and financial assistance for implementation of conservation and environmental practices. They also provide local leadership for small watershed implementation projects.

Conservation and Water Quality Funding

Conservation funding is a top priority for agriculture. Funding for these programs is provided through several different sources. Below is a summary of conservation funds approved by the Iowa Legislature in the 2012 session.

Line Item	Fiscal Year 2013 Funds	Change From FY 2012
Soil Conservation Cost-Share	$6.65 million	Increase of $350,000
Cost-Share Funds to Close Ag Drainage Wells	$1.55 million	Increase of $1.55 million

Watershed Protection Fund	$900,000	No change
Conservation Reserve Enhancement Program (CREP)	$1 million	No change
Conservation Reserve Program	$1 million	No change
Conservation Funding Through Resource Enhancement and Protection Program (REAP)	$2.4 million	No change
Farm Management Demonstration Grants	$625,000	No change
Watershed Improvement Review Board (WIRB)	$1 million	Increase of $950,000

Federal Farm Bill Contributions

The USDA's 2010-15 strategic plan includes two goals that relate directly to Iowa's nutrient strategy: Ensure our national forests and private working lands are conserved, restored, and made more resilient to climate change, while enhancing our water resources; and Help America promote agricultural production and biotechnology exports as America works to increase food security. These two goals and the associated federal resources relate to Iowa's nutrient strategy and will have a major impact on its success.

Most of the direct federal funding for land treatment on working lands in Iowa to help protect water soil and water quality come through the federal farm bill and the Natural Resources Conservation Service (NRCS). The NRCS works to help USDA implement water quality goals through Iowa county soil and water conservation districts. A complete list of the agency's programs can be found at this link.

The federal Farm Service Agency (FSA) also has conservation programs. The FSA's Strategic Plan (2005-2011) can be found at this link. One of the key FSA programs for Iowa is the Conservation Reserve Program, a land retirement program. Total CRP enrollment in Iowa in FY 2008 was more than 1.8 million acres with total annual rental payments to landowners of $200.6 million (cumulative, all signups), compared with more than 1 million acres enrolled at the end of FY2010 and cumulative annual rental payments of more than $115 million.

Iowa farmers' requests for combined federal and state cost-share dollars to match with their own money to protect Iowa's soil and water exceed funds available annually in the range of $25-$100 million.

Iowa Conservation Progress

State and federal cost share programs have contributed significantly in helping Iowa farmers make progress in protecting Iowa's soil and water resources. Here are some examples:

- From 1982-2007, soil erosion in the United States has been reduced by 43 percent, according to the USDA's National Resources Inventory report. Iowa's erosion rate was estimated at 5 tons per acre per year in 2007, down 33 percent from 7.4 tons per acre in 1982.
- A survey of rural well water in Iowa by the University of Iowa showed a decline in the number of wells with detections of nitrates and herbicides, including atrazine. The survey of 473 rural wells in 2006-2008 showed a decline in numbers of wells with pesticides and nitrates detected, and very low concentrations present when detections occurred. It was a follow-up to a similar survey of rural wells in 1988 and 1989. Results include:
    1. No well had a pesticide exceeding or even close to drinking water standards.
    2. Nitrate detections were down 11 percent from 20 years ago.
- Seven major conservation practices used on Iowa farms are estimated to remove as much as 28 percent of the nitrate, 38 percent of the total nitrogen, and up to 58 percent of the phosphorus that

otherwise would be present, according to the Center for Agricultural and Rural Development's *Conservation Practices in Iowa: Historical Investments, Water Quality and Gaps*.

