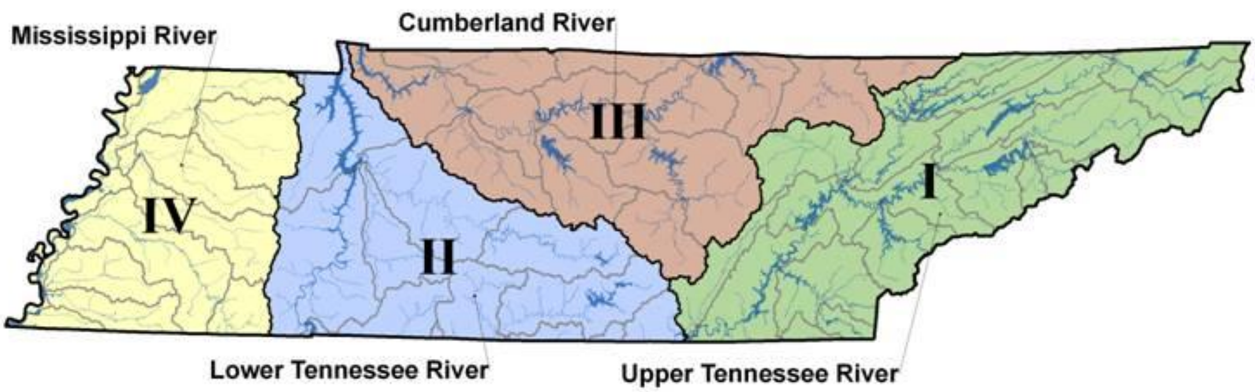
Tennessee Nutrient Reduction Framework



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Division of Water Resources
Tennessee Department of Environment and Conservation

TN Department of Environment & Conservation

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Introduction

Nutrients are naturally occurring and essential components of healthy aquatic systems. Excessive amounts of nutrients, however, can impact water quality. "The enrichment of a waterbody with nutrients, called eutrophication, can result in dense, rapidly multiplying growths, or blooms, of algal species and other nuisance aquatic plants. These can clog water intake pipes and filters and interfere with recreational activities, such as fishing, swimming, and boating. Subsequent decay of algal blooms can overload water bodies with organic debris and result in foul odors, bad taste, and reduced dissolved oxygen levels, which are harmful to other aquatic life" (USGS, 1999). According to the 2012 303(d) list (TDEC, 2014), approximately 3,375 river miles of stream and 15,692 acres of lake in Tennessee are impaired due to nutrients. Excessive nutrient loading also has effects outside of Tennessee: USGS estimates that 5.5% of the total nitrogen flux and 5.3% of the total phosphorus flux delivered to the Northern Gulf of Mexico is contributed by sources in Tennessee (Alexander et al, 2008). Increases in nutrient loading mirror growth in population and corresponding increases in agricultural activities and urban development.

This document describes the development of the Tennessee Nutrient Reduction Framework, the rationale and the methodology used to accomplish long-term nutrient reduction in Tennessee waters. The strategy used for point source nutrient reduction is discussed in Appendix A. Agricultural nonpoint source nutrient reduction strategy is described in Appendix B.

Tennessee Nutrient Reduction Framework

Need

Tennessee has adopted several tools to assess the status of nutrient impairments and designated uses. Such tools include the use of the nutrient translator for wadeable streams and the narrative nutrient criterion for the protection and maintenance of Recreational and Fish and Aquatic Life Uses. The Division recognizes that each waterbody has individual needs as well as tolerance threshold on nutrients. Not enough and too much nutrients are both harmful to the health of the aquatic ecosystem and the intended use of the waterbody. Unlike the dose-response effects expected from toxics, nutrient effects are better characterized as indirect and waterbody-specific. Instead of concentration, annual (or seasonal) load is deemed more appropriate to address nutrient reduction. A detailed discussion of setting water quality-based effluent limits for nutrients can be found in Brown and Caldwell (2014).

To reduce nutrient enrichment in Tennessee waters, the Division of Water Resources (DWR) has developed Tennessee's Nutrient Reduction Framework (NRF). This framework proposes a methodology for rational and achievable short-term and long-term nutrient load reduction in impaired watersheds. It requires no new regulations for either point or nonpoint sources.

Goals

The Tennessee Nutrient Reduction Framework was developed not only to satisfy the needs of Tennessee's streams and rivers, but also to benefit downstream water users as well as to assist in reaching the federal Gulf of Mexico hypoxia nutrient reduction goals. It reflects the goals of EPA's March 16, 2011, Memorandum: *Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions* (Stoner, N., USEPA, 2011). The document states: "Of most importance is prioritizing watersheds on a state-wide basis, setting load-reduction goals for these watersheds based on available water quality information, and then reducing loadings through a combination of strengthened permits for point-sources and reduction measures for nonpoint sources and other point sources of stormwater not designated for regulation." To summarize, through implementation of the framework, the Division will:

- Prioritize watersheds
- Set watershed nutrient load reduction goals
- Ensure effectiveness of point source permits
- Develop implementable watershed plans that maximize the effectiveness of agricultural BMPs
- Encourage nutrient reductions from non-MS4 developed communities
- Establish watershed-based monitoring programs to evaluate effectiveness
- Documentation and reporting of implementation activities

The last goal of the EPA memorandum involves numeric nutrient criteria, which the Division addresses in a separate document, the Tennessee's Numeric Nutrient Criteria Development Plan, which is currently being updated.

Overview

In the framework, the state is divided into four major hydrologic river basins (Figure 1):

I. Upper Tennessee River Basin (including Holston River, North Fork Holston River, South Fork Holston River, Watauga River, Upper French Broad River, Lower French Broad River, Pigeon River, Nolichucky River, Fort Loudoun Lake/Watts Bar Lake, Little Tennessee River, Upper Clinch River, Lower Clinch River, Powell River, Emory River, Hiwassee River, Ocoee River, Conasauga River, Sequatchie River, Tennessee River)

II. Lower Tennessee River Basin (including Guntersville Lake, Wheeler Lake, Upper Elk River, Lower Elk River, Pickwick Lake, TN Western Valley (Beech River), Upper Duck River, Lower Duck River, Buffalo River, TN Western Valley (Kentucky Lake), East Fork Clarks River)

III. Cumberland River Basin (including Barren River, Clear Fork of the Cumberland River, Upper Cumberland River, South Fork Cumberland River, Obey River, Cordell Hull Lake, Collins River, Caney Fork River, Old Hickory Lake, Cheatham Lake, Stones River, Harpeth River, Lake Barkley, Red River)

IV. Mississippi River Basin (including Mississippi River, North Fork Obion River, South Fork Obion River, North Fork Forked Deer River, South Fork Forked Deer River, Middle Fork Obion River, Upper Hatchie River, Lower Hatchie River, Loosahatchie River, Wolf River, Nonconnah Creek)

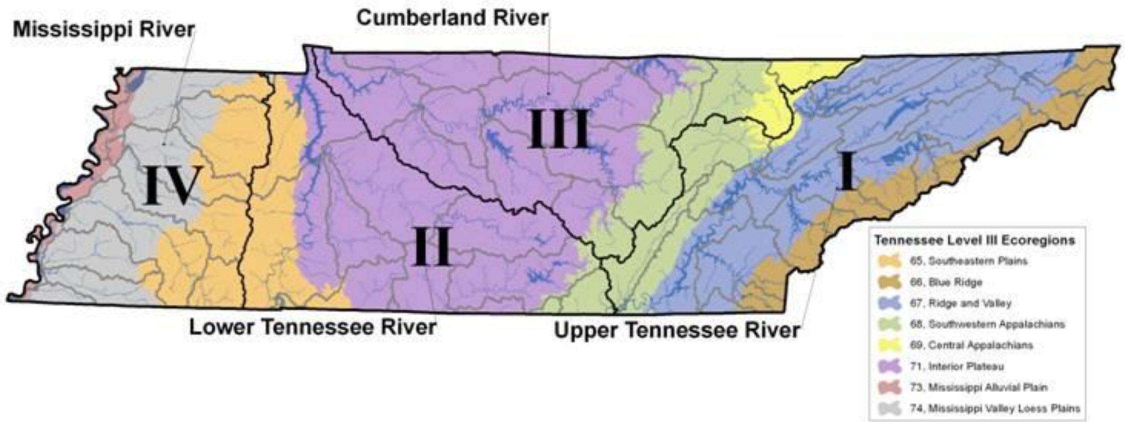

Figure 1. Major River Basins in Tennessee

Land use distribution across Tennessee, which is derived from the 2001 USGS national land cover database, or NLCD (Homer, et al., 2004), is shown in Figure 2. In many cases, land use can be directly related to nonpoint source nutrient loading.

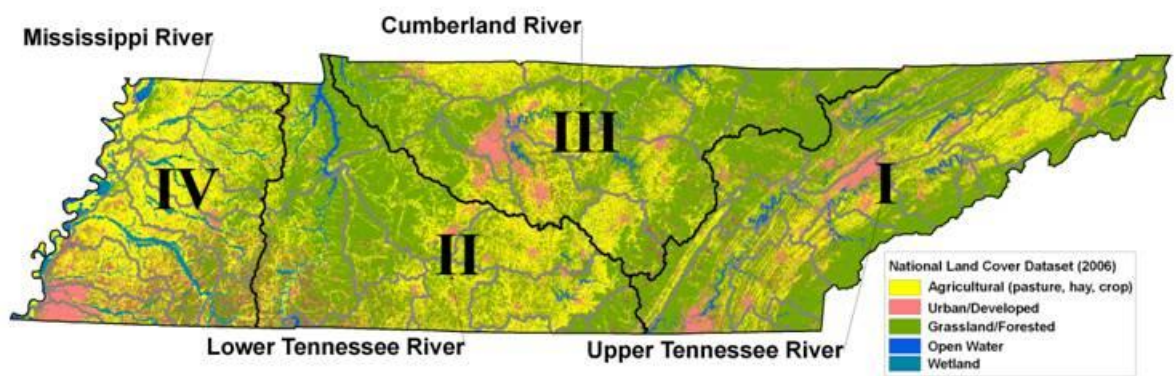

Figure 2. Land Use in Tennessee's River Basins (Agricultural land use is in yellow)

Waterbodies (in red) assessed impaired by nutrients in Tennessee 2012 water quality assessment are presented in Figure 3.

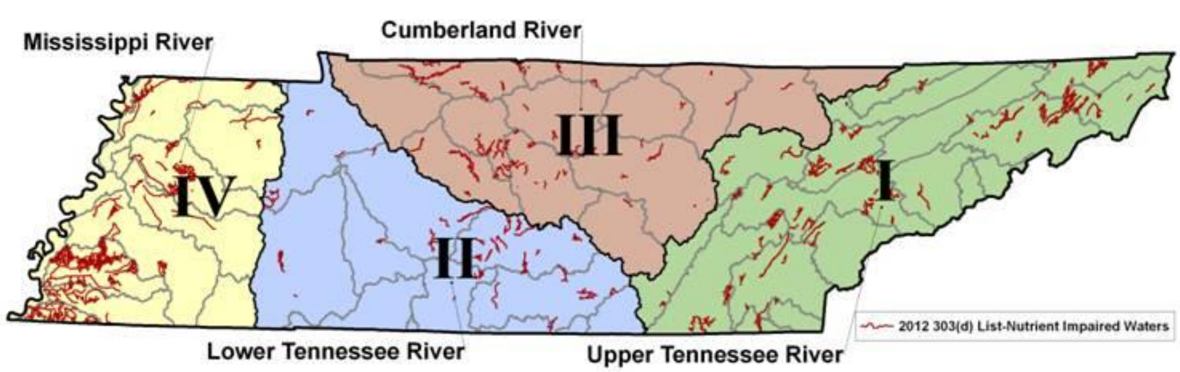

Figure 3. Waterbodies Impaired by Nutrients in Tennessee

The Tennessee Nutrient Reduction Framework (NRF) encompasses nutrient reduction strategies for both point and nonpoint sources. The NRF methodology for point source uses the concept of an enrichment factor (EF) (Becker, et. al, 2009). It is aimed at realizing nutrient load reduction targets for impaired USGS Hydrological Unit Code–10 (HUC-10) watersheds (Seaber, et al., 1987) within the state. An adaptive management process is employed to ensure that the designated uses are protected and accordingly, the state's narrative nutrient criterion is achieved. The EPA approved narrative nutrient criterion for fish and aquatic life (Subparagraph 1200-04-03-.03(3)(k)) states that: "The waters shall not contain nutrients in concentrations that stimulate aquatic plant and/or algae growth to the extent that aquatic habitat is substantially reduced and/or the biological integrity fails to meet regional goals. Additionally, the quality of downstream waters shall not be detrimentally affected." After the NRF is implemented for both point and nonpoint sources, it is expected that nutrient loads in the watershed will be similar to a watershed in the same ecoregion with a healthy and productive ecosystem for fish and aquatic life. This Framework sets realistic management goals for watersheds to protect designated uses and achieve the narrative nutrient criterion within the context of present state of science and available resources. The Division recognizes that the goal of protecting designated uses and accordingly, achieving the narrative nutrient criterion, may require a large nutrient load reduction that is not realistically achievable in one short-term planning horizon. Therefore, the NRF is intended to be a dynamic process that will evolve continuously to reflect new developments and advances in nutrient reduction efforts.

Specifically, within each major river basin, prioritization and action plans will be developed for each HUC-10 watershed. These action plans will include the drafting of nitrogen and/or phosphorus load reduction targets for wastewater treatment plants and coordination with storm water discharges. Agricultural communities and other relevant stakeholders will be engaged to determine potential nutrient trading opportunities. Concurrently, in the Mississippi River Basin, the Agricultural Nonpoint Source Nutrient Reduction Strategy detailed in the Appendix B will be implemented first, with other basins to follow.

Prioritization

The USGS developed a modeling tool called SPARROW (SPAtially Referenced Regression On Watershed attributes) to estimate the nutrient loading in each HUC 10 watershed from all sources that flow off the land into the river and its tributaries. The NRF implementation focuses first on the Upper and Lower Tennessee River basins using the following concepts.

The NRF prioritizes the HUC-10 watersheds with 303(d) listed segments. Where these watersheds are primarily enriched by point sources (as determined by the SPARROW modeling), Tennessee will apply nutrient load reduction through the point source permitting program as described below. For those HUC-10 watersheds with 303(d) listed segments that are primarily enriched by nonpoint sources, the Division refers the listed segment to the Tennessee Department of Agriculture (TDA), which focuses on nonpoint source load reductions.

The published SPARROW modeling tool for watersheds in the Cumberland River Basin does not account for the contribution to background stream phosphorus loads from the phosphate-rich soil and parent rock in the this area. When the SPARROW modeling for the Cumberland River Basin has been revised to better represent background loads, the NRF will apply the approach discussed above in the Cumberland River Basin HUC-10 watersheds. Currently, the Division is actively pursuing funding for completion of SPARROW modeling in the Cumberland River Basin.

As previously stated, the NRF is also focusing on the Mississippi River Basin where the primary land uses are agricultural, and voluntary incentive-based approaches to nutrient pollution reductions will be most effective. TDEC and TDA will collaborate to develop watershed nutrient reduction plans for 10 watersheds over the next 5 years. TDEC and TDA are studying several different methods to prioritize watersheds for nutrient reduction plan development. A description of the prioritization process using EPA's Recovery Potential Screening Tool can be found in Appendix B.

General Description of Methodology

A full description of the development of the NRF methodology, rationale, and analytical methods is detailed in the Appendix A. A summary of the methodology is given below:

1. For watersheds in the Upper and Lower Tennessee River Basins (I & II river basins), the results of the USGS-developed SPARROW models for the South Atlantic–Gulf and Tennessee (SAGT) region will be used to evaluate existing nutrient loading and relative source contributions. For watersheds in the Cumberland River and Mississippi River Basins (III and IV river basins), nutrient loadings from revised SPARROW models will be applied when they become available.

   SPARROW is a "modeling tool for the regional interpretation of water-quality monitoring data. The model relates in-stream water-quality measurements to spatially referenced characteristics of watersheds, including constituent sources and factors influencing terrestrial and aquatic transport. SPARROW empirically estimates the origin and fate of contaminants in river networks and quantifies uncertainties in model predictions" (Schwarz, et al, 2006). SPARROW results are referenced to Reach File 1 (Rf1) catchments and are expressed as average annual loads. There are separate regional models for TN and TP.

   The SPARROW model is described in detail in *SPARROW Surface Water Quality Model: Theory, Application and User Documentation* (Schwarz, et al, 2006). The SAGT nitrogen model is detailed in *Spatial analysis of instream nitrogen loads and factors controlling nitrogen delivery to streams in the Southeastern United States using spatially referenced regression on watershed attributes (SPARROW) and regional classification frameworks* (Hoos and McMahon, 2009). The companion phosphorus model is described in *A Regional Modeling Framework of Phosphorus Sources and Transport in Streams of the Southeastern United States* (Garcia, et al, 2011).

2. Both total nitrogen (TN) and total phosphorus (TP) will be evaluated for reductions. Although phosphorus is generally considered to be the limiting nutrient in freshwater systems (Correll, 1999; Schindler et al, 2008), there are areas (River Basins II and III) in Tennessee that are rich in geologic phosphorus where nitrogen may become the limiting nutrient. In cases where appropriate, reductions of an identified limiting nutrient may precede a reduction in the non-limiting nutrient by one to two NPDES permit cycles (5-10 years).

3. Nutrient loading analysis will be conducted on HUC-10 watersheds in the Tennessee River Basin. (Generally, a HUC-10 unit is comprised of several Rf1 catchments. The outer boundary of the group of catchments aligns with a HUC-10 boundary). Because a HUC-10 is typically comprised of several model units, analysis at the HUC-10 scale

means that model results are aggregated to a larger scale, which improves confidence in model results. The ultimate goal is to implement reductions in nutrient loading in all HUC-10 watersheds. Priority is given to watersheds containing waterbody segments assessed as impaired due to nutrients. In cases where more than one wastewater treatment facility (WWTP) is located within a HUC-10 watershed, facility discharges are aggregated and required effluent limits are applied to all WWTPs in the watershed.

4. Appropriate loading allocated to WWTPs will be established through evaluation of the TN & TP load contributions of these facilities to surface waters, viewed in the context of the overall influence of anthropogenic activity in the watershed. This will be accomplished using a decision-making matrix based on calculated WWTP percent load contribution and enrichment factor (EF) to determine the impact level and associated nutrient effluent limits for each of the WWTPs (a separate matrix is used for each nutrient). The EF is calculated by comparing the existing load in each watershed to the background load (Soil-Parent Rock (S-PR) for TP; atmospheric deposition for TN). Additional factors, such as a facility's existing effluent nutrient concentration, proximity to downstream nutrient impaired waters, and proximity to downstream reservoirs (for phosphorus), will be considered along with operation and maintenance to determine whether the analysis results from the matrix should be adjusted based on best professional judgment.

5. Expected load reductions are specified for precipitation-induced sources based on implementation of appropriate best management practices (BMPs). A 40% reduction in agricultural source loading and a 50% reduction for urban land cover sources are considered to be aggressive, but achievable reductions (Rao, et. al., 2009). BMP reductions are not assigned to the soil-parent rock for TP or atmospheric deposition for TN source categories because these are considered to represent natural background conditions. In the case of TN, that includes conditions that are not necessarily natural background but cannot be managed through watershed-specific actions.

6. For each HUC-10 watershed, a spreadsheet is prepared to calculate a post-reduction annual nutrient load for the watershed after incorporating expected load reductions of point and nonpoint sources. This post-reduction annual nutrient load is referred to as the Protective Annual Watershed Load (PAWL) in the spreadsheet (see Table A11). The PAWL represents an annual watershed nutrient load that is expected to meet Tennessee's narrative nutrients water quality criteria for fish and aquatic life. When the narrative nutrient criterion is achieved and accordingly, designated uses are protected, the PAWL will be regarded as the maximum annual allowable load that meets state's water quality standards for nutrient at the HUC-10 watershed scale. If the narrative nutrient criterion is not achieved, the PAWL will be recalculated with either more stringent WWTP effluent limits or additional load reduction from other contributing sources. This process will be repeated until the stream nutrient loads or concentrations and/or biological condition meet the narrative nutrient criterion. The contribution source loads included in the PAWL calculation are:

    a. WWTPs

       Allocations for WWTPs will be implemented through individual NPDES permits as they are reissued according to the Watershed Management Cycle (TDEC, 2013). It is expected that the permit for each facility will specify an appropriate compliance schedule commensurate with allocation requirements.

b. Urban

Urban BMPs will be implemented primarily through Phase I & II Municipal Separate Storm Sewer System (MS4) permits. Although some large MS4 discharges have individual NPDES permits, most are covered under the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems, Permit No.TNS000000* (TDEC, 2010).

c. Agricultural

Voluntary, incentive-based mechanisms will be used to implement agricultural land cover, fertilizer and manure BMP, in close cooperation with the Tennessee Department of Agriculture (TDA), Natural Resources Conservation Service (NRCS), University of Tennessee Institute of Agriculture and other similar organizations. An agricultural nonpoint source nutrient reduction strategy developed for Tennessee's Mississippi River Basin (area IV) watersheds is found in Appendix B.

