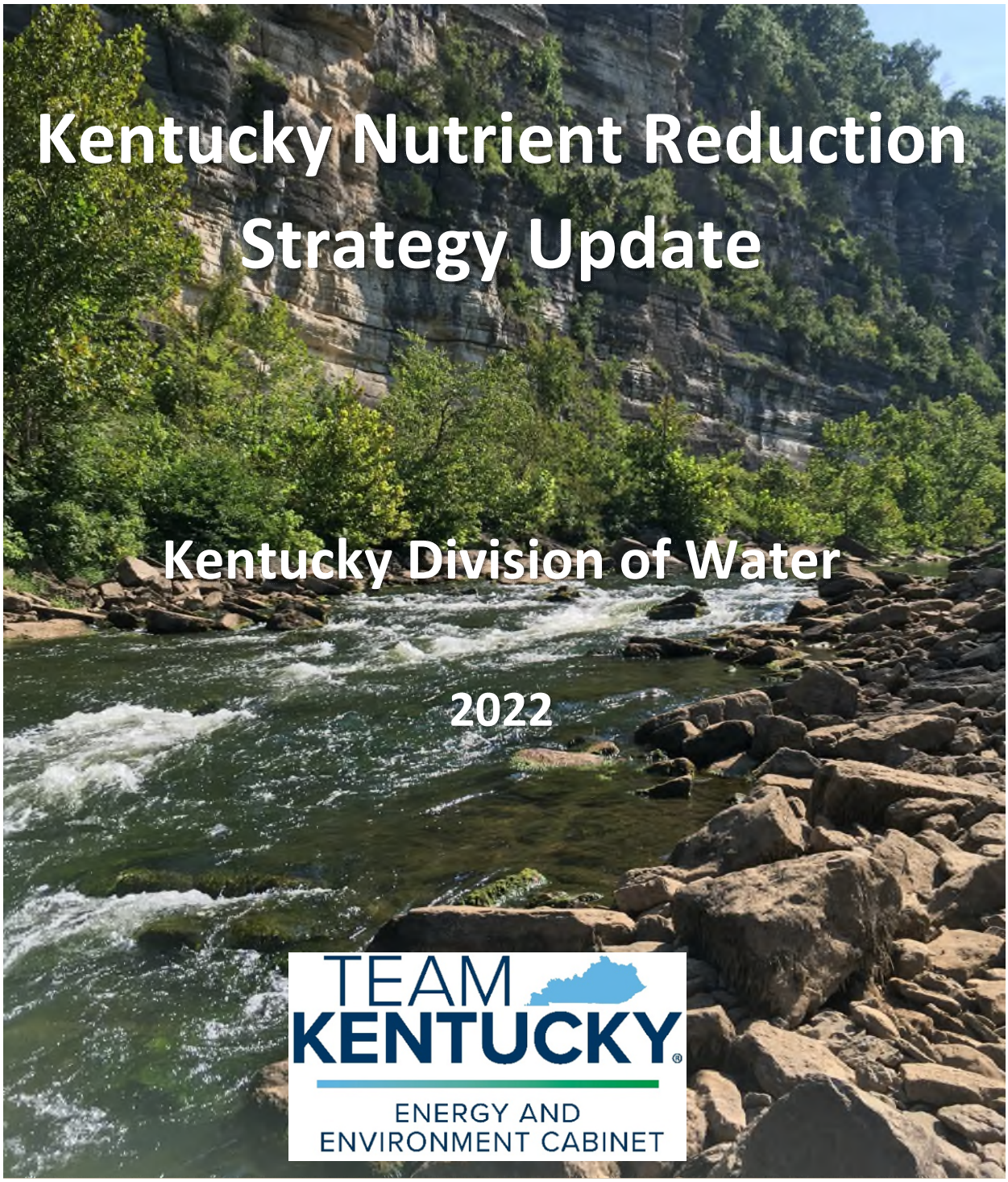

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List of Acronyms

- AWQA - Kentucky Agriculture Water Quality Act
- BMP - Best Management Practice
- CALM - Consolidated Assessment and Listing Methodology
- CWSRF - Clean Water State Revolving Fund
- DAQ - Kentucky Division for Air Quality
- DOC - Kentucky Division of Conservation
- DOW - Kentucky Division of Water
- EPA - Environmental Protection Agency
- EPRI – Electric Power Research Institute
- EQIP – Environmental Quality Incentives Program
- GIS - Geographic Information System
- KOAP - Kentucky Office of Agriculture Policy
- HAB - Harmful Algal Bloom
- HUC – Hydrologic Unit Code
- KPDES - Kentucky Pollution Discharge Elimination Station
- LSPC - Loading Simulation Program in C++
- MARB - Mississippi/Atchafalaya River Basin
- MGD - Million Gallons per Day
- MS4 - Municipal Separate Storm Sewer Systems
- NADP - National Atmospheric Deposition Program
- NASA - National Aeronautic and Space Agency
- NASS- National Agricultural Statistics Service
- NGRREC - National Great Rivers Research and Education Center
- NRCS - Natural Resource Conservation Service
- NRS - Nutrient Reduction Strategy
- NTN- National Trends Network
- POTW - Publicly Owned Treatment Work
- SPARROW - SPAtially Referenced Regressions on Watershed attributes
- STEPL- Spreadsheet Tool for Estimating Pollutant Load
- SWAPP - Source Water Assessment and Protection Program
- TMDL - Total Maximum Daily Load
- TN - Total Nitrogen
- TP - Total Phosphorus
- UK - University of Kentucky
- USDA - U.S. Department of Agriculture
- USGS - U.S. Geological Survey
- WASP - Water Quality Analysis Simulation Program
- WWTP - Wastewater Treatment Plant
- WWAC - Wastewater Advisory Council

Executive Summary

The Kentucky Division of Water (DOW) is a member of the Mississippi River/Gulf of Mexico Hypoxia Task Force, which promotes scientific understanding of the Gulf of Mexico "dead zone" and spearheads efforts to minimize nutrient loss from lands in the Mississippi River Basin. A key vehicle for this effort is the state's nutrient reduction strategy. DOW provides this Nutrient Reduction Strategy Update (NRS Update) to highlight Kentucky's progress to date, and cast vision for the agency's future nutrient reduction efforts. Along with partners and local communities, DOW continues to facilitate and fund adoption of agricultural and wastewater best management practices that improve local water quality and reduce nutrient delivery to the Gulf of Mexico.

This NRS Update highlights the need for point source engagement, and nonpoint source planning and implementation to reduce nutrient inputs to streams, rivers, and lakes. DOW's Nutrient Priority Areas represent high aquatic nutrient concentrations, sensitive drinking water sources, and historic harmful algal bloom locations that require greater agency attention. Where existing water quality data and local engagement is lacking, DOW will review monitoring and outreach efforts to improve outcomes, and assess future nutrient priorities. DOW will provide biennial updates to this strategy to track progress in its nutrient reduction efforts.