- Between 1980 and 2010, U.S. farmers nearly doubled corn production using slightly fewer fertilizer nutrients than in 1980. According to data from the USDA National Agricultural Statistics Service, farmers grew 6.64 billion bushels of corn using 3.9 pounds of nutrients (nitrogen, phosphorus and potassium) for each bushel in 1980. In 2010 they grew 12.45 billion bushels using 1.6 pounds of nutrients per bushel produced. In total, this represents an 87.5 percent increase in production with 4 percent fewer nutrients (The Fertilizer Institute).
- The Iowa Conservation Reserve Enhancement Program (CREP) restores strategically located and designed wetlands to intercept tile drainage water, with 72 wetlands currently restored or under development. These 72 wetlands will remove 76,700 tons of nitrogen over their lifetimes and protect 91,500 watershed acres. CREP wetlands also restore high quality wetland and prairie habitat. A new initiative that builds on the N-removal technology of CREP wetlands continues development – the Iowa Wetland Landscape Systems Initiative. It seeks to optimize drainage systems by redesigning them to reduce surface runoff, erosion, and delivery of agricultural chemicals to surface waters while also increasing agricultural productivity. These systems are integrated with N-removal wetlands at their outlets to complete the package of environmental benefits.
- Iowa farmers used conservation tillage on almost 15.2 million acres in 2007, up about 9 percent from 13.9 million in 2006 (Conservation Technology Information Center).
- Iowa farmers have more than 614,000 acres enrolled in the continuous, targeted Conservation Reserve Program, more than any other state (September 2012, Farm Service Agency). This number increases every month. It's also almost 12 percent of the U.S. continuous CRP signup total.
- Iowa farmers have restored more than 250,000 acres of wetlands, putting Iowa farmers 8th in the nation in terms of voluntarily restoring cropland to wetlands (Iowa NRCS, 2008).
- Since 2004, practices installed through voluntary watershed projects now collectively reduce sediment reaching Iowa's waters by 130,947 tons per year and phosphorus loading by 202,312 pounds per year. (February 2010, Iowa DNR).
- The Mississippi River Basin Healthy Watersheds Initiative (MRBI), sponsored by NRCS and its partners, will help producers in selected watersheds in the Mississippi River Basin voluntarily implement conservation practices that avoid, control, and trap nutrient runoff; improve wildlife habitat; and maintain agricultural productivity. These improvements will be accomplished through a conservation systems approach to manage and optimize nitrogen and phosphorous within fields to minimize runoff and reduce downstream nutrient loading. The Initiative will build on the past efforts of producers, NRCS, partners, and other state and federal agencies in the 12-State Initiative area to address nutrient loading in the Mississippi River Basin. More details here.
- More than $41 million in financial assistance in fiscal year 2010 to Iowa farmers through two of USDA's most popular 2008 Farm Bill financial assistance programs – the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP).
    1. EQIP is a voluntary conservation program that promotes agricultural production and environmental quality. Iowa NRCS obligated more than $20.8 million through 1,267 contracts covering 79,374 acres to farmers in all 99 counties through EQIP. This program offers financial and technical assistance to install or implement targeted structural, vegetative and management practices, including terraces, residue management (no-till), grassed waterways, waste storage facilities, prescribed grazing, and nutrient and pest management.
    2. CSP is a voluntary conservation program that encourages producers to address resource concerns in a comprehensive manner by undertaking additional conservation activities and improving, maintaining, and managing existing conservation activities. CSP pays participants for conservation performance – the higher the performance, the higher the payment. Iowa NRCS

obligated more than $20.2 million through 1,480 contracts covering 797,605 acres through CSP in fiscal year 2010.

In addition to State and Federal publicly cost-shared conservation programs, private sector organizations, non-governmental organizations, agribusinesses and Certified Crop Advisors (CCAs) are contributing to Iowa conservation progress as well. These entities serve important roles in environmental advocacy for advancing better management of natural resources and are making significant investments in the development and implementation of new technologies to address nutrient concerns related to agricultural production.

This strategy calls for expanded and enhanced public-sector roles to assist farmers and landowners in reducing nutrient transport to local and Gulf waters. It also calls for identifying new and enhanced ways for the private sector to continue to provide leadership, new technologies and services to reduce nutrient transport.

It calls for expanded agribusiness consulting and advisory services to farmers as a means to increase water quality and soil sustainability efforts. This strategy seeks ways to better harness the collective power of more than 1,200 CCAs working through retailers, and develop new ways for them to assist farmers and landowners in accountability and certification of achieving water quality and soil sustainability goals.

As conservation efforts are expanded and increased, opportunities need to be identified and actions supported to achieve the rapid adoption of nutrient reduction practices and actions that occur through market-driven solutions. Private and public sector support of market-driven initiatives needs to be aligned to maximize progress through market forces.

The level of future efforts needed to achieve the nutrient reductions called for in this strategy will extend beyond what can be achieved through publicly funded government-centric programs and actions alone, and will depend on private sector actions and solutions as well.

1.4 Nutrient Reduction Strategy

The Iowa Nutrient Reduction Strategy, including the science and technology assessments for both nonpoint and point sources, was developed over a two-year period, and is built on a scientific assessment of actions that will be effective and cost efficient to reduce loading of nitrogen and phosphorus to Iowa surface waters.

This strategy follows the framework provided by the EPA in its March 16, 2011 memo, Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions.

The Water Resources Coordinating Council shall annually evaluate whether the Iowa Nutrient Reduction Strategy needs to be reviewed and updated. This evaluation shall be included in the annual report.

1. Prioritization of Watersheds

To better coordinate various ongoing activities and promote new watershed initiatives, the Water Resources Coordinating Council (WRCC) will prioritize watersheds on a statewide basis for nitrogen and phosphorus loading reductions.