7. Currently there are two major strategies used to remove nutrients from WWTP discharges. One is through design and construction for nutrient removal. Another is optimization of existing treatment. The modifications to these wastewater treatment facilities have the potential to reduce the plant's nitrogen discharge by 66% and phosphorus discharge by 75% (Iowa Nutrient Reduction Strategy, 2013). As a part of the adaptive management strategy, the Division supports the use of operational methods to reduce nutrient discharges from wastewater treatment plants as a first step.

8. Sources will be encouraged to consider nutrient load trading with other sources within the HUC-10 watershed. Trading offers the opportunity for stakeholders to work together to maximize nutrient load reductions per dollar cost. Municipalities that have MS4 permits and municipal and industrial WWTPs are natural candidates for trading. Pollutant trading, including pollutant suitability analysis, financial attractiveness, identification of potential participants and trading procedures are detailed in the Water Quality Trading Assessment Handbook (USEPA, 2004).

9. The NRF approach to nutrient reduction is intended to utilize adaptive management. Regular reassessments of goals and action plans will be conducted by reviewing monitoring data, modeling results and other measures of success. As additional data becomes available (such as WWTP effluent characterization and instream water quality data), model results can be re-evaluated. Likewise, if new treatment technologies or BMP methodologies are developed, the load reductions and source allocations may be revised. This adaptive management process is depicted in Figure 4.

<u>Monitoring and Verification</u>

The Division will continue to conduct scheduled watershed monitoring during the implementation phase to evaluate the impact and effectiveness of controls. NPDES permits for point source facilities may also require monitoring to determine the impact of discharges on the receiving streams. Additionally, the individual stormwater discharge permit (for Memphis, Nashville, Chattanooga, Knoxville and TDOT) requires water quality and biological monitoring at designated stream segments. The Phase II MS4 General NPDES Permit (NPDES General Permit TNS00000, TDEC, 2010) requires permittees to conduct biological monitoring for stream segments within their jurisdictions that are impaired for siltation and/or habitat where MS4 discharges are listed as a source of the impairment. Because nutrient impaired waters often have siltation and/or habitat impairment, this monitoring should also provide a measure of BMP effectiveness. Such a program-with its management and level of data analysis-will require a significant commitment of resources from the municipality and has to be supported by the community's needs and expected outcomes. The monitoring section of the MS4 Permit Improvement Guide (USEPA, 2010) has a water quality monitoring section that addresses the use of Environmental Indicators that may provide flexibility to the municipality to address specific needs of the individual watershed. The monitoring and assessment of these waters will be conducted in accordance with the current watershed schedule of activities (TDEC, 2013).

Figure 4. Adaptive Management Protocol for Nutrient Reduction

Public Outreach and Stakeholder Involvement

The Division will actively engage the public to publicize the role of excessive nutrient loading in water quality impairment and the need to work collaboratively to find solutions. The Division will use watershed meetings and social media to coordinate and collaborate with stakeholders, other state and federal agencies, and NGOs (non-governmental organizations) in the watersheds.

Documentation

For each impaired watershed evaluated, the Division will prepare a nutrient load analysis report (including the source loading evaluation spreadsheet) that will be posted on DWR's website. Since the NRF employs the adaptive management approach, the report will be updated periodically to reflect new developments and advances in nutrient reduction efforts.

Implementation

An implementation plan of the framework is being prepared. In that document, implementation of the NRF will be discussed in detail. In short,

-For nutrient loads contributed by regulated sources:

Following the 5-years rotating watershed schedule that Tennessee uses, starting from 2016 (http://state.tn.us/environment/water/watersheds/index.shtml), effluent nutrient load limits will be assigned for each of the major point source facilities in an impaired HUC-10 watershed based on Enrichment Factor (EF) and %WTTP contribution. The Division anticipates that the state's narrative nutrient criteria could be met within two to three NPDES permit cycles.

-For nutrient loads contributed by non-regulated sources:

As detailed in Appendix B, a draft nutrient reduction strategy for non-regulated agricultural nonpoint sources in the Mississippi River Basin (Major River Basin IV, Figure 2) has been developed. By partnering and working with relevant agricultural stakeholders and voluntary efforts to apply appropriate BMPs, a 40 to 60% nutrient load reduction is achievable in five to ten years. Process, information and experience learned in the Mississippi River Basin will be implemented statewide.

Appendix A

Strategy of Point Sources Nutrient Reduction

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Approach

This NRF methodology uses the concept of an enrichment factor (EF) (Becker, et. al, 2009), which is the ratio of the existing pollutant load (including effects of human activity) to the "natural" background or baseline condition. The enrichment factor is used to determine the appropriate level of nutrient reduction for point sources in an impaired watershed.

For each HUC-10 watershed, a spreadsheet is prepared to calculate a post-reduction annual nutrient load for the watershed after incorporating expected load reductions of point and nonpoint sources (e.g., 50% load reduction from urban, 40% from agricultural sources and required effluent load reduction at aggregated WWTPs). This post-reduction annual nutrient load is referred to as the Protective Annual Watershed Load (PAWL) in the spreadsheet (see Table A11). When the PAWL is achieved, instream nutrient concentrations in the watershed are expected to be similar to those of an unimpaired watershed in the same ecoregion with a healthy and productive ecosystem for fish and aquatic life. The PAWL sets a realistic numeric percent reduction that serves as an indicator of the progress in meeting the narrative nutrient criterion, given available BMPs and other pollutant controls. To protect the designated uses and meet the water quality criterion, this strategy prescribes a reduction in excessive nutrients discharged from point sources and the implementation of BMPs that mitigate or reduce the effects of stressors on the stream's overall ecology.

Tennessee's approach relies on the USGS SPARROW model output for the estimates of nutrient source contributions to stream loads, which are used to derive the enrichment factors and percentage of sources contribution. The SPARROW model is, in theory, "scale independent." However, the uncertainty associated with SPARROW predictions is expected to increase for drainage basin sizes smaller than those of stream monitoring sites used to calibrate the model. The HUC-10 watershed scale is large enough to provide greater certainty of model results, because the typical HUC-10 size (about 225 square miles) is larger than almost one-third of the stream monitoring sites/basins used to calibrate the model (Saad, et al., 2011, Tables S1 and S3).

SPARROW Model

The term "SPARROW" refers to <u>SPA</u>tially <u>R</u>eferenced <u>R</u>egressions <u>O</u>n <u>W</u>atershed attributes, a model that relates in-stream water-quality monitoring data to spatially referenced characteristics of watersheds. These include pollutant sources and transport factors. SPARROW is used to predict stream nutrient loads from nutrient source inputs (using nonlinear least squares multiple regression), to track the fate and transport of constituents discharged to streams, and to predict changes in water quality due to improved management practices. The models are calibrated to minimize the error between predicted and observed values of annual nutrient loads at fixed monitoring sites.

The Division has aggregated SPARROW's South Atlantic Gulf and Tennessee (SAGT) region model (MRB2) output for total nitrogen and total phosphorus for HUC-10 watersheds within Tennessee's borders. Therefore, the framework is currently using output from this specific model: SPARROW-SAGT (Hoos and McMahon, 2009; Garcia, et al., 2011). Nitrogen and phosphorus output from the Great Lakes, Ohio, Upper Mississippi, and Souris-Red-Rainy Major River Basin Model (MRB3) that is applicable for the Cumberland River Basin will be aggregated and then applied. Output from the Lower Mississippi, Arkansas-White-Red, and Texas Gulf River Basin Model (MRB5) will be applied in West Tennessee with the focus on agricultural reductions as stated in Appendix B.

The SPARROW-SAGT model includes source predictor variables. For nitrogen, those include wastewater treatment plant (WWTP) discharges, atmospheric deposition (National Atmospheric Deposition Program, 2006), fertilizer (applied to agricultural land (Ruddy, et al, 2006)), manure from livestock production (Ruddy, et al, 2006) and urban sources (impervious surface area as classified by the 2001 National Land Cover Dataset (Homer, et al, 2004). For phosphorus those include soil-parent rock (S-PR) (phosphorus content of bed sediment in headwater streams based on regionalizing National Geochemical Survey data (Terziotti, et al, 2009), manure (animal waste from both confined and unconfined sources (Ruddy, et al, 2006)), fertilized land (agricultural land in the National Land Cover Dataset (Homer, et al, 2004)), WWTP discharges, urban sources (urban land as classified by the 2001 National Land Cover Dataset (Homer, et al, 2004)) and phosphate mines (phosphorus content of bed sediment in headwater streams affected by mined land, inferred from National Geochemical Survey data (Terziotti, et al, 2009)).

Enrichment Factor

The nutrient loadings from the SPARROW-SAGT model (MRB2) are used to determine the enrichment factor. In this case, the atmospheric deposition load represents background for nitrogen and the soil-parent rock (S-PR) load represents background for phosphorus. Figure A1 shows that natural soil and bedrock in some areas of middle Tennessee are particularly rich in phosphorus. Enrichment factors for nitrogen and phosphorus were calculated for each HUC-10 watershed in the Tennessee River Basin. The enrichment factor calculations for total nitrogen and total phosphorus are given below:

TN:

$$\mathbf{EF} = \frac{\mathbf{Load_{WWTP} + Load_{AtmDep} + Load_{Fertilizer} + Load_{Manure} + Load_{Urban}}}{\mathbf{Load_{AtmDep}}}$$

TP:

$$\mathbf{EF} = \frac{\mathbf{Load_{WWTP} + Load_{S\text{-}PR} + Load_{Fertilized\ Land} + Load_{Manure} + Load_{Urban} + Load_{Mines}}}{\mathbf{Load_{S\text{-}PR}}}$$

The specific loads used were derived from a subset of the SAGT output that included 138 HUC-10 watersheds in the Tennessee River basin. The Upper Tennessee River Basin consists of 73 HUC-10 watersheds and the Lower Tennessee River Basin has 65 HUC-10 watersheds. The source contributions to stream total nitrogen and total phosphorus loads in the Upper and Lower Tennessee River Basins are demonstrated in Box-Whisker plots shown in Figures A2 and A3, respectively. The calculated EFs for all HUC-10 watersheds in the Upper and Lower Tennessee River Basins are shown in Figures A4 and A5 for TN and TP, respectively. Cumulative frequency distributions of calculated EFs in the Upper and Lower Tennessee River Basins are shown in Figures A6 and A8 for TN and TP, respectively. These distributions assist in partitioning the calculated EFs into three zones (bottom, middle, and top), which are used to construct the decision-making matrix (discussed in the Decision-Making Matrix section below). Box-Whisker plots of the calculated enrichment factors in the Upper and Lower Tennessee River Basins are shown in Figures A7 for TN and Figure A9 for TP.

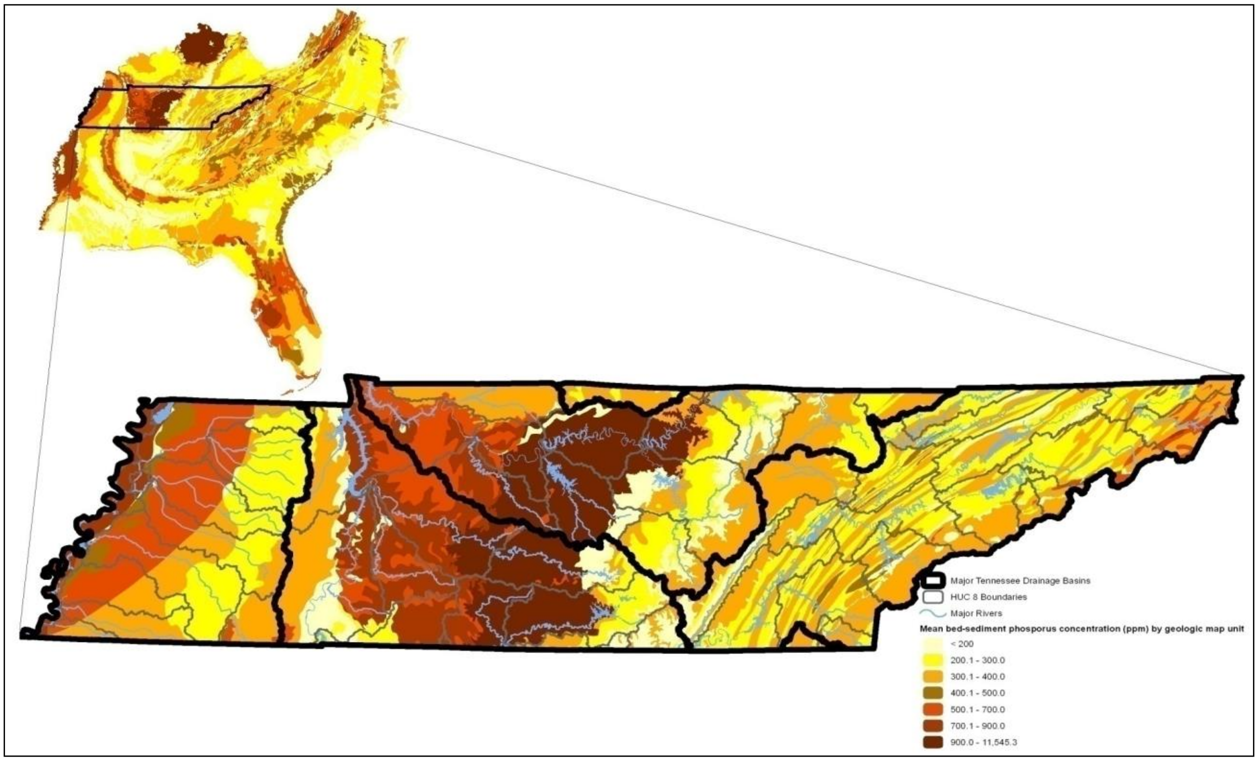


Figure A1. Mean Values of Bed-Sediment Phosphorus Concentration in Tennessee (Terziotti, et al, 2009)

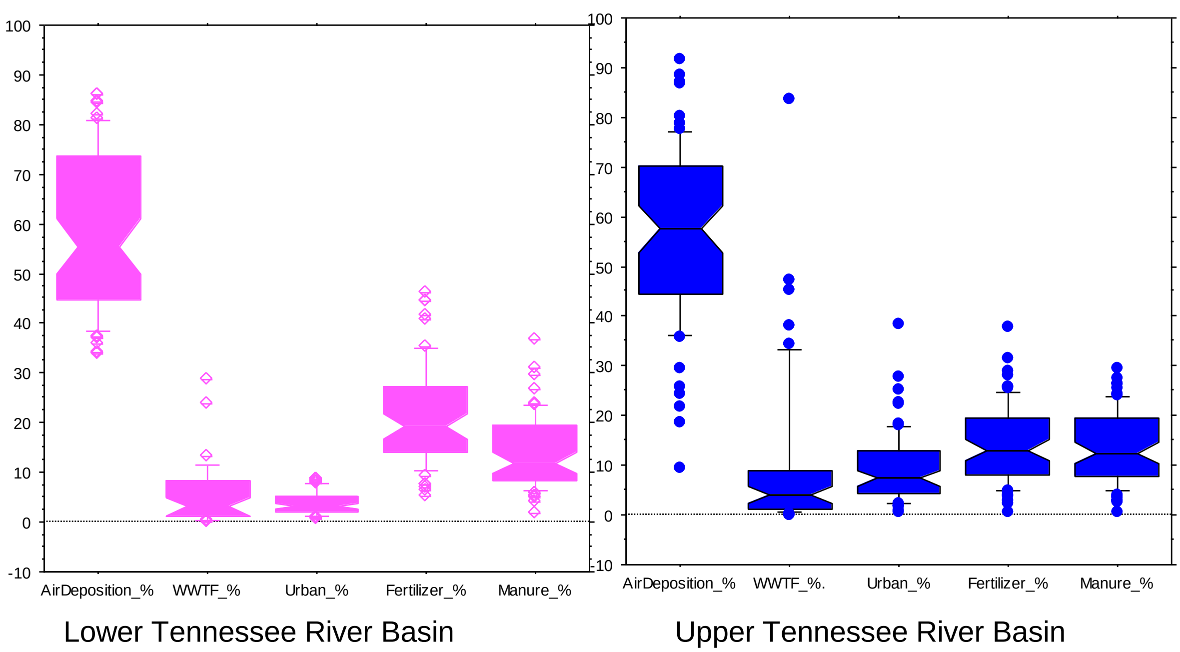


Figure A2. Total Nitrogen SPARROW-SAGT-modeled sources contribution

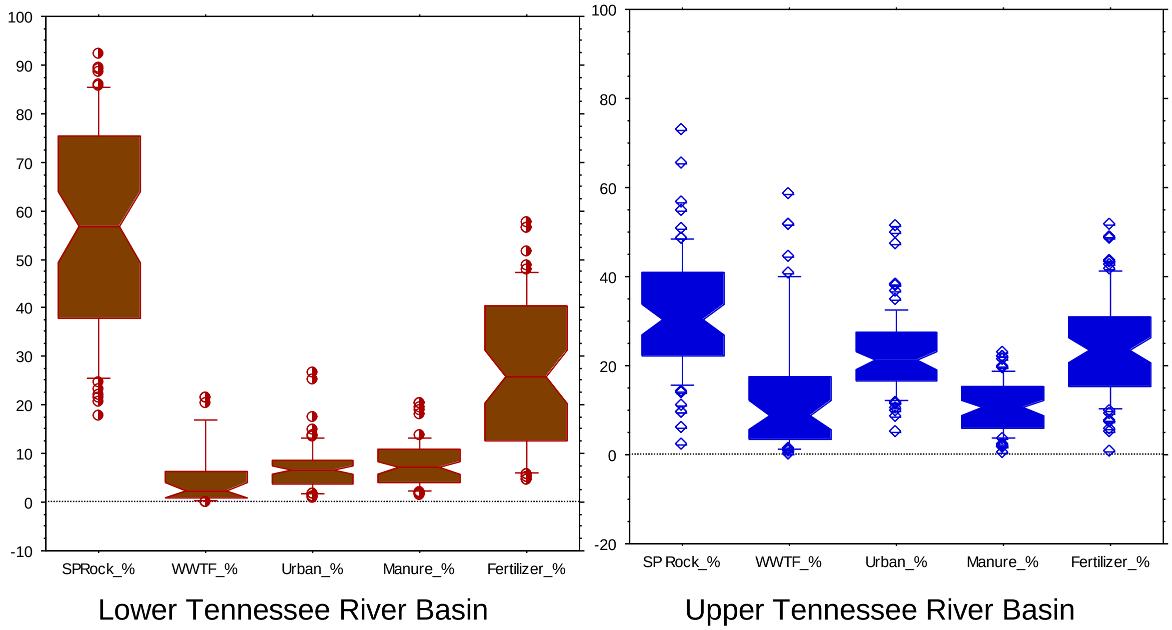


Figure A3. Total Phosphorus SPARROW-SAGT-modeled sources contribution

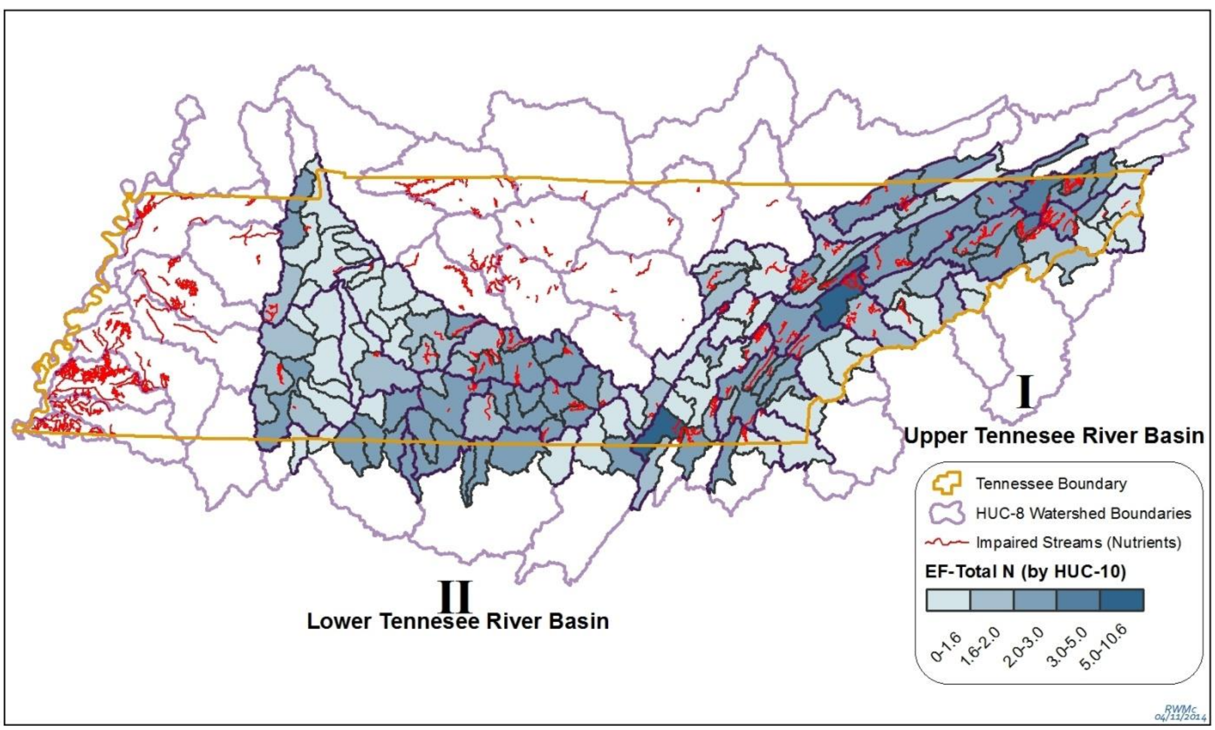


Figure A4. Enrichment Factors for Total Nitrogen in Upper and Lower Tennessee River Basins