Based on previous Iowa reports, including the Iowa Watershed Task Force (2001), the Watershed Quality Planning Task Force (2006), and the Iowa Legislature's Senate File 2363 (2008), a phased adaptive management framework and cycle that prioritizes state watershed management activities will be created. Activities will follow a logical progression of targeting, planning, implementation and measurement, focused primarily on addressing Iowa's nutrient management challenges while optimizing public and private return on investment. The watershed management planning framework also will address other resource needs, such as sediment delivery and flooding. The WRCC will use a variety of data available and in development to prioritize Iowa eight-digit hydrologic unit code (HUC 8) watersheds relative to their contribution to nutrient loading.[2] This prioritization will be reviewed and adjusted every five years.

Coordination, oversight and implementation of this strategy including identification of high priority watersheds will continue through the Water Resources Coordinating Council, which consists of 19 state and federal agencies, in consultation with the nongovernmental organizational membership of the Watershed Planning Advisory Council.

On February 28, 2013 the WRCC selected nine HUC8 watersheds as the initial priority areas in Iowa. These watersheds will serve as areas to focus targeted conservation and water quality efforts through demonstration projects and implementation activities of this strategy. The list of priority watersheds is:

- Floyd
- East Nishnabotna
- West Nishnabotna
- North Raccoon
- Boone
- South Skunk
- Skunk
- Middle Cedar

[2] Hydrologic Unit Codes (HUCs) are part of a U.S. Geologic Survey watershed classification system based on size. Under this system, the United States is divided into major watersheds and subwatersheds. Each watershed is represented by a unique 8, 10 or 12-digit code commonly known as a HUC, with 8-digit HUCs the largest and 12-digit HUCs the smallest.

- Turkey

In addition, within each major watershed that has been identified and prioritized as accounting for the substantial portion of the load, the WRCC will identify existing targeted/priority sub-watersheds on a HUC 12 scale already being implemented, and potential future watersheds to implement targeted N and P load reduction activities.

2. Determine Watershed Goals

The WRCC will coordinate development of measures of success and relate these to watershed improvement based upon a set of mutually agreed-to indicators.

The WRCC will coordinate development of multipurpose indicators that provide Iowa watershed stakeholders information to establish baselines and report water nutrient reduction goal progress. These indicators should be able to be aggregated at a watershed and state scale. These can be integrated across major land resource areas and watersheds to evaluate cumulative impacts and trends. Examples are soil and water indicators, crop performance indicators, economic indicators and social/cultural indicators. These indicators will relate to HUC 8 watershed goals.

3. Ensure Effectiveness of Point Source Permits

Reduction in nitrogen and phosphorus discharges from wastewater treatment facilities will be accomplished via the National Pollutant Discharge Elimination System (NPDES) permit process.

Although continuously evolving, many nutrient removal technologies in wastewater treatment are already proven and well established. Thus, nutrient removal for Iowa's wastewater treatment facilities is technologically feasible. The primary mechanism IDNR will use in assessing the "reasonableness" of nutrient removal for individual facilities is the estimated costs for improvements and the ability of end users to afford those costs.

The goal is to have the major point source dischargers construct or modify treatment facilities or, in the case of some industries, modify plant operations to achieve significant reductions in the amounts of nitrogen and phosphorus discharged into Iowa's rivers and streams.

Iowa has 102 designated major municipal dischargers (Publicly-Owned Treatment Works – POTWs) defined as facilities designed to treat 1.0 million gallons of wastewater or more per day (Average Wet Weather – AWW – Design Flow). There are 28 industries in Iowa designated by the EPA as major industrial dischargers. Ten of these provide biological treatment of process wastewater. There are 18 other industries not designated as major that have existing biological treatment systems for process wastewater that can likely be modified to provide biological nutrient removal. See Section 3.3 for list of affect facilities.

Upon finalization of this strategy, NPDES permit renewals for municipal and industrial NPDES permits for major facilities, and minor industrial facilities with existing biological treatment systems will include a requirement for evaluating the feasibility for biological nutrient removal (BNR) and to develop a schedule for BNR installation. See Section 3.1 for the point source technology assessment and implementation details.

Nutrient reduction costs are generally affordable for most of Iowa's major municipal facilities based on the ratio of estimated project cost to median household income (MHI). These same facilities also have the largest design flows and, in general, the greatest point source nutrient contribution. If the communities served by major municipal facilities can afford a project cost/MHI ratio of 0.5%, the design flow treated by those facilities for which nutrient reduction is affordable is over 550 MGD, or roughly 86% of the total designed flow for all major municipal facilities.

The modifications to these wastewater treatment facilities have the potential to reduce the plants' nitrogen discharge by 66% and phosphorus discharge by 75%.

If successful, this strategy will reduce by at least 11,000 tons per year the amount of nitrogen and 2,170 tons per year the amount of phosphorus discharged annually by these facilities. These figures represent a 4% reduction in nitrogen and a 16% reduction in phosphorus in the estimated statewide nutrient loads to Iowa's streams and rivers.

This technology-based approach also provides benefits to point sources by 1) providing flexibility for implementation considering cost and permit structure, 2) a level of regulatory certainty, and 3) permit limitations that can be met by known wastewater treatment technologies.

Minor POTWs

There are many more minor POTWs in Iowa than "majors" but most of the wastewater is discharged by major POTWs both in terms of volume and the amounts of nutrients. Cost estimates developed for this strategy and elsewhere indicate nutrient removal would likely be unaffordable for smaller communities. Most minor POTWs within the state utilize lagoon or fixed film technologies, which are more difficult to retrofit for biological nutrient removal than the processes, employed by major POTWs. Also, many of the State's controlled discharge lagoon facilities likely already achieve significant nitrogen and phosphorus reductions but data to confirm this is not currently available. Due to the high cost in relation to the amount of nutrient reduction that could be achieved by minor POTWs, this strategy focuses only on major facilities. However, minor POTWs will be required to evaluate total nitrogen and phosphorus as "Pollutants of Concern" within Iowa's Antidegradation Implementation Procedure and implement the least degrading reasonable treatment alternative when designing new or expanded treatment facilities.

Animal Feeding Operations

All livestock farms (Animal Feeding Operations) are regulated by the IDNR for environmental performance. The amount of regulation varies by the type and size of farm.

Confinement Operations:
Farms 1,000 animal units or larger are required to have construction permits to ensure the construction of manure storage facilities will properly contain the manure produced and stored. Stormwater permits also are likely to be required before construction. Farms larger than 500 animal units are required to comply with an IDNR approved manure management plan (MMP), which is updated annually. These plans help ensure that manure is applied at an agronomic rate, thus minimizing the likelihood of over-application. These farms also must have certified applicators land-apply the manure from the farm.

All farms have water quality setback requirements. Setbacks are required from streams, lakes, designated wetlands, drinking water wells, ag drainage wells, and sinkholes. Livestock barns or manure storage structures cannot be located in a 100-year flood plain. These operations must retain all manure between periods of land application. Farms with dry or bedded manure also have regulations governing the stockpiling of dry manure.

Open Feedlot Operations:
Farms that are concentrated animal feeding operations under federal law and that discharge to waters of the United States must have NPDES permits. These farms must comply with nutrient management plans and are also required to obtain permits before constructing effluent basins or alternative technology systems. Set back requirements to water wells as well as limitations on the stockpiling of manure must be followed.

Nutrient Credit Trading

Water quality credit trading involves collaboration between two or more entities, commonly a point source and one or more nonpoint sources, to reduce the amounts of pollutants, in this case nitrogen and

phosphorus, entering a water body. It can provide a means to improve water quality, especially in cases where the technology does not exist or is not affordable to allow a point source discharger to comply with permit requirements or where the same or greater pollutant reductions can be achieved more quickly or at lower cost through controls on nonpoint sources. Trading can benefit not only the parties involved in a trade but everyone who lives, works and recreates within the watershed where pollutant reductions occur.

The motivations for nutrient credit trading can be numerous. For example, agricultural producers and drainage districts may choose to implement measures and practices for the primary purpose of improving drainage, yield or production, but which also reduce nutrient loadings. A municipality may choose to implement measures and practices for the primary purpose of controlling or mitigating the impacts of flooding, but which also reduce nutrient loadings. An industry may choose to implement measures and practices to offset the need to discharge greater amounts of nitrogen or phosphorus associated with the addition of a new production process or increased production level in lieu of constructing wastewater treatment facilities.

Given the potential for nutrient credit trading to further the goals of this strategy, the WRCC and its member organizations will cooperate with and assist non-governmental organizations interested in developing a voluntary nutrient credit trading program in Iowa. Where available and allowed by law, incentives may be provided to encourage and facilitate nutrient credit trading as a means to reduce nutrient loadings to rivers and streams.

4. Agricultural Areas

As Iowa is a national and global leader in the production of food and renewable fuels, a goal of this strategy is to make Iowa an equal national and global leader in addressing the environmental and conservation needs associated with food and renewable fuels production.

Accounting for potential load reduction from point sources, nonpoint sources need to achieve 41% load reduction in nitrogen and 29% load reduction in phosphorus to meet the overall 45% reduction goal. Iowa has nutrient-rich landscapes and significant progress towards these large nutrient reduction targets will take considerable time, effort and funding sources.