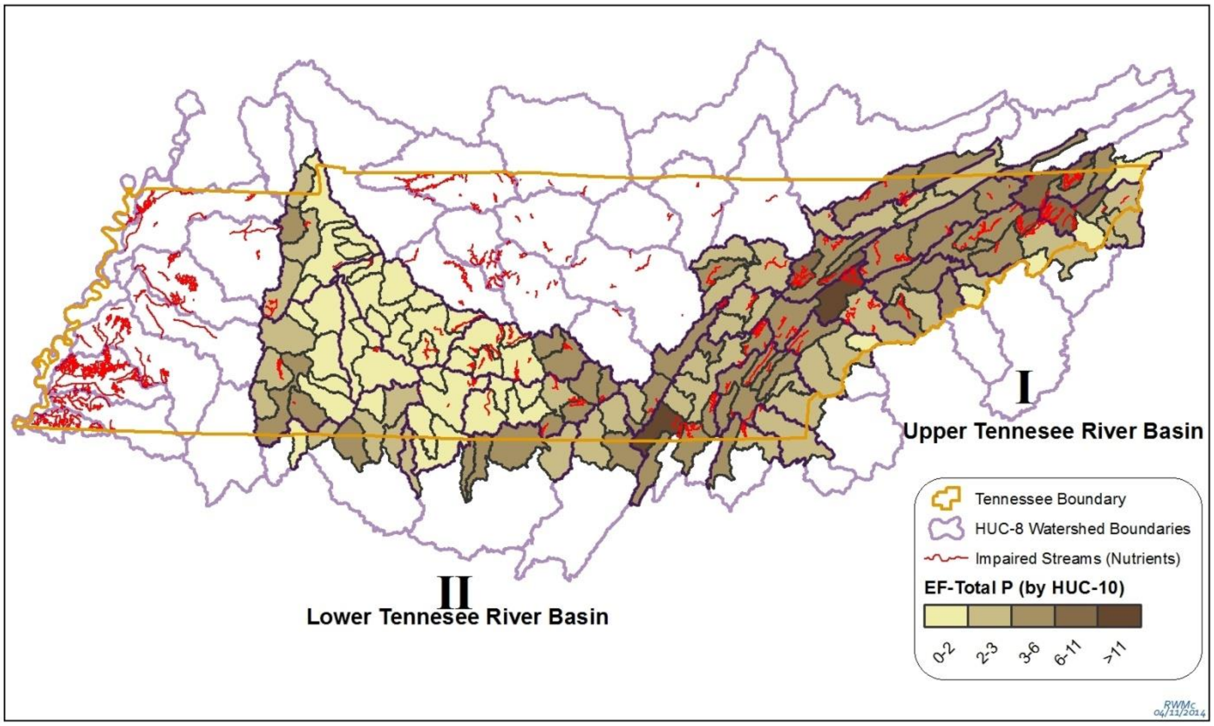


Figure A5. Enrichment Factors for Total Phosphorus in Upper and Lower Tennessee River Basins

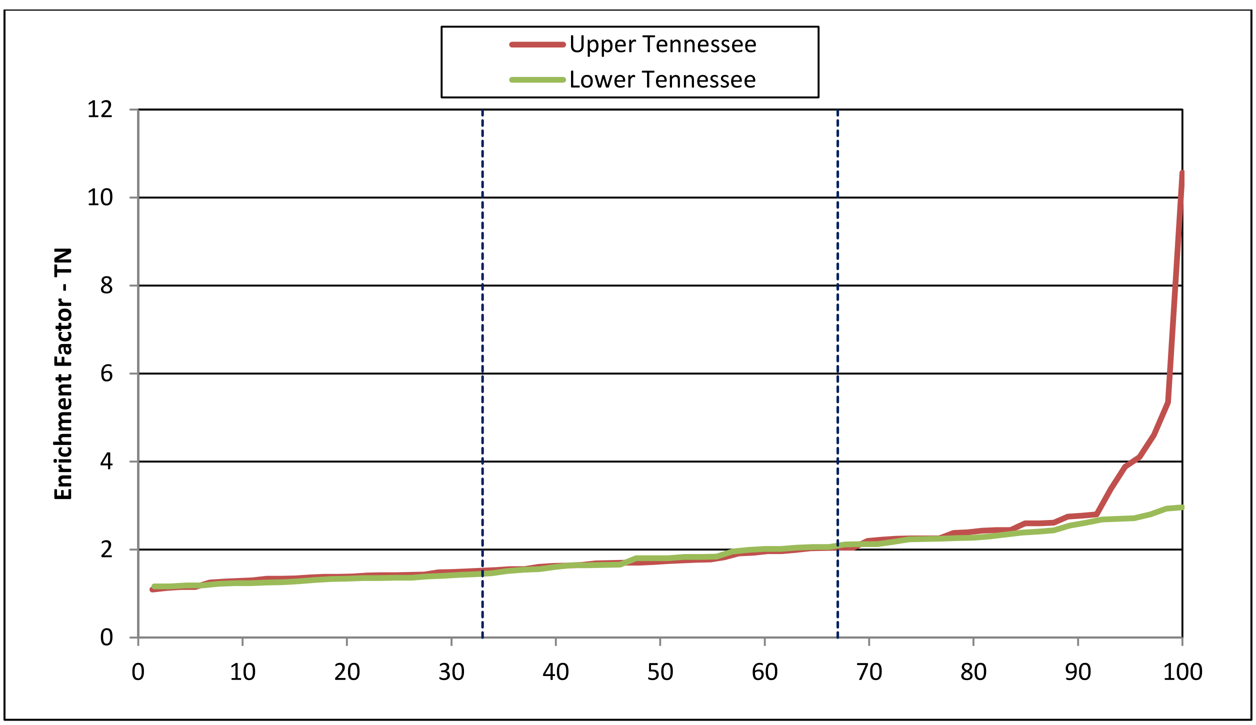
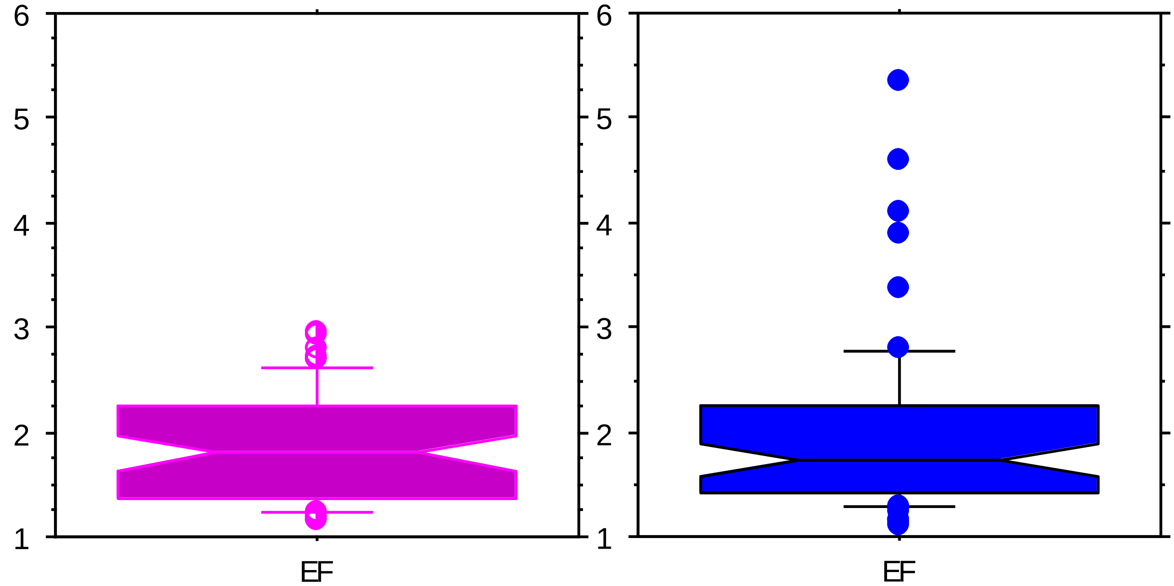


Figure A6. Cumulative frequency distribution of Enrichment Factors for Total Nitrogen



Lower Tennessee River Basin

Upper Tennessee River Basin

Figure A7. Box-Whisker Plot of Enrichment Factors for Total Nitrogen

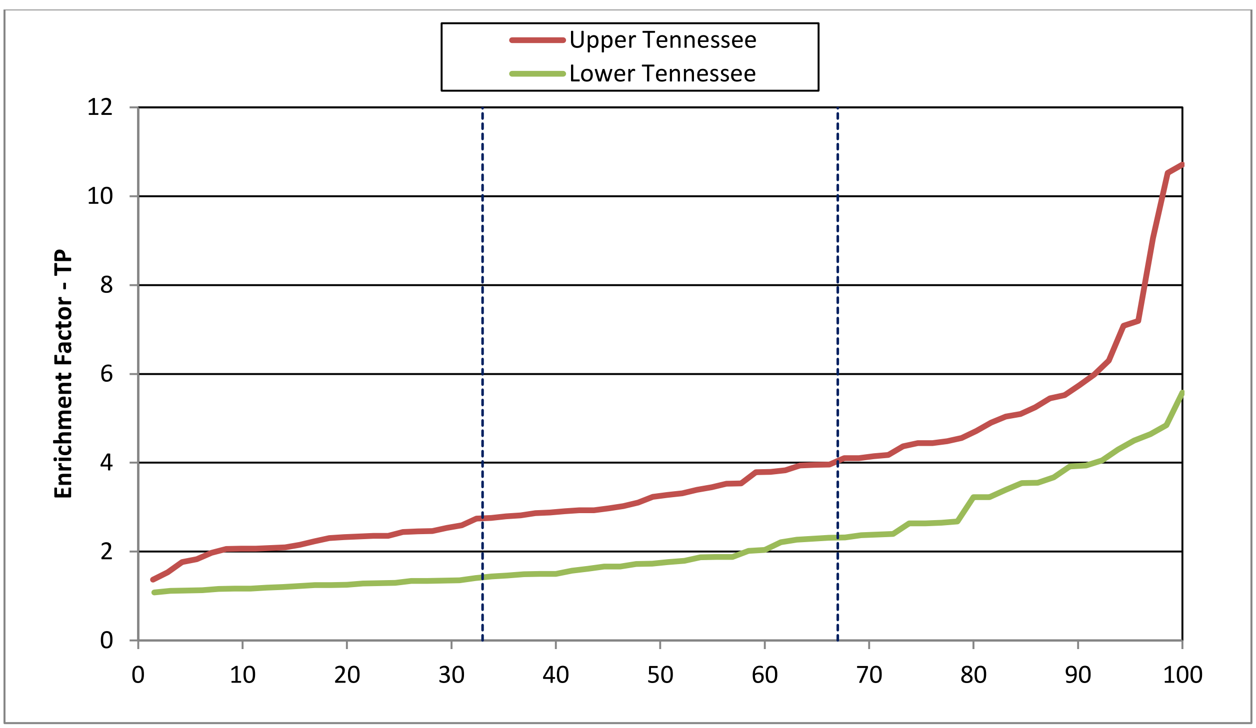
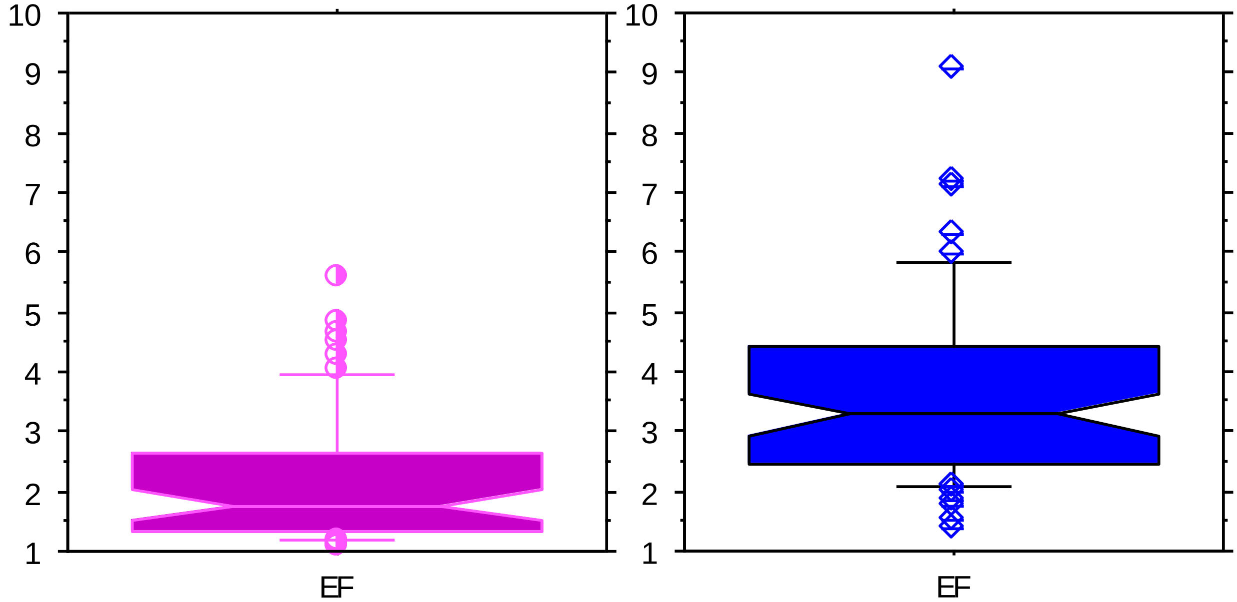


Figure A8. Cumulative frequency distribution of Enrichment Factors for Total Phosphorus



Lower Tennessee River Basin

Upper Tennessee River Basin

Figure A9. Box-Whisker Plot of Enrichment Factors for Total Phosphorus

For Cumberland and Mississippi River Basins (River Basin III and IV), the enrichment factor will be calculated in a similar manner using nutrient loadings from the applicable SPARROW models (MRB3 and MRB5).

Tables A1 and A2 summarize the relative contribution of sources and enrichment factors derived from the SPARROW SAGT output in the Tennessee River basin for total nitrogen and total phosphorus, respectively.

Total Nitrogen Contribution and Enrichment Factor Tennessee River Basin			
Source	**Range**	**Median**	**Mean**
Atm. Deposition	9 - 92%	56%	57%
Wastewater	0 - 84%	3.6%	8%
Urban	0.7 - 38%	4.8%	6.6%
Fertilizer	0.5 - 46%	16%	18%
Manure	0.7 - 37%	12%	14%
Enrichment Factor (EF)	1.1 – 10.6	1.8	2

Table A1. Total Nitrogen Sources Contribution and Enrichment Factor

Total Phosphorus Contribution and Enrichment Factor Tennessee River Basin			
Source	**Range**	**Median**	**Mean**
Soil-Parent Rock	2.3 - 92%	38%	43%
Wastewater	0 - 92%	5.3%	11.9%
Urban	0.9 - 53 %	13%	15%
Fertilized Land	0.7 - 57 %	24%	25%
Manure	0.3 - 23 %	9%	9%
Mines	0 - 12%	0%	0.3%
Enrichment Factor (EF)	1.1 – 11	2.6	3.0

Table A2. Total Phosphorus Sources Contribution and Enrichment Factor

WWTP Effluent Limits

In some HUC-10 watersheds, WWTP discharges represent the major source of nutrient enrichment. Cumulative frequency distribution of the percentage of WWTP contributions in the Upper and Lower Tennessee River Basins are shown in figures A10 and A11 for total nitrogen and total phosphorus, respectively. These distributions assist in partitioning the percentage of WWTP contributions into three zones (bottom, middle, and top), which are used to construct the decision-making matrix (discussed in the Decision-Making Matrix section below).

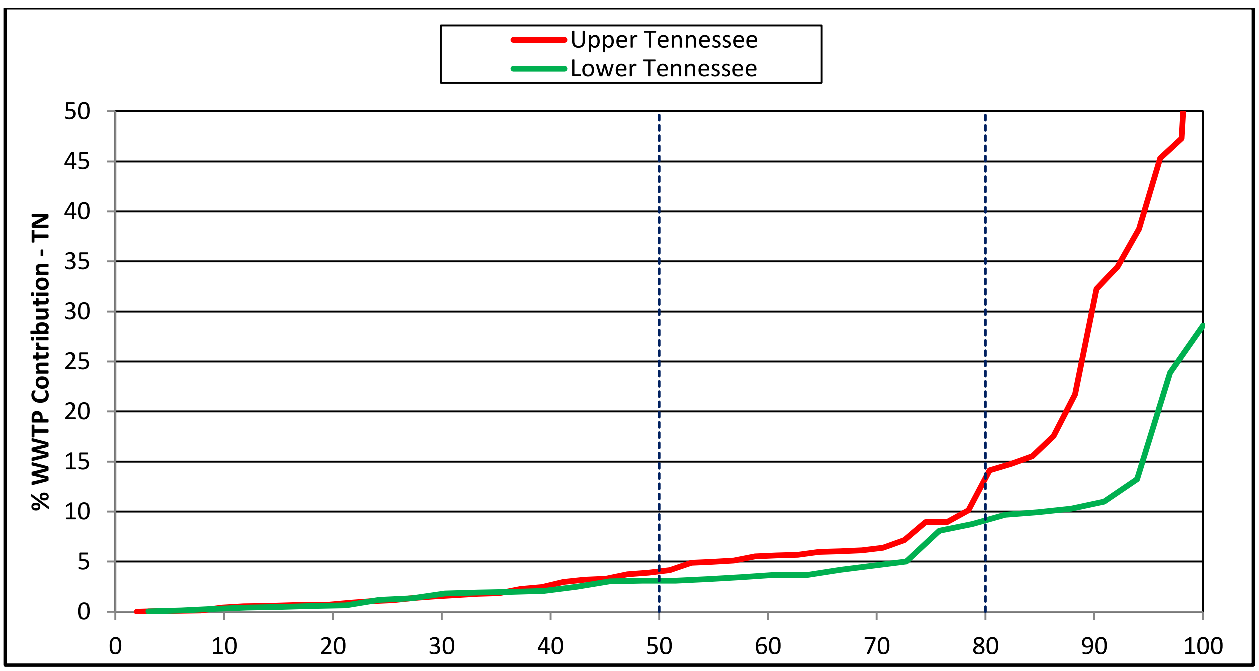


Figure A10. Cumulative frequency distribution of WWTP Contributions for Total Nitrogen

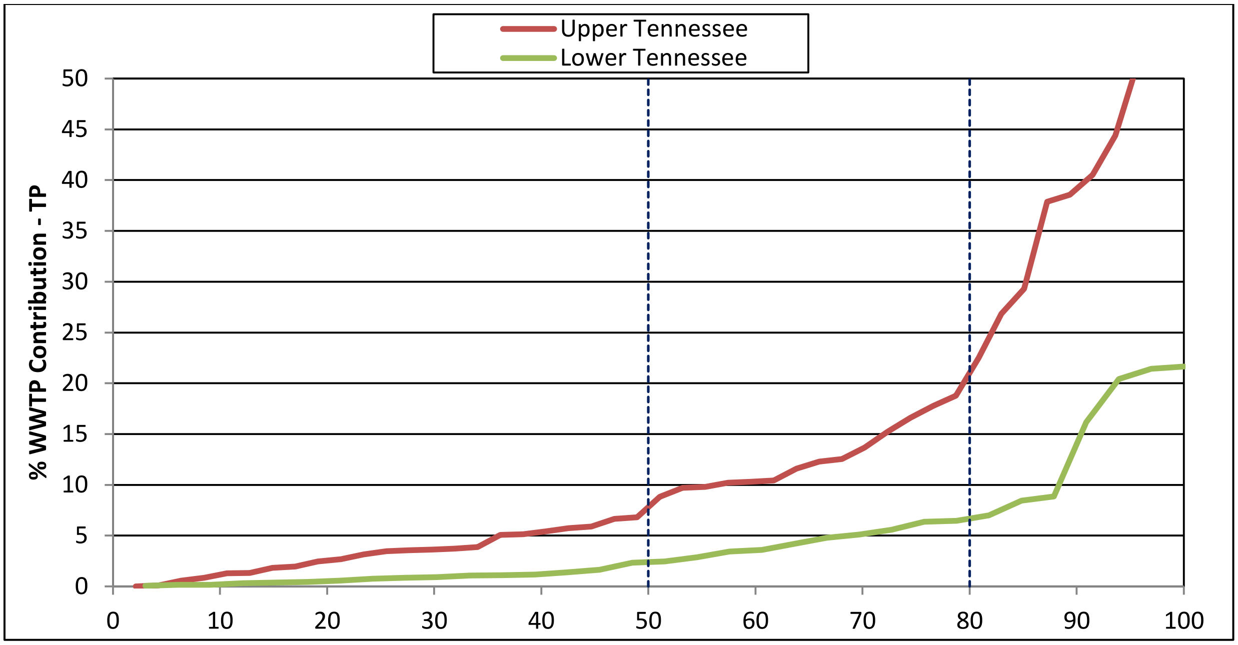


Figure A11. Cumulative frequency distribution of WWTP Contributions for Total Phosphorus

Decision-Making Matrix

Nutrient impact levels in each HUC-10 watershed is evaluated as high, medium, and low based on a combined analysis of EF and percentage of WWTP contribution, That is as follows: The cumulative frequency distributions of EF (Figures A6 and A8) and percentage of WWTP contribution (Figures A10 and A11) were each bracketed into three zones: bottom, middle, and top. For each HUC-10 watershed, if the scores of EF and percentage of WWTP contribution both exceed the top bracket, the nutrient impact from WWTP is considered the high level. When both the EF and percentage of WWTP contribution are below the bottom bracket, the nutrient impact from WWTP is at the low level. In the first stage of implementation, EFs have been bracketed at the 33rd and 67th percentiles and the percent of WWTP contributions have been bracketed at the 50th and 80th percentiles. The decision-making matrices for the Upper Tennessee River Basin based on these brackets are presented in Tables A3 and A4 for total nitrogen and total phosphorus, respectively. Tables A5 and A6 show the same decision-making matrices for the Lower Tennessee River Basin for total nitrogen and total phosphorus, respectively. The partitioning of the EF and percent of WWTP contribution will be periodically assessed and adjusted during the implementation phase to evaluate their impact and effectiveness.