The approach to addressing the diverse and weather-driven nutrient transport from Iowa nonpoint sources involving Iowa's 90,000 farmers must be different from the approach to address the controlled and relatively constant nutrient discharge from Iowa's 130 major cities and industries.

This strategy for agricultural areas includes multiple action items within several categories. Operational plans will be developed and work teams formed to carry the action items forward. Where appropriate, the science assessment and outcomes of the science assessment will be integrated into the operational plans.

Setting Priorities

- Focus Conservation Programs - Coordinate the focus of conservation programs with the goal of reducing nutrient transport to local and Gulf waters. Develop a conservation program infrastructure that fully supports adoption of needed practices that target the reduction of nutrients to water. Increase the delivery of conservation and nonpoint source programs in a straightforward, flexible manner.
- Combination of In-Field and Off-Field Practices - Nutrient transport from cropped lands cannot be solved by in-field practices alone, but instead must include a combined and balanced approach of utilizing off-field nutrient and sediment trapping and removal practices with in-field erosion and nutrient reduction practices. Where possible, watershed planning needs to achieve balanced implementation of off-field and in-field practices, to optimize the resulting reductions of nutrients transported to local and Gulf waters.

- Small Watershed Pilot Projects - In partnership with federal and state agricultural and natural resource partners, non-governmental organizations, private sector partners, landowners, and other stakeholders, local stakeholders will develop and implement HUC 12 watershed-scale plans that target the most effective practices in the HUC 8 watersheds prioritized by the WRCC as pilot watershed projects for implementation of this strategy.
- Nutrient Trading and Innovative Approaches - These groups will look for opportunities to include existing state and federal targeted stewardship incentive programs with nutrient trading and innovative new approaches to accelerate adoption of agricultural conservation practices.

Research and Technology

- New Technologies and Creative Solutions - New technology and creative solutions for nutrient reductions are needed to deliver and optimize implementation at full landscape scale. Retain and enhance the policy framework that facilitates and encourages development and rapid adoption of new technologies for reducing nutrient transport to local and Gulf waters.
- Private and Public Funding for Science and Technology - Enhanced and consistent funding is needed to advance the science and develop new technologies for reducing nutrient transport from agricultural lands to local and Gulf waters. Entrepreneurial opportunity within the private sector needs to be enhanced for development and marketing new technologies that reduce nutrient transport to water. Sustained and consistent public funding of public research activities needs to be enhanced significantly.
- Gulf Hypoxia Zone Research - There are many unanswered science issues concerning the hypoxic zone in the Gulf of Mexico, which will become increasingly important as Iowa moves forward addressing its role in Gulf hypoxia. Support of this type of research is critical to this strategy.

Strengthen Outreach, Education, Collaboration

- New, Enhanced Private and Public Sector Roles - This strategy calls for an expanded and enhanced public-sector role to assist farmers and landowners in reducing nutrient transport to local and Gulf waters. It also calls for identifying new and enhanced ways for the private sector to provide leadership, new technologies and services to reduce nutrient transport.
- Expanded Agribusiness Consulting and Advisory Services to Farmers - Agribusiness retailers and certified crop advisors (CCAs) are a largely untapped and existing resource. This strategy seeks to harness the collective power of more than 1,200 CCAs working through retailers. Enhanced and expanded consulting and advisory services to farmers and landowners through ag product retailers and CCAs are needed. Develop new roles for CCAs to assist farmers and landowners in accountability and certification of achieving water quality and soil sustainability goals.
- Broaden Awareness and Provide Relevant Information - Building broader awareness of the need to address nutrient loss from agricultural lands needs to continue and expand. Current and relevant information to farmers and landowners continues to be needed concerning the available technologies, best management practices and actions that can be taken to reduce nutrient transport. Associated costs and risks of the technologies and practices also is a critical need for optimized decision-making and to achieve sustained adoption.
- Achieve Market-Driven Solutions - Opportunities need to be identified and actions supported to achieve the rapid adoption of nutrient reduction practices and actions that occur through market-driven solutions. Private and public sector support of market-driven initiatives needs to be aligned to maximize progress through market forces.
- Collaborate and Share Information with Other States - This strategy involves increased collaboration among the states within the Mississippi River Basin and networking/sharing information on the efforts and successes within the states for achieving reductions of nutrients to water resources. Continue and expand previous efforts such as the Iowa-Mississippi Farmer-to-

Farmer Exchange, which focused on sharing technologies within the two states on reducing nutrients to local and Gulf waters.