Impact Level			
% WWTP Contribution	**EF<1.5**	**1.5≤EF<2**	**EF≥2**
WWTP≥14.1%	Low	Medium	High
4.2%≤ WWTP<14.1%	Low	Medium	Medium
WWTP<4.2%	Low	Low	Low

Table A3. Total Nitrogen Evaluation Matrix in Upper Tennessee River

Basin (n=73 for EF and n=51 for % WWTP Contribution)

Impact Level			
% WWTP Contribution	**2.8>EF**	**2.8≤EF<4.1**	**EF≥4.1**
WWTP ≥21.7%	Low	Medium	High
8.8%≤ WWTP<21.7%	Low	Medium	Medium
WWTP<8.8%	Low	Low	Low

Table A4. Total Phosphorus Evaluation Matrix in Upper Tennessee River Basin (n=71 for EF and n=47 for % WWTP Contribution)

Impact Level			
% WWTP Contribution	**EF<1.5**	**1.5≤EF<2.1**	**EF≥2.1**
WWTP≥9.3%	Low	Medium	High
3.1%≤ WWTP<9.3%	Low	Medium	Medium
WWTP<3.1%	Low	Low	Low

Table A5. Total Nitrogen Evaluation Matrix in Lower Tennessee River Basin (n=65 for EF and n=33 for % WWTP Contribution)

Impact Level			
% WWTP Contribution	**1.4>EF**	**1.4≤EF<2.3**	**EF≥2.3**
WWTP ≥6.8%	Low	Medium	High
2.5%≤ WWTP<6.8%	Low	Medium	Medium
WWTP<2.5%	Low	Low	Low

Table A6. Total Phosphorus Evaluation Matrix in Lower Tennessee River Basin (n=65 for EF and n=33 for % WWTP Contribution)

In each HUC-10 watershed, the resulting nutrient impact level indicates the appropriate level of nutrient reduction for WWTPs to achieve the PAWL. For both nitrogen and phosphorus, effluent limits (Table A7) will be assigned to WWTPs according to the impact levels determined. The effluent target limits (8 mg/l TN and 1 mg/l TP) assigned to HUC-10s with medium impact represent nutrient concentrations corresponding to conventional biological nitrogen and phosphorus removal and tertiary filtration. The effluent limits (5 mg/l TN and 0.3 mg/l TP) assigned to HUC-10s with high impact represent results of additional chemical treatment for phosphorus removal (WERF, 2010). For plants equipped with biological treatment systems, appropriately modifying and optimizing the operation of existing systems for nitrogen and phosphorus removal may be capable of achieving the required effluent discharge limits. The Division strongly encourages that, if applicable, plant optimization be included as one of the first alternatives in the plant's nutrient removal/reduction plan.

In addition to the nutrient impact level, additional factors can be considered in determining the required nutrient load reductions. Those include current effluent concentrations, proximity (less than 10 miles upstream) to other nutrient or dissolved oxygen (DO) impaired water bodies, and, for total phosphorus, proximity (less than 20 miles) to downstream reservoir segments. Additionally, a facility's operation and maintenance will be taken into consideration. In the first stage of implementation, this strategy will be applied to major municipal as well as permitted industrial WWTPs.

Required Effluent Limits			
	Low Impact	**Medium Impact**	**High Impact**
Total Nitrogen	Cap @ current level	8 mg/l	5 mg/l
Total Phosphorus	Cap @ current level	1 mg/l	0.3 mg/l

Table A7. Required Effluent Limits for Total Nitrogen and Total Phosphorus

Nutrient Reduction in Urban Runoff

In Tennessee urban sources include sanitary sewer overflows, permitted MS4 discharges and discharges from other as yet unregulated developed areas. This framework assumes an achievable 40% - 60% target reduction in annual pollutant load from urban sources. It is supported by observed pollutant removal efficiencies of several commonly applied BMPs (see Table A8). These data suggest that pollutant removal can be within the target range.

The 2012 303(d) list identifies collection system failures as a source of nutrient pollution in 55 impaired segments. Many of these systems are under enforcement to eliminate wet weather discharges of untreated sewage. This framework will identify those systems with mandatory compliance schedules and will target the remainder for future enforcement. Elimination of collection system failure as a source of nutrient pollution is the Division's regulatory goal.

The individual permit for municipal MS4 discharges requires a watershed characterization and management program (TDEC, 2010). Specifically, E. coli and total suspended solids (TSS) are components of the watershed characterization monitoring. Results of watershed characterization are submitted with each annual report to the Division. By the end of a permit cycle (5 years), the permittee will develop a watershed management plan that focuses on one critical watershed. The plan will incorporate components of analytical monitoring, assessment of the monitoring data, design and implementation of BMPs to address the specific pollutants of concern, master planning of critical impervious areas and assessments of targeted BMP effectiveness. The watershed management plan will be drafted in a format that can be extrapolated to other watersheds within the county.

The current Phase II MS4 general NPDES permit requires that stormwater management programs include BMPs specifically targeted to achieve reduction prescribed in TMDLs. This framework will include a similar provision. If necessary, the Phase II General NPDES Permit will be modified to refer to reductions identified in this framework. For all new and redeveloped property, the MS4 permits require runoff reduction through green infrastructure as the preferred method for permanent stormwater control. Green infrastructure is expected to achieve both volume control and pollutant removal.

BMP type	Total Nitrogen		Nitrate		Total Phosphorus	
	Rmvl. Effic. (%)	No. Sites	Rmvl. Effic. (%)	No. Sites	Rmvl. Effic. (%)	No. Sites
Wet ponds	28	27	42.5	16	46	28
Stormwater wetlands	22	14	55	8	32.5	14
Sand filters	41	12	56.5	11	59	11
Bioretention areas	45	4	16	4	71	5

Table A8. Median removal effectiveness for 4 BMPs from Studies in the Southeast and Mid-Atlantic (Wossink and Hunt, 2003).

The Division may designate other developed areas as MS4s and require them to obtain permit coverage pursuant to the applicable deadlines in the NPDES general MS4 permit. Those newly permitted MS4s would then be required to implement the controls described above.

Nutrient Reduction from Agricultural Sources

In the absence of regulatory authority, the Division follows EPA's Memorandum: *Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions* (Stoner, N., USEPA, 2011) by working with agricultural partners to accelerate adoption of agricultural conservation practices by promoting proven land stewardship practices that improve water quality. Rao, *et al.* (2009) found that the range of BMP reductions to be 11-94%, depending on the practice. Table A9 lists several agricultural BMPs and associated nitrogen and phosphorus removal efficiencies. This framework assumes a 40% reduction in nutrient loads from agricultural sources. According to Tennessee's 2012 303(d) list (TDEC, 2014), the bulk of stream impairments due to agriculture are related to livestock grazing and crop production. Where agricultural sources represent a significant portion of the nutrient load in a given HUC-10 watershed, the Division will work with partner agencies such as the Tennessee Department of Agriculture (TDA), Natural Resources Conservation Service (NRCS) and the University of Tennessee Extension (UT) to develop watershed specific plans for agricultural BMP implementation.

BMP Type	Nitrogen	Phosphorus
Filter Strips	70%	75%
Terrace Systems	20 - 55%	70 - 85%
Diversion Systems	10 - 45%	30 - 70%
Reduced Tillage Systems	55 %	45%
Containment Structure	65%	60%
Rotational Grazing	20 %	20%
Livestock Exclusion	50 %	75 %
Riparian Buffer	40 - 70 %	45 - 70 %
Animal Waste Systems	80 %	90%

Table A9. Effectiveness of Agricultural BMPs for Nutrient Control (USEPA, 1993; Agouridis, et al., 2005; Chesapeake Bay Program, 2011)

Since 1994, the Division has been partnering with TDA, which manages Tennessee's 319 Nonpoint Source Program, and the NRCS. Specifically, in 2010, the Division started working with TDA and UT to develop an agricultural nonpoint source nutrient reduction strategy in West Tennessee watersheds (Appendix B) as part of the Mississippi River/Gulf of Mexico Hypoxia Task Force Action Item 1. The methods detailed in this plan can be applied across the state to achieve reductions in agricultural sources of nutrient load. Recipients of 319 or NRCS cost-share program are contractually bound to maintain the BMP through its estimated useful life. Recipients who fail to do so are required to return the cost-share contribution to the funding agency.

Maximum Annual Allowable Load

For each HUC-10 watershed, a spreadsheet is prepared to calculate a post-reduction annual nutrient load for the watershed after incorporating expected load reductions of point and nonpoint sources (e.g., 50% load reduction from urban, 40% from agricultural sources and required effluent load reduction at aggregated WWTPs). This post-reduction annual nutrient load is referred to as the Protective Annual Watershed Load (PAWL) in the spreadsheet (Table A11). The PAWL represents an annual watershed nutrient load that is expected to meet the narrative nutrient criterion. Using the SPARROW-SAGT-derived loadings as an example, PAWLs for nitrogen and phosphorus are determined using the following equations:

For nitrogen:

$$\text{PAWL} = \text{Load}_{\text{WWTPs@ Req'd Reduction}} + (\text{Load}_{\text{Urban}} + \text{Load}_{\text{Fertilizer}} + \text{Load}_{\text{Manure}}) \text{x BMP Reduction} + \text{Load}_{\text{Atm Dep}}$$

For phosphorus:

$$\text{PAWL} = \text{Load}_{\text{WWTPs@ Req'd Reduction}} + (\text{Load}_{\text{Urban}} + \text{Load}_{\text{Fert Land}} + \text{Load}_{\text{Manure}}) \text{x BMP Reduction} + \text{Load}_{\text{S-PR}} + \text{Load}_{\text{Mines}}$$

Where:

Expected BMP Reduction =40%; and

$\text{Load}_{\text{Urban}}$, $\text{Load}_{\text{Fertilizer}}$, $\text{Load}_{\text{Manure}}$, $\text{Load}_{\text{Fert Land}}$, $\text{Load}_{\text{Atm Dep}}$ and $\text{Load}_{\text{S-PR}}$ are from SPARROW-SAGT Model output

$$\text{Load}_{\text{WWTPs@ Req'd Reduction}} = \sum(\text{WWTP effluent concentration x WWTP flow})_{\text{HUC-10, outlet}}$$

When the PAWL improves instream nutrient concentrations and/or biological condition in the HUC-10 watershed to the narrative nutrient criterion, the PAWL is considered the maximum annual allowable load. If not, a new PAWL will be recalculated with more stringent effluent limits and additional load reductions from other contributing sources (including trading among point and nonpoint sources). Stream nutrient concentrations and biological condition will be monitored again after the new PAWL has been implemented. The process is repeated until the stream nutrient concentrations and/or biological condition meet the narrative nutrient criterion. Reaching the narrative nutrient criterion is expected to result in a significant reduction in nutrient load in the watershed. The Division expects that in many cases, especially where WWTPs and urban sources are primary contributors, this should result in use support in a timely manner within 2 to 3 permit cycles. That represents a time frame of ten to fifteen years.

The Division recognizes that, in some impaired streams, the narrative nutrient criterion may not be achieved with effluent limits imposed even at the highest nutrient impact level. In these cases, the Division will work with permittees to collect the necessary data for modeling to determine final effluent limits protective of narrative nutrient criteria. Limits based on the Division's nutrient reduction strategy will be implemented as interim limits. Dischargers may choose to forego interim limits and data collection for modeling; instead, to implement an assessment based nutrient target directly.

A Case Example

This framework is demonstrated in a HUC-10 watershed in the Upper Tennessee River Basin, the West Prong Little Pigeon River. Table A10 below gives the percent source contributions in the watershed under current conditions.

	Total Nitrogen %	Total Phosphorus %
WWTPs	19.6	42.3
Urban land	10.3	25.2
Fertilizer/ Ag. land	4	5.8
Manure/ Animal Waste	3.3	2.0
Background (Atm. Dep./ Soil-P Rock)	62.8	24.7

Table A10. SPARROW-SAGT Model Source Contribution

An evaluation of the source loadings (Table A11) and comparison with the Total Phosphorus Evaluation Matrix for the appropriate region (Upper Tennessee, Table A4) show that the HUC-10 watershed has a phosphorus enrichment factor of 4.1 (in the high range) and a %WWTP contribution of 42.3 percent (in the high range), and therefore the nutrient impact level is determined as high. Each of the wastewater plants in this HUC-10 watershed will be assigned a total phosphorus effluent limit of 0.3 mg/l.

			Wastewater	S-P Rock	Ag. Land	Manure	Urban Land	Total
SPARROW	Source (Existing) Load	lbs/yr	18,363	10,716	2,507	867	10,937	**43,390**
	Percent	%	42.3	24.7	5.8	2.0	25.2	**100.0**
HUC-10	**Enrichment Factor**							**4.1**
WWTPs	Σ Design Flow	MGD	12.00					
	Σ Existing Flow	MGD	5.103					
	Avg. TP Concentration	mg/L	1.664					
	Impact Level		High					
	Required Treatment Level (RTL)	mg/l	0.3					
	Allocation (WWTP #1)	lbs/yr	5,479					
	Allocation (WWTP #2)	lbs/yr	5,479					
	Allocation (In-stream at HUC-10)	lbs/yr	7,783					
	Load Reduction (WWTP #1)	%	59					
	Load Reduction WWTP #2)	%	56					
	Proposed Reduction	%			40	40	50	
Precipitation Induced Sources	Load Allocation (assumes 40% and 50% reduction in agricultural and urban loading, respectively)	lbs/yr			1,504	520	5,469	
	Protective Annual Watershed Load (PAWL)	lbs/yr	7,783	**10,716**	1,504	520	5,469	**25,992**
HUC-10 Overall	Overall Load Reduction	%						**40.1**

Table A11. Total Phosphorus Load Analysis

Figure A12 compares the PAWL load for the West Prong Little Pigeon River (25,992 lbs/yr or 0.27 lbs/yr/acre) with the SPARROW–SAGT estimated load for the healthy unimpaired East Prong Little Pigeon River (26,579 lbs/yr or 0.21 lbs/yr/acre), which has a similar watershed size (94639.5 ac vs. 128551 ac). This strongly suggests implementation of this framework in the West Prong Little Pigeon River will likely restore the water quality and meet the narrative ambient nutrient criteria.

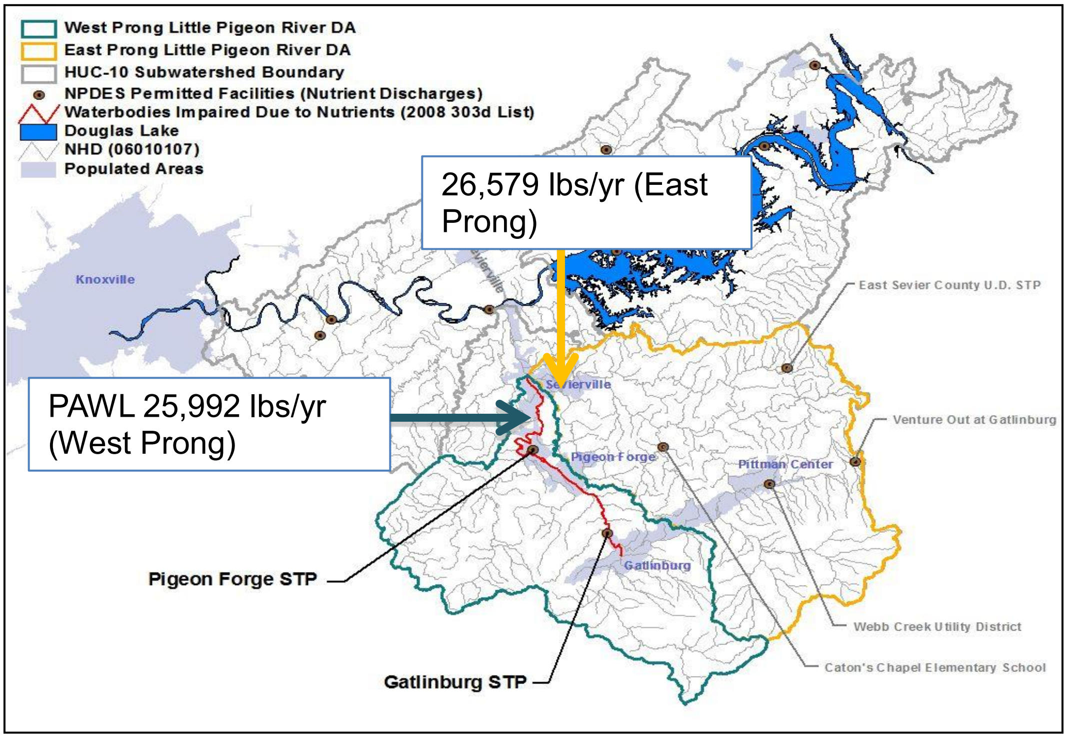


Figure A12. East and West Prongs, Little Pigeon River

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Note: This Nutrient Reduction Framework was originated from a white paper titled ‘State of Tennessee Nutrient Reduction Strategy for Rivers and Streams’ prepared by Saya Qualls, P.E. (former TDEC employee) in 2012 and is revised in 2014 with contributions from Bruce Evans, P.E. (retired TDEC employee), Ann Hoos (USGS), Vicki Steed, P.E. (TDEC), Karina Bynum, P.E. (TDEC), and Regan McGahen (GIS, TDEC).

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Appendix B

Agricultural Nonpoint Source Nutrient Reduction Strategy in Tennessee's Mississippi River Basin Watersheds

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Introduction

The State-EPA Nutrient Innovations Task Group, which released a report in August 2009 entitled *An Urgent Call to Action*, summarizes the increasing environmental and drinking water supply degradation associated with excess levels of nitrogen and phosphorus in the nation's waters. The Mississippi River/Gulf of Mexico Hypoxia Task Force and the Gulf of Mexico Alliance have plans that call for the reduction of nutrients reaching the Gulf of Mexico and are stated in the *Mississippi Delta Nutrient Reduction Strategies*. Various health and ecological impacts are thought to be associated with high nutrient concentrations in water.

Tennessee is developing a nutrient reduction framework to address nutrient loads in our watersheds. As a component of this framework, Tennessee is developing an agricultural nonpoint source nutrient reduction strategy for Mississippi River Basin watersheds (see Figure B1).

Tennessee intends to develop a farmer-led approach by using voluntary, economic-based incentives that enable landowners to make wise land use decisions that maintain profitability and reduce environmental impacts from farming.

The goals of the West Tennessee agricultural nonpoint source nutrient reduction strategy are to:

- Use science-based solutions and adaptive management to develop a comprehensive set of results-oriented nutrient load reduction approaches that promote stakeholder involvement and capitalize on the successes of other states
- Protect drinking water sources from high nitrate contamination
- Reduce nutrient loads from Tennessee's watersheds that drain to the Mississippi River (Mississippi River Basin Watersheds)
- Increase opportunities for federal funding

Watersheds in this basin, and their HUC-8 numbers, are:

- 08010100 (Mississippi River)
- 08010202 (North Fork Obion River)
- 08010203 (South Fork Obion River)
- 08010204 (North Fork Forked Deer River)
- 08010205 (South Fork Forked Deer River)
- 08010206 (Middle Fork Fork Obion River)
- 08010207 (Upper Hatchie River)
- 08010208 (Lower Hatchie River)
- 08010209 (Loosahatchie River)
- 08010210 (Wolf River)
- 08010211 (Nonconnah Creek)

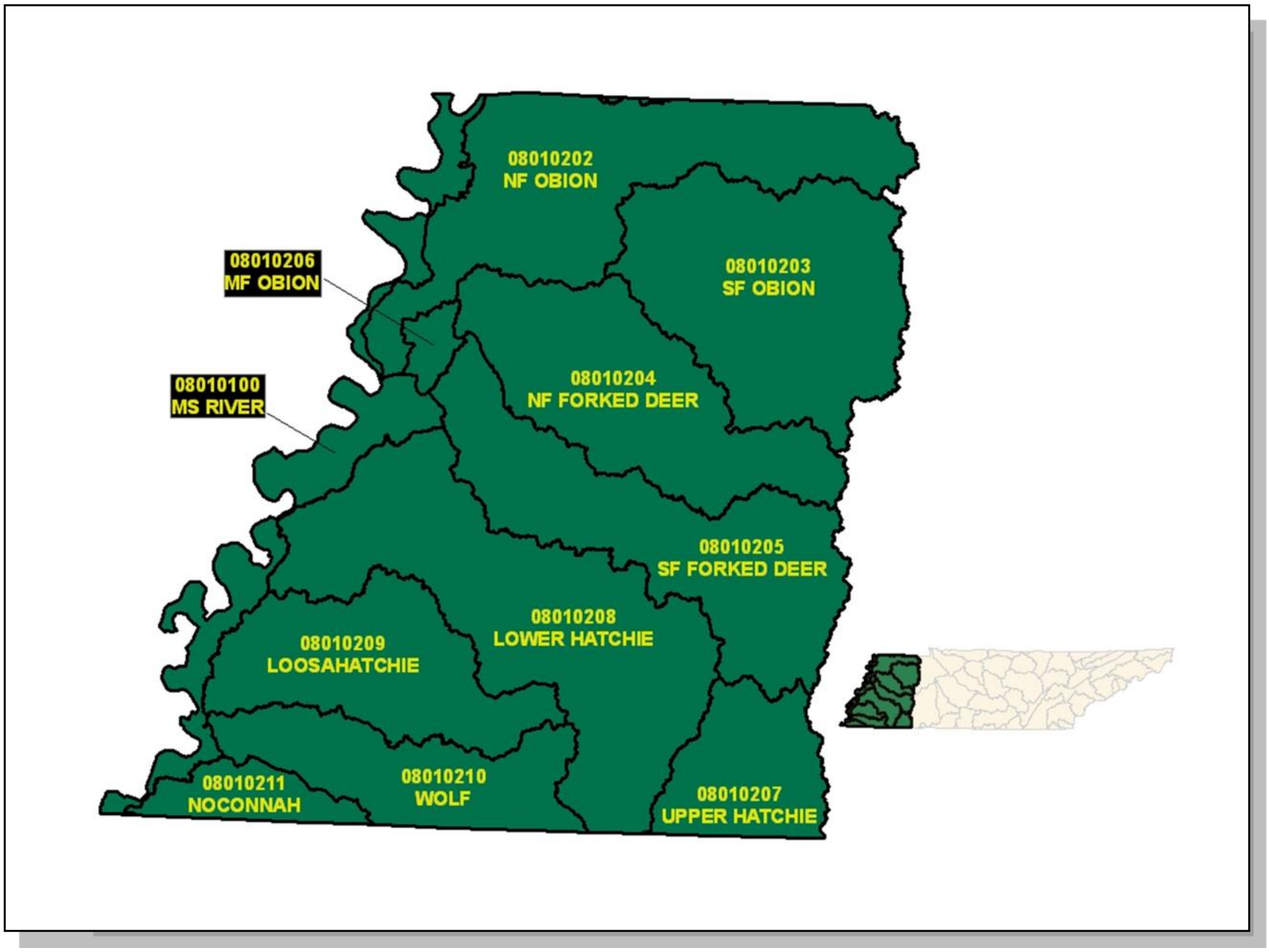

Figure B1. Watersheds in the Mississippi River Basin in Tennessee

Tennessee's agricultural nonpoint source reduction strategy in West Tennessee's Mississippi River Basin watersheds is being developed by TDEC, TDA, and UT-Extension. This plan follows the process described in *Mississippi Delta Nutrient Reduction Strategies* dated December 15, 2009.

These three agencies (TDEC, TDA, UT-Extension) formed the State-Level Organizing Committee (committee) in 2011. The committee began the process of developing a draft nutrient reduction strategy focused on reducing nutrient sources and promoting stakeholder involvement. The committee has begun the process of partnering with agricultural producers, federal agencies, universities, nonprofit organizations, and watershed groups to refine the plan.and to ensure it reflects the expertise of the partner groups

A variety of sources can contribute nutrients to streams, including wastewater and industrial discharges, fertilizer applications to agricultural and urban lands, geology, wildlife, and atmospheric deposition. High nutrient levels contribute to stream eutrophication, creating deleterious effects such as low dissolved oxygen and stress to aquatic life, and ultimately contribute to downstream effects like gulf hypoxia.

Nutrients are among the leading causes of impairment in Tennessee streams and rivers. According to the 2012 water quality assessment, nutrients are the cause of impairment for 3,375 miles of the 13,573 miles of streams assessed as impaired, and 15,692 acres of the 181,829 acres of lakes assessed as impaired (Table B1). In Tennessee's Mississippi River Basin watersheds, 42% of miles and 99% of lake acres that are assessed as impaired include nutrients as a cause.

HUC	WATERSHED NAME	NUTRIENT-IMPAIRED STREAM MILES	NUTRIENT-IMPAIRED LAKE ACRES
08010100	Mississippi River	28.5	
08010202	NF Obion River	81.8	15,500
08010203	SF Obion River	44.3	
08010204	NF Forked Deer River	186.5	87
08010205	SF Forked Deer River	70.7	
08010206	MF Obion River		
08010207	Upper Hatchie River		
08010208	Lower Hatchie River	96.6	
08010209	Loosahatchie River	537.6	
08010210	Wolf River	123.7	
08010211	Nonconnah Creek	152.0	
TOTAL		**1,321.7**	**15,587**

Table B1. Nutrient-Impaired Waters in West Tennessee Watersheds (According to the 2012 water quality assessment, nine of eleven Mississippi River Basin watersheds are known to have streams impaired for nutrients. Empty cells indicate that watershed assessments showed no impairment due to nutrients.)

This strategy reflects the goals of EPA's March 16, 2011, Memorandum "Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions"(Stoner, 2011). The document states (under Recommended Elements of a State Framework for Managing Nitrogen and Phosphorus Pollution): "In partnership with Federal and State Agricultural partners, NGOs, private sector partners, landowners, and other stakeholders, develop watershed-scale plans that target the most effective practices where they are needed most. Look for opportunities to include innovative approaches, such as targeted stewardship incentives, certainty agreements, and nitrogen and phosphorus markets, to accelerate adoption of agricultural conservation practices. Also, incorporate lessons learned from other successful agricultural initiatives in other parts of the country."

The West Tennessee agricultural nonpoint source nutrient reduction strategy being developed aligns with the Mississippi River Gulf of Mexico Watershed Nutrient Task Force Action Plan. This action plan describes a national strategy to reduce, mitigate, and control hypoxia in the northern Gulf of Mexico and improve water quality in the Mississippi River Basin. The West Tennessee nonpoint source nutrient reduction strategy also aligns with the Mississippi River/Gulf of Mexico Hypoxia Task Force Action Item 1 which calls for development of state nutrient reduction strategies specifically targeted for states in the Mississippi River Basin, and for states to "Complete and implement comprehensive nitrogen and phosphorus strategies for states within the Mississippi/Atchafalaya River Basin (MARB) encompassing watersheds with significant contributions of nitrogen and phosphorus to the surface waters of MARB and ultimately the Gulf of Mexico."

Tennessee's approach is consistent with the *Mississippi Delta Nutrient Reduction Strategies* and the *Gulf of Mexico Alliance Action Plan II*. These principles are:

1. Promote voluntary, incentive-based, practical cost-effective actions
2. Utilize existing programs over creating new ones
3. Use adaptive management strategies
4. Identify funding gaps and funding opportunities
5. Seek out opportunities for innovative, market based solutions

In addition, the West Tennessee agricultural nonpoint source nutrient reduction strategy is built on four building blocks:

1. Work in partnership with agricultural producers, teams of stakeholders, governmental agencies, nongovernmental organizations, universities, and businesses to develop the nonpoint source portion of the Tennessee nutrient reduction framework.
2. Collaborate with stakeholders regarding other sources of nonpoint nutrient enrichment.
3. Leverage resources (budgetary, personnel, technical expertise) whenever possible, including EPA 604(b) planning grants.
4. Work with readily available data and recognize that adaptive management strategies will lead to increases in additional data.
5. Emphasize local watershed improvements, which will also provide cumulative, regional benefits for downstream waterbodies including the Gulf of Mexico.

By basing a nutrient reduction plan on a framework used by other MARB states' elements and approaches, Tennessee's agricultural nonpoint source nutrient reduction strategy will be comparable, compatible, and consistent with other Mississippi River Basin states. The benefits are:

- A common vision and path forward for nutrient reduction plans
- Improved collaboration and communication among states in designing and implementing nutrient reduction strategies
- Opportunities for leveraging state and federal resources in obtaining reductions useful to multiple basin states

USDA-NRCS and the National Institute of Food and Agriculture (NIFA) released a study of 13 projects from 2004 to 2011 as part of the overall Conservation Effects Assessment Project (CEAP). The study resulted in a fact sheet titled Insights for Developing Successful Agricultural Watershed Projects, which listed conservation and implementation lessons learned from the nationwide project:

- An effective watershed management program requires many participants working in concert, with input from key stakeholders, including farmers and others affected by water quality concerns and the actions proposed to address them
- Work at a watershed scale
- Develop and assess background information
- Define the problem
- Determine land treatment options
- Determine the human factors
- Set project objectives
- Select team members carefully

- Design the project
- Allocate and coordinate resources, including funding and personnel
- Identify and forge partnerships.
- Review project and adapt. Constant oversight and monitoring are necessary to make sure the project stays on course and to minimize the impact of errors and surprises:
- Analyze results.
- Report outcomes and highlight accomplishments.

A more complete summary of the NIFA study is in Attachment 4.

Approach

This strategy describes a suite of options that landowners can use to reduce nutrient loads. Working with the USDA-NRCS, TDA and UT-Extension will provide the technical expertise, education, and outreach necessary to implement the proven land stewardship techniques known to reduce nutrient loadings from agricultural sources. Some restoration plans will be the driving force behind listing a nutrient-impaired stream "5R" (an EPA Region 4 designation whereby streams are listed as impaired but there is a restoration plan in place, making development of a TMDL unnecessary for 6 years). The HUC-12 subwatershed will be used as an organizing unit for developing and tracking watershed restoration plans for agricultural nonpoint source nutrient reductions.

Tennessee will use an adaptive approach to nutrient reduction whereby a process is employed that continually improves management policies and practices by learning from the outcomes of previously employed policies and practices. The implementation of this approach relies heavily on voluntary, incentive-based solutions to agricultural nonpoint sources of pollution. Stakeholders have an integral role in recommending and adopting new, innovative, cost-saving solutions. Progress is judged based on stream monitoring results.

A new management planning tool to set priorities for watershed restoration is EPA's Watershed Prioritization Tool (Recovery Potential Screening Tool). This tool provides a screening method for comparing HUC-12 watersheds using ecological, stressor, and social indicator data sets. More information about the tool and its output is in Attachment 3.

Partners

Partnerships build upon the strengths of the individual partners, create a synergy, and reduce the likelihood of conflicting messages to stakeholders. Landowners working with the Tennessee Department of Agriculture Water Resources Program (administrators of the 319(h) program) and the University of Tennessee-Extension have the expertise and experience for innovative solutions and can provide the greatest opportunity for recruitment of additional participants in the agriculture community with a range of expertise and interests. As the strategy is implemented, new partners will be recruited (Table B2).

LANDOWNERS		Primary Producers (Farmers)	
GOVERNMENT	Local	Soil Conservation Districts	
		City Mayors	
		County Mayors	
		MS4s	Stormwater Managers
	State	TDEC	Water Resources
			West TN River Basin Authority
		TDA	Water Resources Program
			Division of Forestry
		TWRA	
	Federal	TVA	
		USACOE-West TN	
		USGS	
		USDA	Farm Services Administration
		USDA-NRCS	District Conservationists
UNIVERSITY	UM	Groundwater Institute	
	UT-Knoxville	CTAS	
		MTAS	
		UT Extension	
		UT Research Education Center	
		UT-WRRC	
	UT-Martin		
NGO	Watershed Associations	Friends of Reelfoot Lake Friends of the Hatchie River Wolf River Conservancy	
	The Nature Conservancy	Hatchie River Project	
	RC&D Councils		
OTHER	TACD		
	Private labs		
	Aricultural input Suppliers	Agronomic service providers Certified Crop Advisors	
	TN Farm Bureau		
	TAUD		
	NPDES Dischargers		

Table B2. Partners in West Tennessee Agricultural Nonpoint Source Nutrient Reduction Plan (**UM**, University of Memphis; **CTAS**, County Technical Assistance Service; **MTAS**, Municipal Technical Assistance Service; **NGO**, Nongovernment Organization; **USDA-NRCS**, Natural Resources Conservation Service; **RC&D**, Resource Conservation and Development; **SRF**, State Revolving Fund; **TACD**, Tennessee Association of Conservation Districts; **TAUD**, Tennessee Association of Utility Districts; **TDA**, Tennessee Department of Agriculture; **TDEC**, Tennessee Department of Environment and Conservation; **TVA**, Tennessee valley Authority; **TWRA**, Tennessee Wildlife Resources Agency; **USACOE**, U.S. Army Corps of Engineers; **USGS**, U.S. Geological Survey; **UT**, University of Tennessee; **WRRC**, Water Resources Research Center)

Action Plan

Background

a. USGS

In the report "Ecological Health in Our Nation's Streams," the US Geological Survey (USGS) conducted an intensive study of nutrient enrichment—elevated concentrations of nitrogen and phosphorus—in streams in eight agricultural basins in the conterminous United States. These studies were done to improve understanding of how nutrients influence stream ecosystems and had two primary objectives: (1) to determine the health of streams—based on assessments of the condition of biological communities—in agricultural, urban, and mixed land-use watersheds and (2) to investigate how land and water use influence the chemical and physical factors that reduce biological condition and, ultimately, stream health.

The report provides a national assessment of stream health based on the condition of biological communities in relation to the degree of changes made to streams and the concentrations of nutrients and pesticides that have made their way into the waters. Specifically, USGS scientists looked at communities of algae, macroinvertebrates, and fish to gauge the biological health of streams since they "provide a direct measure of stream health because they live within streams for weeks to years, therefore integrating through time the effects of changes to their chemical and physical environment." Algae, macroinvertebrates, and fish are the biological communities most often evaluated in water quality assessments by local, state, and federal authorities. Each of these communities represents a different functional role in the ecosystem, responds in different ways to manmade environmental change, and thus provides different and complementary perspectives on water quality and stream health.

Chemical, hydrological, and other environmental data were integrated with biological condition to examine relationships between land use and stream health. Their findings are that in urban settings, 89 percent of sites assessed had at least one altered biological community, compared with 79 percent of sites in agricultural settings and 83 percent of sites in mixed-use settings. All three biological communities were altered in 22 percent of assessed streams. At the same time, the USGS found that "nearly one in five streams in agricultural and urban areas was in relatively good health, signaling that it is possible to maintain stream health in watersheds with substantial land and water-use development."

The report concluded that the incidence of altered biological communities increased with greater agricultural or urban land development within stream riparian zones because disturbed riparian zones lose their ability to filter potentially harmful contaminants in runoff from developed upland areas, thereby increasing the risk that sediments, nutrients, and harmful chemicals will enter the stream. Biological communities, particularly algae, were more frequently altered in streams with elevated nutrients such as total nitrogen.

Nutrient concentrations in streams in urban and agricultural lands across the nation are as much as six times greater than background levels. With increasing nutrient concentrations in streams, the incidence of altered biological communities increased from 21 to 39 percent for algae, from 15 to 17 percent for macroinvertebrates, and 13 to 17 percent for fish.

Harmful effects to aquatic animals occur when elevated nutrients cause excessive growth of algae and aquatic plants, which consume oxygen in the water as they grow and decompose. Algae that flourish in streams with excess nutrients can become prolific and consume the oxygen in water, often leading to the death of aquatic animals.

b. USDA-NRCS

As part of a Conservation Effects Assessment Project (CEAP), USDA's National Institute of Food and Agriculture (NIFA) and USDA-NRCS jointly funded 13 projects to evaluate the effects of cropland and pastureland conservation practices on spatial and temporal trends in water at the watershed scale. The study resulted in a fact sheet titled CEAP-NIFA Watershed Studies: A Synthesis, which lists 13 conservation and implementation lessons learned from the nationwide project. A summary of the fact sheet is in Attachment 4.

Upon considering these lessons, Tennessee has organized the agricultural nonpoint source nutrient reduction strategy in Mississippi River Basin watersheds into 4 implementation activities that occur concurrently (BMP installation, monitoring, economics, and education/outreach).

BMPs

Agricultural conservation practices (Best Management Practices, or BMPs) include nutrient management, which refers to the application of fertilizers using the 4Rs principle; conservation tillage or continuous no-till; cover crops to reduce erosion and keep nutrients in the field; and vegetative buffers, which protect aquatic ecosystems from agricultural runoff and provide other residual benefits. USDA-NRCS promotes this through a multi-agency CEAP. Other programs include USDA Farm Bill activities such as Environmental Quality Incentive program (EQIP) which includes the National Water Quality Initiative (NWQI), Conservation Reserve Program (CRP) administered by Farm Service Agency, Wetlands Reserve Program (WRP), Wildlife Habitat Incentive Program (WHIP), Conservation Security Program (CSP), and Grassland Reserve Program (GRP). Using these agricultural management practices helps landowners improve profitability while meeting land stewardship responsibilities. Tennessee initiatives include funding for BMP implementation through the Agricultural Resources Conservation Fund and the 319 Nonpoint Source Program (administered by TDA) and the Tennessee Healthy Watershed Initiative (administered by TDEC).

a. Soil Testing

Soil testing is a cost-effective, science-based start to planning a profitable harvest. Soil tests estimate nutrients available to crops and are used to make a recommendation about how much lime and fertilizer are needed by a particular crop in a specific area of a field. A trained soil scientist can interpret soil tests and make recommendations about crop needs and how crops respond to different ratios of nutrients. Similarly to Kentucky, in Tennessee, farmers receive differing fertilizer application recommendations and projected crop yields, costs, and economic returns depending on the lab and tester. Farmers typically want to harvest a greater yield at a lower cost. One way to achieve this is to begin with soil testing followed by application of nutrients sufficient for "most profitable" yield. Sometimes called sufficiency philosophy, this approach costs the least and produces the same yield compared to more costly recommendations (for comparison, see UK Extension Publication AGR-151).

Complete and accurate soil tests are the starting point of any farm nutrient management plan. From the soil test results, base fertilizer recommendations for each field are given. Soil tests can determine current soil phosphorus levels and how much is needed for the crop to be grown. The combination of soil tests and realistic yield goals are critical to ensuring proper phosphorus fertilization and optimum yields with the benefit of lower cost of production, while protecting the environment.

Soil testing can also be beneficial to non-farm applications, such as open spaces, recreational areas, golf courses, and residential lawns and common spaces.

b. USDA-NRCS' 4Rs Principle

Nutrients should be managed properly to meet crop requirements without negatively affecting human or animal health or the quality of water resources. Landowners have long used nutrient management plans when controlling nitrogen and phosphorus applications on their land. To make progress in reducing nutrient runoff from agricultural lands, farmers are encouraged to optimize their use of fertilizers (although fertilizer management has been improving over the past two decades). 4Rs nutrient stewardship principle builds upon landowner farming expertise by utilizing the expertise of UT-Extension, TDA, and USDA-NRCS to promote the Right source, Right time, Right place, and Right amount (or rate) of nutrient application. In this way, use of the 4Rs Principle promotes a cost-effective approach to optimize use of nutrients, control nutrient runoff, and trap nutrients before they enter surface waters.

The Fertilizer Institute endorses the 4Rs principle and describes it as is a science-based approach that enhances environmental protection, expands production, increases farmer profitability, and improves sustainability. USDA-NRCS Revised Conservation Standard for Nutrient Management (CPS 590) uses the 4Rs Principle to manage nutrients for plant production, minimize agricultural nonpoint source pollution, and maintain or improve soil conditions.

Illinois has used the 4Rs principle to institute a "Keep it for the Crops by 2025" campaign. The collaborative program—directed by the Illinois agriculture community—is committed to keeping nutrients in the fields where they're needed. The program lays out a framework to promote, implement, and measure adoption of the 4R Principle by producers and agricultural retailers who provide custom nutrient applications.

Right Source. According to USDA-NRCS CPS 590, nutrient sources utilized must be compatible with the application timing, tillage and planting system, soil properties, crop, crop rotation, soil organic content, and local climate to minimize risk to the environment.

UT-Extension has published many articles on the use of fertilizers in crop management. In their publication called Fertilizers and their Use, they list nitrogen, phosphorus, and potassium as the essential plant nutrients that crops need and discuss the choices farmers have in selecting and using fertilizers for productivity and profit.