Increased Public Awareness and Recognition

- Farmer Recognition Program - To increase public recognition of farmers and landowners who are leaders in achieving reduction of nutrients leaving their farms and entering Iowa's and Gulf waters, this strategy includes the development of a watershed or farmer recognition program. This program could be similar to the Rathbun Land and Water Alliance's Lake Protectors Program, which encourages and recognizes actions by individuals to protect Rathbun Lake. The program will be delivered in prioritized watersheds. This new program will build on the Iowa Farm Environmental Leader Award program that began as an initiative of Iowa Governor Terry Branstad and Iowa Secretary of Agriculture Bill Northey. Beginning in 2012, 67 farmers were recognized for their environmental and conservation actions. Additional awards will be presented annually at the Iowa State Fair.
- Statewide Education and Marketing Campaign - The Iowa Watershed Quality Planning Task Force recommended in 2007 a statewide marketing or public educational campaign be undertaken by public agencies and other organizations to rekindle the conservation ethic in all Iowans. The WRCC will consider how to prioritize or reallocate existing funds to implement this recommendation.

Funding

- Effective Use of Funding Resources - Initially, Iowa will rely on existing funding sources, or as applicable, reallocation of existing funding sources, to fund implementation of this strategy. The WRCC will consider recommendations to the executive and legislative branches on the most effective use of these limited resources, including maximizing benefits per amount expended. It is recognized in this strategy and as a matter of state policy that these funds are often limited and over-subscribed by citizens who desire to make further progress in addressing their soil and water resource needs. The pace of the strategy's implementation will be subject to available financial and human resources. A variety of watershed grants are available to local interested groups. Individual famers, industries and communities may apply for a variety of state and federal cost-share programs.

5. Storm Water, Septic Systems, Minor POTWs, and Source Water Protection

Since nutrient loading in Iowa from storm water, septic systems, and minor POTWs sources is minor, emphasis will be on monitoring, inspections, education/outreach and upgrades as needed.

Stormwater

No specific nutrient reductions have been targeted for municipal or industrial storm water discharges. Due to the intermittent nature of such discharges and their relatively small contribution to the statewide nutrient load this document does not address specific storm water reduction targets. It is anticipated that implementation of municipal separate storm sewer system (MS4) permits, industrial storm water permits will result in some nutrient reduction. While statewide the contribution is small it may be more significant at smaller watershed scales and should factor in to any watershed planning effort.

An emphasis will continue to be placed on encouraging low impact development and utilization of green infrastructure for new growth and re-development projects throughout Iowa. The focus will continue to be on infiltration of the water quality volume – or the runoff from up to 1.25 inches of rainfall. While there is a trend toward more large storms, it is likely that the large majority of annual precipitation will continue to occur as frequent, small rainfall events. (Historically, about 80% of rainfall has been 0.5 inch/24 hour events or smaller and 90% of rainfall events have been less than 1 inch/24 hours).

By managing the water quality volume, reductions of 80 to 85% of annual runoff volumes could be achieved. By focusing on reducing runoff volumes we could significantly reduce loading of nutrients and other pollutants common in storm water flows (sediment, hydrocarbons, heavy metals, bacteria, floatable litter, thermal pollution, etc). Flashiness of flows in urban streams would also be significantly reduced,

which would reduce stream corridor erosion and address the largest contributor to sediment loading. Efforts to increase education and outreach opportunities for urban storm water issues will be explored including urban lawn care practices and golf course management.

Further targeting of activities designed to reduce storm water nutrient loads will come through development and implementation of stream and lake TMDLs.

Private Sewage Disposal Systems

Iowa currently has more than 300,000 private sewage disposal systems and their associated impact on nutrient loadings in Iowa is considered marginal statewide. Therefore, no specific nutrient reductions have been targeted for private sewage disposal systems. Evaluation of nutrient contributions from private sewage disposal systems is recommended in targeted watersheds as the impacts may vary from watershed to watershed. Much of Iowa's efforts with private sewage disposal systems consist of upgrading failing systems through routine inspections by counties and through Iowa's "time of transfer" septic system inspection law that took effect in 2009. This law requires that every home/building served by a septic system have the system inspected prior to sale or deed transfer. The law is intended to eliminate sub-standard or polluting septic systems. Since taking effect, there have been approximately 18,000 time of transfer inspections and 6,000 new septic systems installed as a result of the inspections. The state offers the On-Site Wastewater Assistance Program (OSWAP), a unique low-cost financing option for septic system replacement. The OSWAP program has administered 1,464 loans totaling $11.5 million since 2002. Other efforts include working with Iowa's 500+ unsewered communities to ensure basic wastewater treatment is occurring.