The majority of any nutrient management plan for farms with livestock will deal with a manure spreading plan. The amount of manure the farm produces has to be applied to fields in a manner that makes sense both agronomically and environmentally. Planned manure applications should be made at rates that do not exceed crop nutrient needs as identified in the soil test report. Many crop specialists try to refine fertilizer application to match crop uptake needs and minimize residual nitrogen left in the fields and recommend these considerations be taken into account:

- Make manure application part of nutrient management plan and crop plan
- Don't apply manure on frozen fields, grassed waterways, sinkholes, buffer strips, or near water wells
- Consider nitrogen and phosphorus from manure if applying additional fertilizer
- Planned manure applications should be made at rates that do not exceed crop nutrient need as identified in the soil test report

According to USDA-NRCS CPS 590, the total single application of liquid manure:

- Must not exceed the soil's infiltration or water holding capacity
- Be based on crop rooting depth

The publication "Moving Forward on Gulf Hypoxia Annual report 2009," summarizes research that USDA Agricultural Research Service (ARS) scientists from the National Soil Dynamics Laboratory in Auburn, AL did to develop a new tool that applies poultry litter to fields in shallow bands by digging shallow trenches 2-3 inches deep, places litter, then covers it with soil. The applicator is attached to a tractor and digs four shallow trenches per pass. In one test farm in Arkansas, applying this method to forage crops reduced nitrogen and phosphorus runoff by 80-95% compared to conventional broadcast application. Improved results were also observed for corn in AL, KY, and MD, and for cotton in MS and GA.

Right Time. According to USDA-NRCS CPS 590, timing and placement of all nutrients must correspond as closely as practical with plant nutrient uptake (utilization by crops), and consider nutrient source, cropping system limitations, soil properties, weather conditions, drainage system, soil biology, and nutrient risk assessment results. The practice does not allow for surface-application if nutrient losses offsite are likely. This precludes spreading:

- On frozen and/or snow-covered soils
- When the top 2 inches of soil are saturated from rainfall or snow melt

The GENERATIONS program is an innovative partnership between the Future Farmers of America and experienced farmers. Funded by EPA's Conservation Technology Information Center and Bunge International, this innovative program pairs farmers and future farmers to collect cornstalk samples and test them for nitrate content. First tried in southeast Missouri, the end-of-season cornstalk testing is a fertilizer management tool that is used with soil maps, yield maps, varietal differences, and different forms of fertilizer to help ensure famers apply enough nitrogen at the right times to reach harvest goals and improve profitability of farming operations while minimizing nitrogen washing off from fields.

Right Place. Fertilizer applied properly means taking into account the type of crop, cropping system, and soil properties so nutrients are placed where crops can get to them and where use efficiency is maximized. By working with an USDA-NRCS or UT-Extension agent, farmers can reduce nutrient loss—and improve farm profitability—by taking into account variability within the field so they meet site-specific crop needs and limit potential losses from fields (see precision agriculture section below).

Right Amount. Nitrate movement is greatest when nitrogen inputs are higher than plant requirements and in soils where water movement to groundwater is high. These soils are typically sandy type soils or those soils where the distance to groundwater is shallow. Using soil testing, famers can be assured that they match application rates with crop needs. Knowledge of crop history, in-season testing, and crop nutrient budgets all affect nutrient application rates as well as time and money spent.

c. *Tillage Practices*

No-Till. Tennessee is a leader in no-till farming. Today, over 70% of West Tennessee farmers use no-till practices which have proven to be profitable and good for the environment. One of the major reasons for this successful shift in farming practices from conventional tilling is Milan No-Till Field Day, which has been held at the UT Ag-Research and Education Center in Milan, TN since 1981.

USDA-NRCS Practice 329 describes the methods to manage the amount, orientation, and distribution of crop and other plant residue on the soil surface year round while limiting soil-disturbing activities to only those necessary to place nutrients, condition residue, and plant crops. The benefits of no-till farming listed are:

- Reduce sheet and rill erosion
- Reduce wind erosion
- Improve soil organic matter content
- Reduce CO_2 losses from soil
- Reduce soil particulate emissions
- Increase plant-available moisture
- Provide food and escape cover for wildlife
- Reduce energy use

Landowner cooperation with USDA-NRCS or UT-Extension agents can help farmers increase profitability and minimize environmental hazards by adopting no-till practices.

d. *Precision Agriculture*

Precision farming uses data to maximize farm profits and has the potential to minimize agriculture's impact on the environment. The web site hosted by the Department of Agricultural and Resource Economics at the University of Tennessee's Institute of Agriculture describes their program in precision agriculture. The web site describes the use of global positioning satellites (GPS) to adjust the management of soils and crops to precise conditions in the field. In so doing, farmers can increase profits by decreasing operating costs associated with nutrient and pest management as well as reduce the environmental hazards associated with crop production.

Grid or zone sampling of soils is required for precision agriculture because, as described in a University of Tennessee Journal of Extension publication, precision farming uses information about the differences in soil and other characteristics within a farm field to make management decisions about seed, fertilizer, lime, and chemicals more accurately. The publication by UT professors used farmer surveys to summarize the state of precision agriculture in Tennessee in 2002.

USDA-NRCS promotes precision agriculture. In the publication "Agronomy Technical Note #1," the agency points out the building blocks of a precision agriculture practice and some of the positive environmental impacts of adopting the practice that are based on the reduced or targeted placement of crop inputs such as nutrients, pesticides and water (via variable rate irrigation).

USDA-NRCS district conservationists and UT-Extension agents are available to help farmers adopt precision agriculture systems for their farms in order to save money and minimize negative environmental impacts of farming.

e. Cover Crops

Where cover crops have been used for several years, organic matter typically increases, which improves rainfall infiltration and soil water holding capacity. Cover crops also result in better rooting of the cash crop, they provide a residue blanket that reduces soil moisture loss, they help in pest management below and above the soil, and they discourage weed establishment. A video produced by USDA-NRCS that features farmers' experiences with cover crops can be viewed at http://www.brownrevolution.org/. A mix of cover crops increases cash crop yield, reduces cost, and increases profits while improving soil moisture retention which helps in the drought months. Also, legumes planted as cover crops return nitrogen to the soil lessening the amount of fertilizer needed.

The Conservation Technology Information Center (CTIC) and the USDA North Central Region Sustainable Agriculture Research and Education program (SARE) released the results of a survey of farmers who use cover crops. The key findings are:

- Corn planted after cover crops had an almost 10% increase in yield compared to side-by-side comparison of fields with no cover crops. Soybean yield increased by almost 12%.
- In the Midwest, following the drought of 2011, yields increased even greater (an additional 1-2%).
- From 2008 to 2012, the total acreage of cover crops among farmers surveyed increased 350%. An additional 39% increase is expected from 2012 to 2013.
- Farmers reported the main benefit of cover crops to be improved soil health. Additional benefits mentioned were reduced soil compaction, improved nutrient management, and reduced soil erosion.
- Agronomists reviewing the survey results noted how significant were the yield improvements in an extremely dry year.

Indiana is promoting an integrated approach to nutrient management called Conservation Cropping Systems. The approach integrates conservation tillage technologies with best management practices in nutrient management, pest management, and cover crops to improve soil health and increase profitability for farmers. USDA-NRCS in Tennessee has launched a statewide emphasis on cover crops and soil health.

f. Conservation Buffers

Conservation buffers are strips or small areas of land in permanent vegetation that can filter runoff. Buffers slow water runoff, trap sediment, and enhance water infiltration. Buffers also trap fertilizers, pesticides, bacteria, pathogens, and heavy metals, minimizing the chance of these potential pollutants reaching surface waters.

There are many kinds of buffers that landowners can use to improve and protect surface water quality, reduce soil erosion on cropland and stream banks, and provide protection and cover for livestock, wildlife, and fish. The USDA lists many types of buffers in their Program Aid document called Buffers: Common Sense Conservation. A summary of the buffer types described is in Attachment 4.

The USDA considers conservation buffers to be especially helpful in maintaining productive, profitable, and responsible farming operations, especially when combined with other proven conservation practices such as conservation tillage, nutrient management, integrated pest management, and erosion control. Erosion control practices associated with crop production help to reduce the potential of off-site impacts from sheet and rill erosion while improving soil fertility, soil health, and sustainable crop production.

g. Nutrient Transport Management

Since nutrients are transported by water, controlling nutrient-laden water before it reaches a stream may be a good nutrient load reduction approach in some cases. The way in which water is managed for agricultural purposes can have a great effect on streams. Surface water runoff of nutrients can be reduced by retaining water on fields, although this can also reduce crop production if soils become waterlogged. Three proven examples of nutrient transport management are:

1. Water Conservation:
    - Increase the potential for nitrogen removal without decreasing crop productivity by Identifying water management practices that will increase water residence time on farm field soils.
    - Reduce nutrient input requirements and satisfy crop water requirements by recycling nutrients in runoff back onto fields.
    - Evaluate soil moisture and plant turgor probes or sensors for scheduling irrigation.
2. Alternative Water Supplies:
    - Create additional onsite water storage to increase nitrogen removal, reduce runoff, reduce sediment/phosphorus loads, and provide irrigation source water by using tailwater recovery ponds and off-stream storage ponds.
3. Constructed Wetlands

The USDA has created a fact sheet about Best Management Practices for Farmers. Part of the Conservation Effects Assessment project (CEAP), the document titled Conservation Practice Implementation and Adoption to Protect Water Quality lists 11 lessons learned from the nationwide project. The 11 lessons are summarized in Attachment 4.

Tennessee will continue to promote these practices and encourage their adoption statewide, especially within those watersheds impaired by nutrients. A list of contacts is in Table B3.

GOAL	AGENCY	CONTACT
Cover Crops	UT-Extension, USDA-NRCS	frwaker@utk.edu
Precision Agriculture	UT-Extension	mbuscher@utk.edu
No-Till farming	UT-Extension	frwalker@utk.edu
Soil Testing Recommendations	UT-Extension, USDA-NRCS, Local Co-Ops	frwalker@utk.edu
State Cost Share Programs	Tennessee Department of Agriculture	john.mcclurkan@tn.gov
Federal Cost Share Programs	USDA-NRCS	carol.chandler@tn.usda.gov

Table B3. Goals and Contacts for Adopting Successful Land Stewardship Practices That Improve Water Quality

Monitoring for Successful Landowner BMP Installation

a. Trend Analysis

Trend analysis is one common way to analyze long-term water quality data. A good description of using trend analysis for agricultural nonpoint source water quality monitoring is in NWQEP

Notes Issue 135, the water quality group newsletter produced by North Carolina State University/North Carolina A&M University Cooperative Extension. Trend analysis is used to characterize and account for sources of change in a data set and to identify and quantify a trend in a statistically rigorous way. Trend analysis can illustrate steady improvements (Is water quality improving as landowners adopt no-till farming practices over time?) or sudden changes (Has water quality improved since a specific landowner installed a BMP on a specific date?). Trend analysis is best suited for situations where 1) The land treatment program has been successful in implementing BMPs over an extensive portion of the critical area, 2) Implementation occurs over several years, 3) Data collection is collected at regular intervals over the entire length of the study, and 4) Water quality change is expected to be gradual.

b. Upstream/Downstream, Paired Sites, and Before/After

Three additional approaches to analyzing success are monitoring upstream/downstream, paired sites and before/after. Upstream/downstream and paired site monitoring both consist of two sites of similar stream attributes, location, and land use. Ideally, all three approaches should include two time periods of study: monitoring for an extended length of time before BMP installation for a baseline, as well as monitoring after BMP installation. The upstream/downstream approach requires one monitoring site upstream (control) of the BMP as well as one site downstream of the BMP. The paired site approach requires use of monitoring sites on two different streams, one with a BMP installed and one without. The third approach, before/after, requires the use of only one monitoring site which is located downstream of a BMP installation. The NWQEP newsletter points out that in the short term, monitoring before and after a BMP is installed, or above and below an installed BMP, may be more appropriate than trend analysis because it directly accounts for the influences of climate and hydrology in short-term studies.

All three approaches assume that the only change over time is the installation of a BMP. Advantages of these monitoring approaches include 1) ability to attribute water quality changes to a specific land practice and 2) shorter time frame to see results than with trend analysis.

Economics

The USDA has created a fact sheet about the economics of conservation practices on farms and the factors that increase the chance that a farmer will adopt conservation practices. Part of the Conservation Effects Assessment project (CEAP), the document titled How Farmers and Ranchers Make Decisions on Conservation Practices lists 12 lessons learned from the nationwide project. A summary of these lessons is in Attachment 4.

Nutrient Trading. The USDA's Office of Environmental Markets partnered with Willamette Partnership to publish "In it Together: A How-To Reference for Building Nonpoint Water Quality Trading Programs." In the document, the USDA proposes that the quantification of ecosystem services and development of ecosystem markets present opportunities for funding voluntary conservation practices on private lands. USDA-NRCS has followed this up with two web-based tools: Nutrient Tracking Tool and Water Quality Index for Agriculture, which help landowners get an indication of the benefits of land management changes by comparing current practices with hypothetical new ones.

In states of the Ohio River Valley (Ohio, Indiana, and Kentucky), nutrient trading between electric power providers and farmers is underway. Partners entered a water quality trading pilot program in which farmers earned income from power producers by reducing nutrient-loaded runoff from fields and selling them as credits. Updates on ORSANCO (Ohio River Sanitary

Commission) trading activities is on the web at http://www.orsanco.org/nutrient-reduction-activities.

Education and Outreach

The USDA has created a fact sheet about educating land owners about conservation practices. Part of the Conservation Effects Assessment project (CEAP), the document titled Effective Education to Promote Conservation Practice Adoption lists 10 lessons learned from the nationwide project.

The USDA fact sheet concludes that, in order to be effective, outreach programs must be carefully tailored to the target audience(s); clearly communicate the issues, needs and opportunities; be consistent; and reach the audience. A summary of the report is available in Attachment 4.

Tennessee's approach is consistent with the lessons listed in the USDA fact sheet. Tennessee will actively engage the public in order to communicate where high nutrient loads impair water quality and to work collaboratively to find solutions. TDEC will use watershed meetings and social media to request feedback and to develop an enhanced understanding of program objectives and approaches among stakeholders. Facilitating stakeholder actions that lead to improved water quality range from watershed meetings and meetings with landowners to technical engagement with TDA, USDA-NRCS, and UT-Extension staff. Tennessee will also use group educational experiences as well as one-on-one education; both coordinated by UT-Extension, local USDA-NRCS District Conservationists, and soil conservation district staff as well as field days, fact sheets, and specialty seminars at UT-Extension field stations. Whenever possible, education is led by farmer groups.

Tennessee will use education and outreach opportunities in the following ways:

Encourage practices that will reduce nutrient loading:

- Farmer-to-Farmer training
- Incentives for Soil Testing and promotion of "most profitable yield" concept
- Multi-year farm scale nutrient studies
- Cost Share incentives focused on nutrient management

Assist landowners to reduce nutrient loading voluntarily

- TDA—Grants for cost-share funding, applied research, and peer-to-peer events
- USDA-NRCS—Cost share funding and technical assistance for implementation
- UT-Extension—Economic analysis, training, and education

Focus education/outreach activities:

- Targeted watersheds impaired by nutrient enrichment
- Tailor education/outreach based on UT-Extension experiences with landowners
- Track implementation of voluntary agricultural conservation practices in order to account for nutrient reductions

Account for nutrient reductions by tracking implementation of the voluntary conservation practices:

- TDA will run the STEP L model for all completed conservation practices

- TDA will report on the cumulative nitrogen, phosphorus, and sediment load reductions
- TDA will conduct educational events that include evaluations/surveys to assess the level of landowner's knowledge and adoption of BMPs

Action Items

Milestones for addressing agricultural nonpoint sources in Mississippi River watersheds:

5 Years:
Engage general public in 30% of Mississippi River Basin watersheds
Develop 10 watershed plans (EPA Region 4 5R restoration plans)

10 Years:
Engage general public in 100% of Mississippi River Basin watersheds
Engage 25% of farmers in Mississippi River Basin watersheds
Develop 25 watershed plans (EPA Region 4 5R restoration plans)

15 Years:
Engage 50% of farmers in Mississippi River Basin watersheds
Increase percentage of farmers who test soils by 25%
Increase percentage of farmers who use cover crops by 25%
Develop 50 watershed plans (EPA Region 4 5R restoration plans)

A summary of action items and their status is presented in Table B4.

ACTION	LEAD	DETAILS	STATUS
Form partnership	TDEC, TDA, UT-Extension	Establish organizing committee	Completed
Engage USDA-NRCS	TDA	Brief USDA-NRCS State Conservationist	Completed
Engage Farm Bureau	TDA	Briefing at TN Farm Bureau Office	Completed
Engage agriculture agencies/organizations	TDA, UT-Extension	FSA, SCDs, Co-ops	Ongoing
Engage farmers	TDA, UT-Extension	Meetings in 2013-2015	Ongoing
Engage all stakeholders in watershed	TDEC	Meetings beginning in 2013	Ongoing
Expand partnership to other agencies	TDEC, TDA, UT-Extension	USDA-NRCS, TWRA, WTRBA , USACOE, USGS	Ongoing
Technical Assistance to farmers	TDA, UT-Extension	319 program, ARCF program, EPA grants, USDA Farm Bill programs	Ongoing
Field days	UT-Extension	Milan No-till, cover crops	Ongoing
On-farm demonstrations	TDA, UT-Extension	SCD field days, USDA-NRCS soil health demonstrations	Ongoing
One-on-one farm visits	UT-Extension	Ongoing extension programs	Ongoing
Work with USDA-NRCS to select NWQI watersheds	TDEC, TDA	Meet annually to select HUC-12	Ongoing
Partner with other universities	TDEC, TDA, UT-Extension	UM, UT-M, UT-K WRRC	Planning
Engage watershed groups	TDEC	Friends of Reelfoot Lake, TNC (Hatchie River), Wolf River Conservancy	Planning
Engage local officials/government	TDEC, TDA, UT-Extension	County mayors, city mayors, MS4s	Planning
Leverage other programs/monies	TDEC, TDA, UT-Extension	NWQI, 604(b) planning grants, SRF	Planning
Develop Restoration Plans	TDEC	EPA 5R	Planning

Table B4. Action Items for Agricultural Nonpoint Source Nutrient Reduction Strategy (**ACRF**, Agricultural Resource Conservation Fund; **CCPI**, Cooperative Conservation Partnership Initiative; **CIG**; Conservation Innovation Grant; **FSA**, Farm Services Agency; **MS4**, Municipal Separate Storm Sewer System**; USDA-NRCS**, Natural Resources Conservation Service; **NWQI**, National Water Quality Initiative; **SRF**, State Revolving Fund, **TDA**, Tennessee Department of Agriculture; **SCD**, Soil Conservation District; **TDEC**, Tennessee Department of Environment and Conservation; **TNC**, The Nature Conservancy; **TWRA**, Tennessee Wildlife Resources Agency; UM, University of Memphis; **USACOE**, United States Army Corps of Engineers; **USGS**, United States Geological Survey; **UT**, University of Tennessee; **UT-K WRRC**, University of Tennessee at Knoxville Water Resource Research Center; **UT-M**, University of Tennessee at Martin; **WTRBA**, West Tennessee River basin Authority)

Summary

The Tennessee Department of Environment and Conservation (TDEC), the Tennessee Department of Agriculture (TDA), and the University of Tennessee Extension (UT-Extension) met in April 2010 to begin the process of developing an agricultural nonpoint source nutrient reduction strategy for watersheds in Tennessee's Mississippi River Basin which will be a component of the larger Tennessee nutrient reduction framework being developed. Discussions at regularly scheduled monthly conference calls as well as in-person meetings, and supported by an EPA 104(b)(3) grant, have led to the development of this draft document. The document will be reviewed by stakeholders including agricultural producers, US Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS), Nongovernmental Organizations (NGOs), universities, and watershed groups. In the initial phase of the Tennessee strategy to reduce nutrient loading from agricultural nonpoint sources in the Mississippi River Basin Watersheds, a state-level organizing committee composed of TDEC, TDA, and UT was formed to set milestones:

- Develop the process used for implementation of West Tennessee agricultural nonpoint source nutrient reductions under the statewide nutrient reduction framework.
- Engage farmers to take a leadership role in development of the agricultural nonpoint source nutrient reduction strategy, and engage other appropriate stakeholders to address other sources of potential nonpoint source nutrient enrichment.
- Engage the general public to promote the agricultural nonpoint source nutrient reduction strategy.
- Begin, maintain, and track implementation of the agricultural nonpoint source nutrient reduction plan.
- Fully integrate this strategy into the Tennessee Nonpoint Source Management Program EPA §319(h) program).

The Committee has met monthly since 2010 to develop this strategy.

The West Tennessee nonpoint source agricultural nutrient reduction strategy focuses on a process that is results-oriented and promotes stakeholder involvement by building upon proven land stewardship practices that are known to improve water quality. The process capitalizes on the success of other states and 1) is watershed-based, 2) relies on voluntary, incentive-based solutions for agricultural nonpoint source nutrient reductions, and 3) uses adaptive management for long-term corrective actions.

The West Tennessee agricultural nonpoint source nutrient reduction plan is composed of four components: 1) Best Management Practices, 2) monitoring, 3) economics, and 4) education and outreach. The West Tennessee strategy will be followed by additional strategies for the Cumberland River and Upper and Lower Tennessee River Basins. The Mississippi River Basin was chosen first because of the relatively high percent of land use used for farming compared to the rest of the state, and the historic willingness of farmers to enroll in nutrient runoff reducing practices like no-till farming. Lessons learned from applying the agricultural nonpoint reduction strategy in West Tennessee will be applied to the Cumberland and Tennessee Basins.

Glossary and Web Links

305(b). The section of the Clean Water Act that describes the requirement for states to submit a report on the status of water quality. The 305(b) report is submitted to EPA every two years.

319(h). The section of the Clean Water Act that describes funding mechanisms for states to control nonpoint sources of pollution. The 319(h) program is administered by the Tennessee Department of Agriculture. More information is available at http://www.tn.gov/agriculture/water/nps.shtml.

5R. A use support category for which a restoration plan is approved by EPA Region 4. TMDLs may be delayed for up to six years in 5R streams in order to allow time to demonstrate success.

604(b). The section of the Clean water Act that reserves funds for states to conduct planning for pollution reduction. Tennessee issues 604(b) planning grants to regional development districts on a yearly basis.

ACRF. Agricultural Conservation Research Fund. The Fund is administered by the Tennessee Department of Agriculture and makes payments to Tennessee landowners to install Best Management Practices that reduce agricultural water pollution. More information is available on the web at http://www.tn.gov/agriculture/water/arcf.shtml.

Adaptive Management. A systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices.

Agricultural Producers. Those who work on or manage farms.

Basin. In this document, a Basin is a group of contiguous watersheds.

BMP. Best Management Practice. Systems, activities or structures that can be employed to prevent nonpoint source pollution. BMPs are called Conservation Practices by USDA-NRCS.

CCPI. Cooperative Conservation Partnership Initiative. CCPI is a voluntary conservation initiative administered by the Natural Resources Conservation Service that enables the use of certain conservation programs along with resources of eligible partners to provide technical and financial assistance to owners and operators of agricultural and nonindustrial private forest lands. More information is available at: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/ccpi/.

CEAP. Conservation Effects Assessment Project. A multiagency program that measures environmental effects of conservation programs that guide USDA conservation policy and program development in order to help farmers make more informed conservation decisions. More information is available at: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/ceap/.

CIG. Conservation Innovation Grant. Funded by USDA-NRCS, CIG provides funding through several programs. More information is available at: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/cig/.

Committee. The oversight committee composed of Tennessee Department of Agriculture, Tennessee Department of Environment and Conservation, and University of Tennessee Extension.

CRP. Conservation Reserve Program. A program administered by the Farm Service Agency with technical guidance from the Natural Resources Conservation Service as part of their implementation of the Federal Farm Bill. CRP is a voluntary program that provides incentives and assistance to landowners to address soil, water, and related natural resource concerns on their property in an environmentally beneficial and cost-effective manner. CRP encourages landowners to convert highly erodible cropland and other environmentally sensitive areas to permanent cover. More information is available at: http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp.

CTAS. County Technical Assistance Service. A part of the UT Institute for Public Service that promotes better county government through direct assistance to county officials and their associations. More information is at http://www.ctas.utk.edu/public/web/ctas.nsf/FrontPage?readform.

EQIP. Environmental Quality Incentives Program. A program administered by the Natural Resources Conservation Service as part of their implementation of the Federal Farm Bill. EQIP is a voluntary program that supports agricultural production and environmental quality as compatible goals. Through EQIP, farmers can receive financial and technical assistance with manure storage and conservation practices. More information is available at: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/.

Eutrophication. An increase in the concentration of chemical nutrients in an ecosystem to an extent that it increases the primary productivity of the ecosystem. Eutrophication is often associated with negative effects such as a dramatic decrease in oxygen concentration, an increase in algal mats, and a decline in aquatic organisms.

FSA. Farm Service Agency. The mission of the Farm Services Agency is to serve all farmers, ranchers, and agricultural partners equitably through the delivery of effective, efficient agricultural programs for all Americans. The Farm Services Agency administers the Department of Agriculture's Conservation Reserve Program (CRP). More information is available at: http://www.fsa.usda.gov/FSA/webapp?area=home&subject=landing&topic=landing.

Groundwater. Water stored in water-saturated layers of underground rock, sand, or gravel below the water table.

HUC. Hydrologic Unit Code. HUCs are assigned to drainage areas by the United States Geological Survey. HUCs are usually described as HUC-8 (larger) or HUC-12 (smaller). There are 55 HUC-8 watersheds that are all or partially within Tennessee (11 in the Mississippi River Basin). HUC-8 areas range from 71 to 2,892 square miles. There are 1,112 HUC-12 watersheds that are all or partially in Tennessee. HUC-12 areas range from <5 to 126 square miles.

Hypoxia. Reduced dissolved oxygen content of a body of water detrimental to aerobic organisms.

MARB. Mississippi/Atchafalaya River Basin.

MTAS. Municipal Technical Assistance Service. A part of the UT Institute for Public Service that promotes better municipal government through direct assistance to municipal officials and their associations. More information is available at http://www.mtas.tennessee.edu/web2012.nsf/Web/Home.

NGO. Nongovernmental Organization. A legally constituted group organized at the local, state, or national level that operates independently from the government.

NIFA. National Institute of Food and Agriculture. More information is available at: http://www.csrees.usda.gov/.

Nonpoint Source. Pollution sources that are not distinct and are diffuse or distributed over large areas. Nonpoint source pollution is usually associated with precipitation events.

Nonpoint Source Nutrient Reduction Strategy. Part of Tennessee's Nutrient Reduction Framework that describes approaches to reduce nutrient loads from nonpoint sources.

NPDES. National Pollutant Discharge Elimination System. A program by which the Tennessee Department of Environment and Conservation issues permits for the release of wastewater to state surface waters such that the federal Clean Water Act and state water quality criteria are supported.

USDA-NRCS. Natural Resources Conservation Service, an agency of the federal Department of Agriculture responsible for administering the Farm Bill. More information is available at: http://www.nrcs.usda.gov/wps/portal/nrcs/site/national/home/.

Nutrient. Nitrogen and phosphorus. In this document, "nutrients" includes all the forms (species) of these elements.

NWQI. National Water Quality Initiative. A program administered by USDA-NRCS as part of EQIP. NWQI targets small watersheds to help producers implement systems of conservation practices to reduce nutrient and sediment losses from farms. More information is available at: http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/financial/eqip/?cid=STELPRDB1047761.

RC&D. Resource Conservation and Development. RC&D councils are 501(c)(3) organizations that identify unmet conservation needs in their communities and work with USDA-NRCS to solve them through a wide range of actions. More information is available through the National Association of RC&D Councils at http://narcdc.org/membership.html.

Runoff. Water flow that occurs when soil is saturated to full capacity and excess water from precipitation or other sources flows over the land.

Sediment. Naturally-occurring fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits and is transported by, suspended in, or deposited by, flowing water.

SRF. State Revolving Fund. SRF is a Tennessee Department of Environment and Conservation program that administers both the Clean Water State Revolving Loan Fund and The Drinking Water State Revolving Loan Fund. SRF makes loans to cities, counties, utility districts, and water/wastewater authorities. More information is available at http://state.tn.us/environment/water/fund.shtml.

Stakeholder. Any individual or organization that has a vested interest in water management activities.

TACD. Tennessee Association of Conservation Districts. TACD promotes the programs of Tennessee;s Soil Conservation Districts. More information is available at: http://tnacd.org/.

TAUD. Tennessee Association of Utility Districts. An association that provides the highest quality technical, legal, and operational support to assist its members in delivering safe and efficient services in the public interest. More information is available at http://www.taud.org/.

TDA. Tennessee Department of Agriculture. More information is available at: http://www.tn.gov/agriculture/.

TDEC. Tennessee Department of Environment and Conservation. More information is available at: http://state.tn.us/environment/.

TVA. Tennessee Valley Authority. More information is available at http://tva.gov/.

TWRA. Tennessee Wildlife Resources Agency. More information is available at http://tn.gov/twra/.

USACOE. U.S. Army Corps of Engineers. More information is available at: http://www.lrn.usace.army.mil/Missions/Regulatory/DistrictBoundaries/Tennessee.aspx.

UM. University of Memphis. More information is available at http://www.memphis.edu/.

USDA. United States Department of Agriculture. The Department of Agriculture houses the Natural Resources Conservation Service. More information is available at: http://usda.gov/wps/portal/usda/usdahome.

USGS. United State Geological Survey. USGS is an agency of the federal Department of the Interior that functions as a fact-finding research organization with no regulatory responsibility. More information is available at http://www.usgs.gov/.

UT-Extension. University of Tennessee-Extension. UT-Extension is the outreach unit of the Institute of Agriculture. More information about UT-Extension is available at: https://utextension.tennessee.edu/Pages/default.aspx.

UT-M. University of Tennessee at Martin. More information is available at http://www.utm.edu/.

Watershed. The entire land area that ultimately drains into a particular watercourse or body of water. Watersheds can be many different shapes or sizes. Everyone lives in a watershed.

WRRC. Water Resources Research Center. The University of Tennessee WRRC serves as a primary link among water-resource experts in academia, government, and the private sector. More information is available at http://isse.utk.edu/wrrc/.

WTRBA. West Tennessee River Basin Authority. More information is available at:

http://www.tn.gov/environment/board_west-tn-river-basin-authority.shtml.

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Mississippi Delta Nutrient Reduction Strategies
http://www.deq.state.ms.us/mdeq.nsf/pdf/WMB_MississippiDeltaNutrientReductionStrategies/

Mississippi River/Gulf of Mexico Nutrient Task Force Action Plan
http://www.epa.gov/owow_keep/msbasin/actionplan.htm

Insights for Developing Successful Agricultural Watershed Projects
http://www.soil.ncsu.edu/publications/NIFACEAP/Factsheet_1.pdf

EPA Recovery Potential Screening Tool
http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/recovery/overview.cfm

Ecological Health in Our Nation's Streams
http://pubs.usgs.gov/circ/1391/pdf/circ1391.pdf

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http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1047813.pdf

Gulf of Mexico Alliance Governors' Action Plan II
http://gulfofmexicoalliance.org/pdfs/ap2_final2.pdf

Kentucky Cooperative Extension Service report "Evaluating Fertilizer Recommendations"
http://www.ca.uky.edu/agc/pubs/agr/agr151/agr151.pdf

4Rs Principle
http://www.tfi.org/introduction-fertilizer/environmental-stewardship/4r-nutrient-stewardship

USDA-NRCS Conservation Practice Standard for Nutrient management (CPS 590)
http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1046433.pdf

Illinois Keep it for the Crops Program
http://www.agprofessional.com/news/Keep-it-for-the-Crop-by-2025-nutrient-stewardship-program-announced--129085803.html

Tennessee Watershed Water Quality Management Plans
http://tn.gov/environment/watersheds/wsmplans/

Fertilizers and Their Use
https://utextension.tennessee.edu/publications/Documents/PB1637.pdf

Urea Fertilizer fact Sheet from University of Arkansas Research and Extension
http://www.uaex.edu/Other_Areas/publications/PDF/FSA-2169.pdf

Moving Forward on Gulf Hypoxia: Annual Report 2009
http://water.epa.gov/type/watersheds/named/msbasin/upload/Hypoxia_Task_Force_Annual_Report_2009.pdf

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http://www.ctic.org/Partners%20Magazine/2010/December/31/

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http://www.soil.ncsu.edu/publications/NIFACEAP/Factsheet_2.pdf

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http://milan.tennessee.edu/MNTFD/

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http://efotg.sc.egov.usda.gov/references/public/WI/329.pdf

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http://economics.ag.utk.edu/precisionag.html

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http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1043474.pdf

USDA-NRCS publication “Conservation Practices that Save: Precision Agriculture”
http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_023626.pdf

Link to video on soil health
http://www.brownrevolution.org/

Effective Education to Promote Conservation Practice Adoption
http://www.soil.ncsu.edu/publications/NIFACEAP/Factsheet_4.pdf

2012-2013 Cover Crop Survey
http://www.northcentralsare.org/content/download/70390/998785/file/SARECTIC%20CC%20Survey%20Report%20V2.8.pdf.

Conservation Cropping Systems
http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_030490.pdf

Buffers: A Common-Sense Approach (USDA Program Aid Publication 1615)
http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_015533.pdf

Conservation Practice Implementation and Adoption to Protect water Quality
http://www.soil.ncsu.edu/publications/NIFACEAP/Factsheet_2.pdf

NWQEP Notes Issue 135
http://www.bae.ncsu.edu/programs/extension/wqg/issues/notes135_monotonic_trends.pdf

In it Together: A How-To Reference for Building Nonpoint Water Quality Trading Programs
http://willamettepartnership.org/in-it-together/

USDA-NRCS Nutrient Tracking Tool
http://willamettepartnership.org/ecosystem-credit-accounting/nutrient-tracking-tool

Water Quality Index for Agriculture
http://www.waterefficiency.net/WE/Articles/WQIAG_Water_Quality_Index_for_Runoff_Water_From_Ag_19046.aspx

ORSANCO web site
http://www.orsanco.org/nutrient-reduction-activities

Water Quality Index for Runoff Water from Agricultural Lands Tool
ftp://ftp.wcc.nrcs.usda.gov/wntsc/WQI/RunoffWaterQualityIndex.pdf

Additional References

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http://ccsin.iaswcd.org/

EPA Website on Cover Crops for Agricultural Nonpoint Source Control
http://water.epa.gov/polwaste/nps/agriculture/covercrops.cfm

EPA's Agriculture Website
http://www.epa.gov/agriculture/index.html

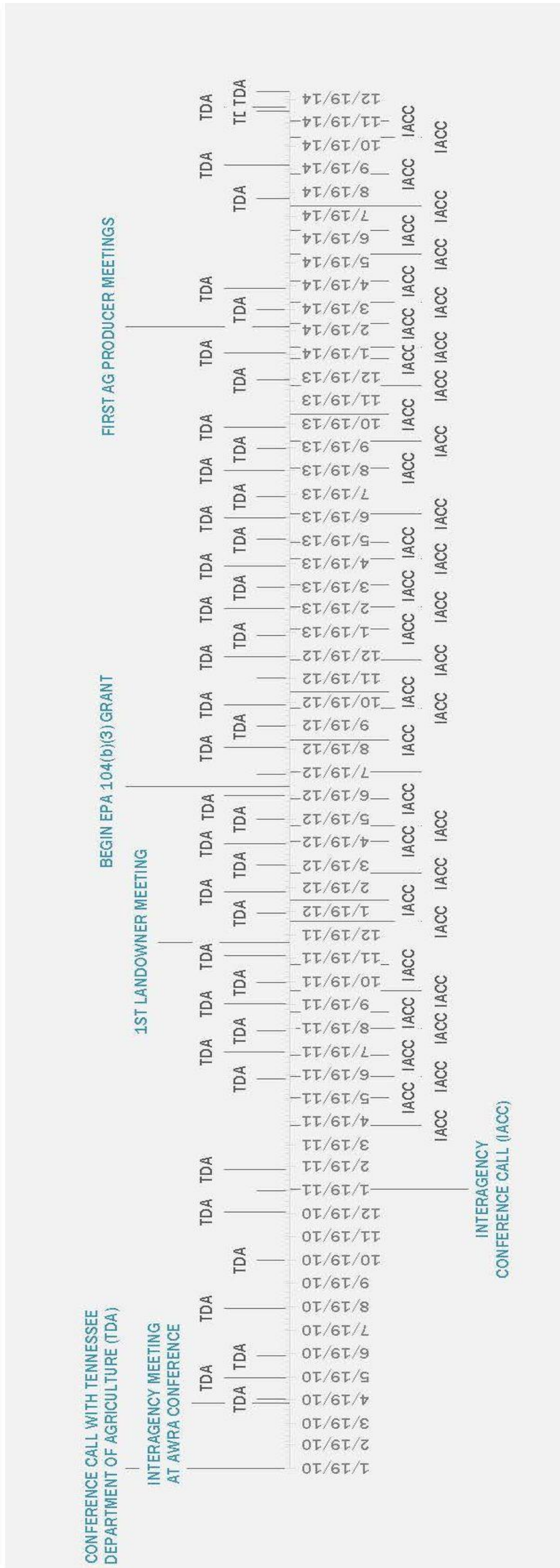
EPA's Nutrient Pollution Website
http://www2.epa.gov/nutrientpollution

USDA NRCS's Soil Health Website
http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/

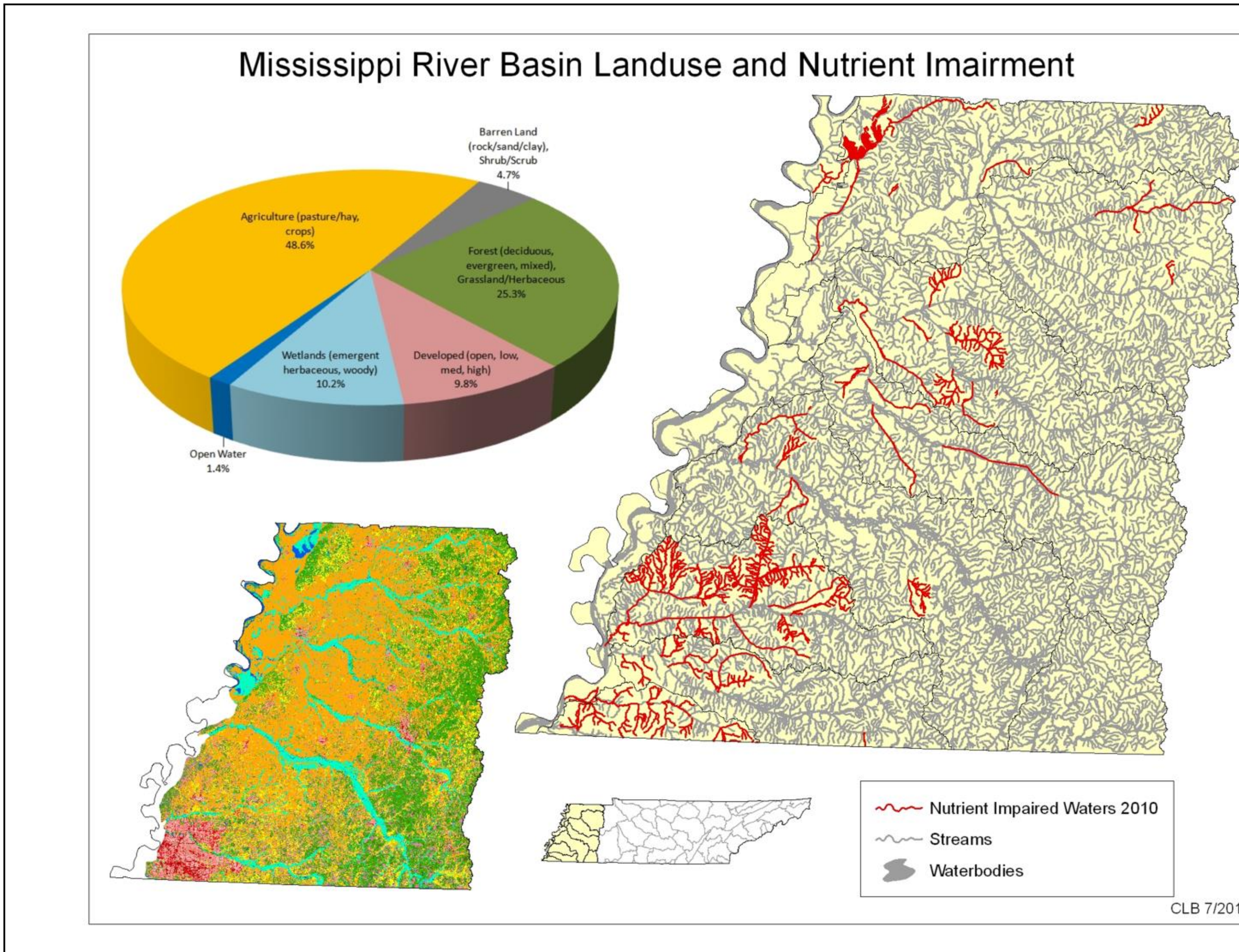
A link to USDA NRCS's new Cover Crop Termination Guidelines
http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/crops/?cid=stelprdb1077238