Source water protection efforts in Iowa utilize many of the same practices outlined in the strategy for reducing nutrient impacts on groundwater. These efforts also provide nutrient reductions to surface waters in Iowa.

Source Water Protection

Most Iowans rely on groundwater for potable water uses including drinking water, bathing and other household uses. In addition, many Iowa industries use groundwater in their manufacturing and processing operations. Protecting groundwater from non-point source and point source contamination is important to the health and well-being of all Iowans as well as the states' economy.

Nitrate is the most common contaminant in Iowa's groundwater. It enters groundwater primarily through the application of nitrogen-based fertilizers and manure on row crop acres, the treatment and disposal of sewage from septic systems and fertilizer application in urban settings. Once nitrate enters the groundwater it is expensive to remove and for some communities treatment of source water for drinking water becomes an economic hardship. . Nitrate is not changed or destroyed by normal drinking water treatment processes but is typically discharged into a river or stream where it contributes to the overall statewide nutrient load.

Iowa's Source Water Protection Program seeks to educate the public, and especially local officials, on the benefits of preventing contamination of groundwater, especially groundwater that is or may be used as a drinking water source. The framework described in this strategy can provide a major impetus for implementing practices that will aid in reducing current nitrate contamination while protecting susceptible water supplies from future nitrate contamination.

Funding

Publically funded incentives for point sources such as community wastewater facilities and stormwater control can be found at this link. Iowa's Clean Water State Revolving Fund (CWSRF) offers loan funding

to assist in financing design for these facilities' improvements. The CWSRF program is jointly administered by IDNR and the Iowa Finance Authority. IDNR oversees the specific aspects of the CWSRF program.

6. Accountability and Verification Measures

The IDNR will convene a technical work group beginning in 2013 to define the process for providing a regular nutrient load estimate (i.e., nutrient budget) based on the ambient water quality data network. This will include specifying the most appropriate mathematical model, the acceptability of the data, and a process for making future adjustments based on the latest information and advancements in science and technology.

Regarding point sources, the IDNR will convene a technical workgroup to define the process for providing a regular nutrient load estimate for point sources. The IDNR will track progress for implementing the point source nutrient reduction strategy using several measures:

1) Number of permits issued that require nutrient reduction feasibility studies
2) Number of nutrient reduction feasibility studies submitted
3) Number of permits amended with nutrient removal/reduction construction schedules
4) Number of nutrient removal/reduction facilities in place/in design/under construction
5) Number of facilities monitoring nutrient in their effluent
6) Total nitrogen and phosphorus loads discharged from point sources
7) Results from comprehensive annual ambient stream monitoring and analysis utilizing existing permanent monitoring locations and focused study areas

Regarding nonpoint sources, develop new and expanded frameworks to track progress, beyond the traditional ambient water quality monitoring networks. Encourage expansion of geographic coverage and frequency of statistical surveys that characterize on-farm actions to adopt nutrient-reduction practices. Seek to develop new frameworks through ag retailers and CCAs to characterize farmer and landowner adoption of new technologies and practices that reduce nutrient transport to water from nonpoint sources.

The WRCC will collaborate with Iowa State University CALS nutrient science assessment team to support science and technical assessments of success measurement for the strategy.

The WRCC member agencies will apply their data, programs and resources to help implement this strategy within targeted/priority sub-watersheds to estimate reductions within a watershed in a statistically valid manner.

Establishment and refinement of a public-private reporting system that documents nutrient management and conservation system application within watersheds will be coordinated through the WRCC.

This system has these elements:

1. Private sector tracking system of conservation practices, structures, fertilizer sales and other farm inputs and outputs by HUC 12s. Privacy rights of individual farms shall be maintained.
2. Conduct a regular, periodic Iowa Natural Resource Inventory to establish HUC 12 baselines, monitor progress and verify effectiveness.
3. Enhance the state's water monitoring to support watershed implementation strategies and to be useful in verifying performance.
4. Use appropriate modeling to project expected performance of implementation strategies.

7. Public Reporting

WRCC annual reports will document calculated or modeled load reductions from quantified best management practices and will document point source implementation efforts.

The WRCC will use survey data, a new Iowa Natural Resource Inventory of management practices, and physical landscape structures aggregated at the HUC 8 scale. The following shall be incorporated into the reports:

a. Watershed management plans shall include strategies to assess/demonstrate progress in implementing and maintaining management activities and achieving load reductions goals. These strategies shall include baselines of existing N and P loads and current BMPs, including in-field and edge-of-field technologies, and shall be implemented in each targeted/priority HUC 12 sub-watershed. An evaluation of BMP effectiveness will be used in making future plan adjustments.
b. Progress in reductions of TN and TP. Narrative updates on efforts detailed in the strategy for both point source and nonpoint source elements.
c. The WRCC shall annually report publically on the state's website with request for comments and feedback for an adaptive management approach to improve implementation, strengthen collaborative local, county, state, and federal partnerships, and identify additional opportunities for accelerating cost effective N and P load reductions.
d. The WRCC shall annually evaluate whether the Iowa Nutrient Reduction Strategy needs to be reviewed and updated. This evaluation shall be included in the annual report.

8. Nutrient Criteria Development

This strategy emphasizes implementation of technology-based nutrient reductions in the near-term, with continued assessment and development of suitable nutrient criteria as a long-term goal.

The IDNR is the designated agency with responsibility to establish and periodically update Iowa's water quality standards. Under the Federal Clean Water Act (CWA), the U.S. EPA also has the authority to promulgate water quality standards for Iowa when it is necessary. In the last five years IDNR has made significant progress evaluating the relationship between nutrients and water quality for lakes and streams.

Lakes:
New research is being conducted by Iowa State University that will assist in defining protection of lake aquatic communities. The focus of this work is development of biological assemblage indicators (e.g., algae, invertebrates, and fish) that quantify the biological health of Iowa's lake ecosystems. Lake biological assemblage indicators will be calibrated against several measures of lake condition, including nutrient status, and will provide an objective basis for determining whether or not a lake is supporting aquatic life use goals under the Clean Water Act. After receiving the final report from ISU, the IDNR will review the information and work products as the need for nutrient standards is evaluated.

Rivers and Streams:
In 2010, the IDNR convened a technical advisory committee (TAC) to assist with approaches to nutrient criteria for the protection of stream aquatic life. The TAC is examining many technical issues concerning nutrients and their effects in streams and will provide recommendations that represent the best available scientific information. This will include an analysis of the available data, science, and need for further research.

Nutrient criteria approaches continue to evolve as many states explore the best alternatives for establishing appropriate nutrient standards. For the reasons described in Section 1.2, IDNR is evaluating other methods besides the statistical data distribution alternative initially presented by EPA. These include analysis of stream nutrient stressor-response relationships for the determination of site-specific nutrient criteria. This approach would involve the application of nutrient response indicator criteria (e.g., dissolved oxygen, chlorophyll A) as a means to establish appropriate site-specific nutrient targets, which together would form the basis for identifying nutrient-related impairments of beneficial water uses.

Section 3.4 shows a conceptual flow chart outlining potential steps for determining site-specific nutrient status and management actions within a watershed context. Similar to how the IDNR currently addresses nutrient-related impairments of lakes and streams, the model allows point source nutrient limits to be established as part of an adaptive watershed management plan that is solution-driven and provides flexibility in setting load reduction targets for point and nonpoint sources. Ambient water monitoring and effluent monitoring are key components of the assessment framework, allowing tracking of point source nutrient load reductions. Best management practice data collection and modeling are key components of nonpoint source nutrient load reduction programs. Both elements support the evaluation and application of site-specific nutrient targets.

The site-specific nutrient criteria approach is one of several alternatives that will be further evaluated as part of the DNR's triennial water quality standards review process.

1.5 References

CH2MHILL. “Final Report - Statewide Nutrient Removal Cost Impact Study” and Technical Memoranda. Prepared for Utah Division of Water Quality, October 2010.

Foess, G. W., Steinbrecher, P., Williams, K., and Garrett, G.S. 1998. Cost and Performance Evaluation of BNR Processes. Florida Water Resources Journal, December, 11-13.

Libra, R.D., Wolter, C.F., and Langel, R.J. 2004. Nitrogen and Phosphorus Budgets for Iowa and Iowa Watersheds. Iowa Geological Survey Technical Information Series 47, 43 p.

Smith, R.A., Alexander, R.B., & Schwarz, G.E. 2003. Natural background concentrations of nutrients in streams and rivers of the conterminous United States. *Environmental Science & Technology, 37*, 3039 – 3047.

Stoner, Nancy K. 2011. Working in partnership with states to address phosphorus and nitrogen pollution through use of a framework for state nutrient reductions. Memorandum, March 16, 2011. Office of Water, United States Environmental Protection Agency. 6 p.

Gulf Hypoxia Action Plan 2008. Mississippi River Gulf of Mexico Watershed Nutrient Task Force. 61p.

U.S. EPA. 1998. National strategy for the development of regional nutrient criteria. EPA 822-R-98-002. Office of Water, U.S. Environmental Protection Agency. 45 p.

U.S. EPA. 2000. Nutrient criteria technical guidance manual: lakes and reservoirs. First Edition. United States Environmental Protection Agency, Office of Water. EPA-822-B00-001.