USDA Publications
http://wqic.nal.usda.gov/publications/dynamic-bibliographies

Attachment B1. Timeline of Interagency Meetings



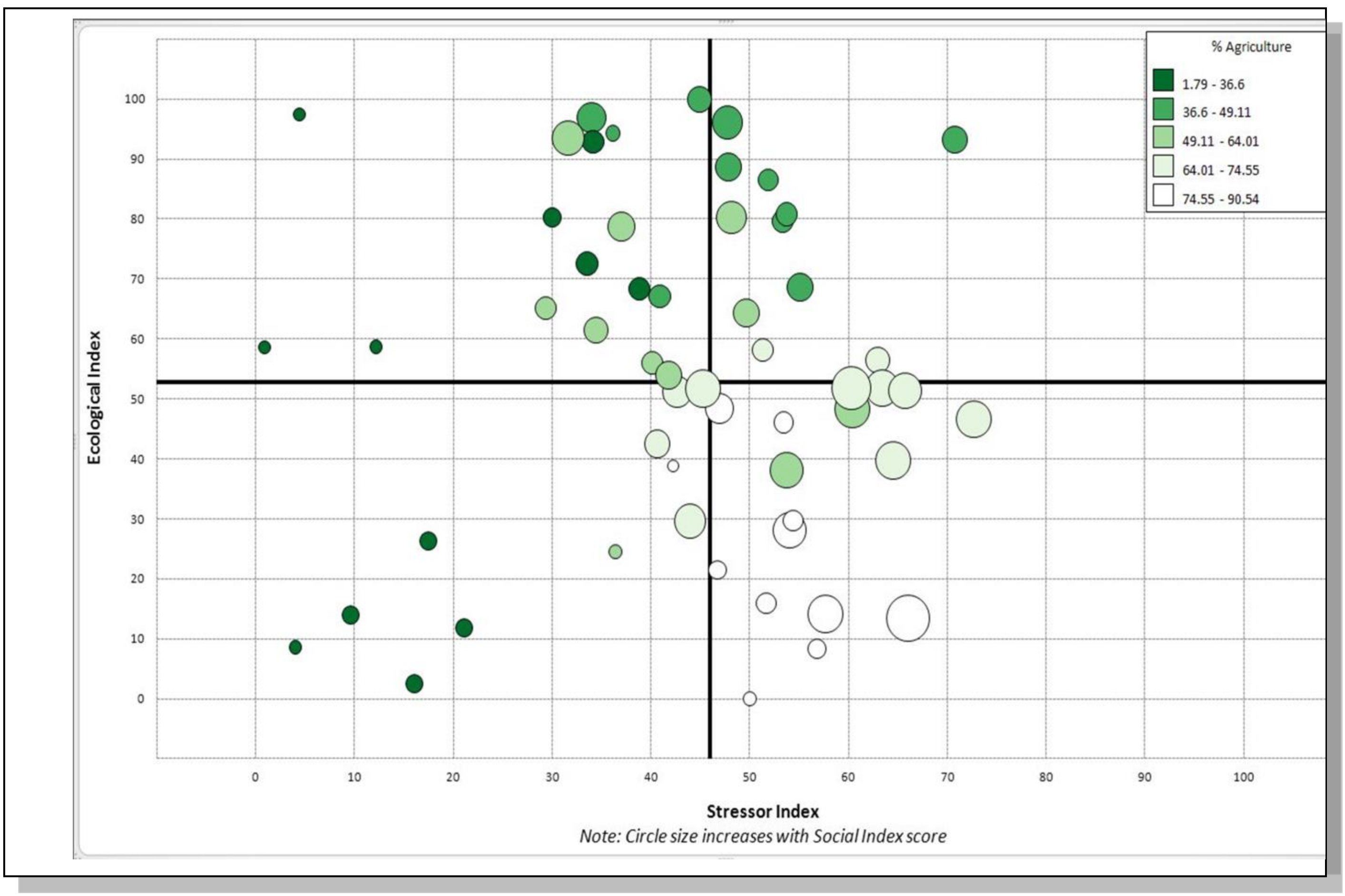
Attachment B2. Land Use in Tennessee's Mississippi River Basin Watersheds



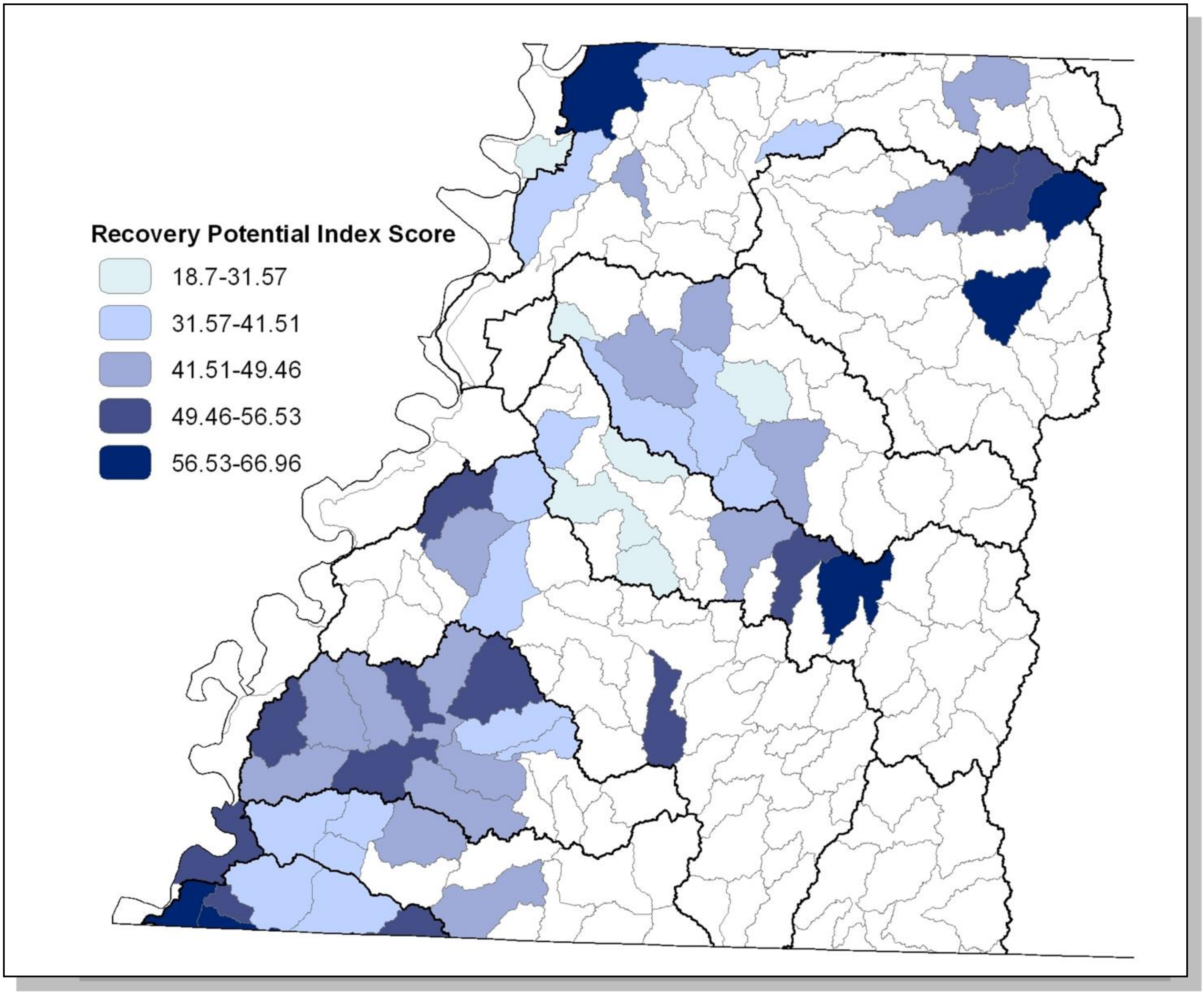
Attachment B3. EPA's Watershed Prioritization Screening Tool

EPA's watershed protection Screening Tool provides a screening method for comparing HUC-12 watersheds using ecological, stressor, and social indicator data sets. The Bubble Plot shown below is an example of a product the tool EPA's Watershed Prioritization Tool (Recovery Potential Screening Tool) can generate. In this example, only nutrient-impaired watersheds in West Tennessee (Mississippi River Basin watersheds) were considered. Ecological indicator scores (in this example, % natural cover of stream corridor in HUC-12 subwatershed) are plotted against stressor indicator scores (in this example, impaired stream length and % of HUC-12 in agriculture in the subwatershed). The size of the bubbles reflect the social indicator scores (in this example, number of existing 319 projects, aggregated number of USDA-NRCS projects, and jurisdictional complexity in the HUC-12). The darkest colored bubbles represent the HUC-12s least impacted by agriculture, while the lightest colored bubbles illustrate the most impacted. Bubbles in the upper left quadrant represent HUC-12s with high ecological value and low stressor pressure, so these HUC-12s should be maintained. Bubbles in the lower right quadrant represent HUC-12s with low ecological value and high stressor pressure, so these HUC-12s are candidates for improvement. The largest bubbles in the lower right quadrant that are closest to the axes are the best candidates for restoration because they are expected to respond the most with modest intervention.

Bubble Plot of Nutrient-Impaired HUC-12s in West Tennessee Watersheds



The same data are shown in map form below (HUC-12 subwatersheds with darker blue colors represent greater likelihood of success).



Attachment B4. Summaries of cited studies

<u>NFI's Insights for Developing Successful Agricultural Watershed Projects:</u>

- An effective watershed management program requires many participants working in concert, with input from key stakeholders, including farmers and others affected by water quality concerns and the actions proposed to address them.
- Work at a watershed scale:
    - The smaller the area, the greater the ability to determine the effects of conservation practices on water quality.
    - Lag times between treatment and response may be shorter in small watersheds than in large watersheds.
    - Tracking land management and conservation practices, and controlling for other sources of pollutants, are easier in small watersheds
- Develop and assess background information
- Define the problem
- Determine land treatment options:
    - What are the agricultural practices contributing to the water quality problem?
    - What conservation practices exist to address the water quality problem?
    - Are available conservation practices functional and adaptable to local production systems?
- Determine the human factors:
    - What individual and community characteristics contribute to the problem?
    - What individual and community characteristics contribute to the potential solutions?
- Set project objectives:
    - Water quality outcomes (protect drinking water sources, restore a fishery, meet water quality standards, etc.)
    - Conservation practice implementation (number of practices installed, prioritized locations, acres treated, change in agrichemical use)
    - Water quality monitoring (e.g., annual pollutant load, storm event concentration, detection of change over time)
    - Watershed modeling (e.g., role of modeling, hypothesis to be tested)
    - Socioeconomic analysis (e.g., approaches promoting conservation adoption, education, outreach activities)
- Select team members carefully
- Design the project:
    - Land treatment. Select conservation practices that control the pollutant(s) of concern and their sources. It is important to think through conservation practices not only as individual measures, but also considering the system as a whole. The best conservation practices simply will not do the job if they do not treat the right problem.
    - Critical pollutant source areas must be identified prior to implementing conservation practices, and all conservation practices need to be prioritized to these critical areas.
    - Water quality monitoring. Design a monitoring strategy to detect change in pollutant concentration or load in response to land treatment:
        - Monitor water quality variables that best match the water quality problem, the pollutant sources, and the conservation practices being implemented. Look for creative or alternative indicators of response to treatment.
        - Understand watershed hydrology to guide effective monitoring.

        - Select monitoring designs such as paired watersheds, above/below, or multiple sub-basins that can control for effects of weather and other sources of variability.
        - Establish the statistical design for monitoring at the outset. In many cases, it is important to collect background data by monitoring before land treatment begins.
        - Follow good monitoring practices that provide accurate measurements of desired parameters often enough to be capable of detecting response to treatment.
        - Coordinate monitoring activities in a comprehensive quality assurance and quality control program that assures the collection of useful data of high and consistent quality.
    - Land treatment monitoring. No matter how rigorous the water quality monitoring program, it will be impossible to link observed changes in water quality to land treatment without rigorous monitoring of conservation practice implementation and management activities.
    - Modeling. Model application for conservation assessment and planning at the watershed scale must address these concerns:
        - Select a model based on its ability to represent essential characteristics of the system and land treatment options at desired spatial and temporal scales. Consider also the availability of hydrologic and water quality data along with watershed data, such as chemical usage and conservation practices, that are required to run the model.
        - Adopt procedures for model parameterization, calibration and validation, and evaluation of uncertainty.
        - Develop a formal Quality Assurance Project Plan (QAPP) for model application prior to conducting the effort.
        - Provide adequate technical and personnel support for the modeling effort.
    - Socioeconomic analysis. Use knowledge of social and economic conditions in the watershed to identify factors that influence farmers' adoption of conservation practices, to develop cost-share approaches and other incentives, and to leverage institutional influences on conservation. Plan economic modeling to evaluate real trade-offs between conservation and farm finances and to apply the results of economic analysis to support project goals.
    - Outreach. Develop a comprehensive outreach education plan with goals, objectives, target audiences, implementation strategies, and responsibilities at the beginning of the project, and adjust the plan as the project proceeds. Provide opportunities for one-on-one education, coordinated by a trusted educator experienced in local farming practices and respected in the community. Farmer-led groups can be very effective. Integrate outreach education into the overall project leadership team.

- Allocate and coordinate resources, including funding and personnel:
    - Focus particular attention on assembling personnel with the knowledge and skill to conduct the monitoring, modeling, and other technical project activities.
    - Establish the proper sequence for project activities so that all project components have required information at the proper time.
    - Integrate water quality monitoring, simulation modeling, and conservation practice implementation into coordinated activities that encourage communication and feedback among participants throughout the project.

- Identify and forge partnerships. Partnerships are essential for all aspects of the project to work together. Identify and engage watershed stakeholders and key partners during the planning stage, including local farmers, government agencies, universities and watershed groups.
- Review project and adapt. Constant oversight and monitoring are necessary to make sure the project stays on course and to minimize the impact of errors and surprises:
    - Review status and collected data regularly to assess progress as project activities continue.
    - Make changes to appropriate project activities based on the review.
    - Build in frequent communication and feedback opportunities so that problems can be addressed quickly and project work adapted to changing situations.
- Analyze results. Careful data analysis and interpretation are required to turn data into information:
    - Analyze collected data to address project objectives using appropriate tools.
    - Characterize confidence levels and uncertainties as they apply to conclusions drawn from the data.
- Report outcomes and highlight accomplishments. Conveying project results in a useful manner is the final step and critically important. The audience is diverse, and a variety of methods and channels are needed to deliver findings:
    - Allocate adequate time and resources for effective reporting of project results to the scientific community, watershed farmers, resource managers, and other stakeholders.
    - Use a broad spectrum of reporting media; do not rely only on individual journal articles or printed reports to communicate the project's important outcomes.
    - Actively extend project findings to local, regional, and national stakeholders.

<u>CEAP-NIFA Watershed Studies: A Synthesis</u>:

- With dwindling resources and mounting environmental degradation, it is essential that lessons from (past projects) be integrated into policy and agency protocol if water resources are to be protected or improved.
- Conservation planning must be done at the watershed scale with sufficient water quality data and, if available, modeling information.
- Before implementing conservation practices, identify the pollutants of concern and the sources of the pollutants.
- Identify the critical source areas of the watershed—those that generate the most pollution—and prioritize conservation practices in those areas to ensure the most effective use of resources.
- Identify farmers' attitudes within the watershed toward agriculture and conservation practices to promote adoption.
- After conservation practices have been adopted, continue to work with farmers on their maintenance and sustained use.
- Economic incentives were often required for adoption of conservation practices not obviously profitable or compatible with current farming systems.
- Technical assistance to farmers is most effective when delivered by a trusted local contact; however, it is very people intensive. Reduced funding is eroding the ability of USDA-NRCS, Extension, and Soil and Water Conservation Districts to deliver effective programming.
- Conservation practice adoption is a multivariate choice. Although economics are exceptionally important, many other factors are part of the decision-making process.

- Most conservation implementation projects should conduct water quality monitoring which is technically very challenging and expensive.
- For projects that do conduct water quality monitoring, monitoring systems should be designed to specifically evaluate response to conservation practice implementation and must include necessary resources and expertise.
- To link water quality response to land treatment changes, conservation practices must be tracked as intensively as water quality monitoring, and at the same temporal and spatial scales.
- Knowledge of land use, management, and conservation practices is essential to understanding the effectiveness of conservation programs. Data on conservation practices or land management are often unavailable due to confidentiality agreements or are incomplete.

<u>Buffers types described in USDA's Buffers: Common Sense Conservation:</u>

- Riparian buffers. Streamside plantings of trees, shrubs, and grasses that can intercept contaminants from both surface water and groundwater before they reach a stream.
- Filter strips. Strips of grass used to intercept or trap field sediment, organics, pesticides, and other potential pollutants before they reach a body of water.
- Grassed waterways. Strips of grass seeded in areas of cropland where water concentrates or flows off a field. Grass waterways can be combined with filter strips to trap contaminants or field sediment in addition to preventing gully erosion.
- Field windbreaks. A row, or rows, of trees, shrubs, or other plants used to reduce wind erosion, protect young crops, and control blowing snow. Field windbreaks are located along crop field borders or within the field itself.
- Contour grass strips. Narrow bands of perennial vegetation established across the slope of a crop field and alternated down the slope with strips of crops. Properly designed and maintained contour grass strips can reduce soil erosion, minimize transport of sediment and other water-borne contaminants, and provide wildlife habitat.
- Cross-wind trap strips. Rows of perennial vegetation planted in varying widths and oriented perpendicular to the prevailing wind direction. Cross-wind trap strips can effectively prevent wind erosion in cropping areas with high average annual wind speeds.
- Field borders. Grass-seeded areas along the edges or ends of croplands.
- Alley cropping. Crops planted between rows of larger mature trees.
- Herbaceous wind barriers. Perennial vegetation established in rows across the prevailing wind direction.
- Vegetative barriers. Narrow, permanent strips of dense, tall, stiff, erect perennial vegetation established parallel and perpendicular to the dominant slope of the field.

<u>Lessons learned from the Conservation Practice Implementation and Adoption to Protect Water Quality CEAP:</u>

- Identify the pollutant(s) of concern before attempting to select the conservation practice(s) that will be used for pollution control.
- Indentify pollutant sources accurately because the best conservation practices will not work if they do not treat the problem.
- Identify and prioritize BMP implementation to critical source areas after talking with farmers in the area during the project planning phase.
- Anticipate practices with unintended consequences so that tradeoffs can be considered in advance and activities modified to reduce adverse impacts.

- Post-implementation education and technical support must be used to assist farmers with adaptive management to ensure sustained effectiveness of conservation practices.
- Technology supported by research and extension outreach can effect changes in conservation and management.
- A conservation practice such as conservation tillage may have different environmental outcomes in different settings depending on factors such as the pollutant, soil type, or climate.
- Nutrient reductions will require selection and use of conservation practices that manage nutrients as well as sediment, and will also require significant adoption throughout the watershed.
- Some practices may require unique or enhanced incentive packages to promote adoption, especially when economic disincentives exist.
- Farmers tend to show more interest in controlling sediment with practices such as conservation tillage than in controlling pollutants such as nutrients.
- The control of nonpoint sources of agriculturally-derived nutrients will be a major challenge because (1) Management practices, which are less likely to be sustained, are more effective than structural practices; (2) Many conservation practices designed to control nutrients are disliked (nutrient management and buffers); and (3) Farmers cannot readily observe nutrient losses, whereas they can observe soil losses.

<u>Lessons learned from the USDA CEAP document How Farmers and Ranchers Make Decisions on Conservation Practices</u>:

- Conservation practices that increase profits are most successful.
- The most important factor in conservation practice adoption is that a practice makes the farmer money, directly or indirectly.
- Economic incentives were often required for adoption of conservation practices not obviously profitable or fitting with current farming systems.
- Farmers like to have financial as well as technical help from universities, agencies, and peers.
- Government agencies influence conservation profitability, and therefore, their policies are important determinants in agricultural implementation.
- Farmers adopt conservation practices because of strong stewardship or conservation ethics (farmers adopted conservation projects on their own either for religious or spiritual reasons, or because they believed they had a responsibility to protect the environment).
- Farmers are more likely to adopt conservation practices that serve more than just a conservation role, such as improved animal health and profit .
- Farmers are most willing to invest in practices that have a farm benefit that is easy to observe, such as reduced erosion from conservation tillage. Practices that have less direct benefits, such as nutrient management, are adopted less frequently.
- Farmers are more easily persuaded when trusted agribusinesses develop a new technology or machinery, the product provides superior results, or both.
- Conservation adoption is most successful when farmers identify the solution.
- Relationships between farm organizations, government agencies, and nonprofit organizations can greatly affect conservation practice adoption, especially when all groups have the same goal and deliver the same message.
- Local farmer-led initiatives make farmers feel better about conservation practices.

<u>The USDA fact sheet drew several conclusions:</u>

- Farmer participation increased when the conservation program was administered with farmers leading and involved, allowing farmers flexibility.

- Conservation adoption by farmers may involve difficult choices about the agricultural system as well as farm economics and management.
- Because it is the farmer who ultimately adopts the conservation practices, they must work for the farmer by increasing revenue, lowering costs, reducing labor or time, or supporting other factors important to the farmer.
- Financial incentives may be necessary but are not sufficient for most adoption decisions.
- Conservation is important, but it has to be cost-effective or it competes with the time a farmer could be using to make money.

<u>The USDA CEAP document titled Effective Education to Promote Conservation Practice Adoption lists ten lessons learned from the nationwide project:</u>

- Success rate increases when conservation outreach programs have clearly stated goals and objectives.
- Outreach education to promote conservation practice adoption is most effective when focused on the most meaningful issues for farmers: profit, flexibility, and convenience.
- Multiple outreach education techniques should be used to reach farmers.
- Outreach education activities are most effective in promoting conservation practice adoption when conducted one-on-one and coordinated by a trusted, local “point-of-contact” who is experienced with local farming practices and respected by the agricultural community.
- Outreach education activities were very effective in promoting conservation practice adoption when organized by the farmers themselves and supported by outside financial resources.
- Greater results are obtained through partnerships.
- Nonprofit organizations can provide valuable information and contacts.
- Post-installation outreach, follow-up, and support are important to ensure that practices are implemented, and to assist farmers with promoting long-term sustainability.
- In an era of diminishing public resources, Extension, USDA-NRCS, and state conservation agencies must reassess and determine how to work together more effectively to package, market, and deliver critical education and technical assistance to agricultural producers.
- Education and behavior change should not be confused. Education alone was rarely sufficient to adopt conservation practices.

One final lesson noted is that multiple outreach education techniques should be used to reach target audiences. Examples cited include:

- One-on-one farm visits
- Group meetings and presentations
- On-farm demonstrations
- Field days
- Newsletters
- Fact sheets
- Training and certification
- Community networks
- Watershed maps
- Electronic presentations

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