1 Background

Nutrient pollution is a growing water quality concern locally and regionally. Excess nutrients such as nitrogen and phosphorus have negative impacts on local water quality, and in Kentucky, are associated with seasonal eutrophic conditions characterized by low dissolved oxygen, nuisance plant growth, and the death of fish and other aquatic organisms. Algal blooms, including toxic harmful algal blooms (HABs), disrupt fishing and swimming, harm aquatic life, increase drinking water treatment costs, and impair taste. In October 2019, unsafe HAB concentrations in the Ohio River resulted in the cancellation of the swimming portion of the Louisville Ironman race, affecting over 2,000 athletes. Elevated nutrients or HABs in farm ponds are associated with decreased fertility, low weight gain, sickness, and death in livestock[1]. Nutrient pollution in Kentucky also affects downstream coastal waters and regional seafood markets in the Mississippi River Basin.

The Mississippi River Basin

The Mississippi River originates at Lake Itasca in northern Minnesota and travels 2,350 miles south to the Gulf of Mexico. Along this path, hundreds of tributaries join the Mississippi River, including the Ohio and Tennessee Rivers, which flow through Kentucky. Water from portions of 31 states creates a drainage basin over 1,245,000 square miles in size. The Mississippi River ultimately meets with the Atchafalaya River and empties into the Gulf of Mexico (see **Figure 1**).

Nutrient loading to the Mississippi River Basin is the leading contributor to the hypoxic zone in the Gulf of Mexico off the coasts of Louisiana and Texas. Along with 11 other states and 5 federal agencies, Kentucky committed to develop a state-specific strategy to address nutrients through the Mississippi River/Gulf of Mexico Watershed Hypoxia Task Force (the "Hypoxia Task Force" or HTF). Kentucky began its initial efforts to reduce nutrient loading to its waterways through the 2014 Nutrient Reduction Strategy (NRS).

Since 2014, DOW has worked extensively with public agencies, universities, and citizen groups to expand public understanding of the unique pollutant impacts in Kentucky, and has awarded over $9.9 million in federal grants to reduce nutrient loads through nonpoint source best management practices, septic system improvements, and education programs. To maximize water quality improvements, DOW continues collaborating with federal, state, and local agencies, universities, citizen groups, and non-profit organizations.

The 2021 Nutrient Reduction Strategy Update (NRS Update) builds upon existing partnerships and local efforts, while incorporating lessons learned. As the strategy evolves and tasks are completed, priorities will be adapted to meet local needs using the best available data. **Section 2** highlights progress since 2014, and **Sections 3-7** refine the goals of the 2014 NRS to improve transparency and focus limited resources.

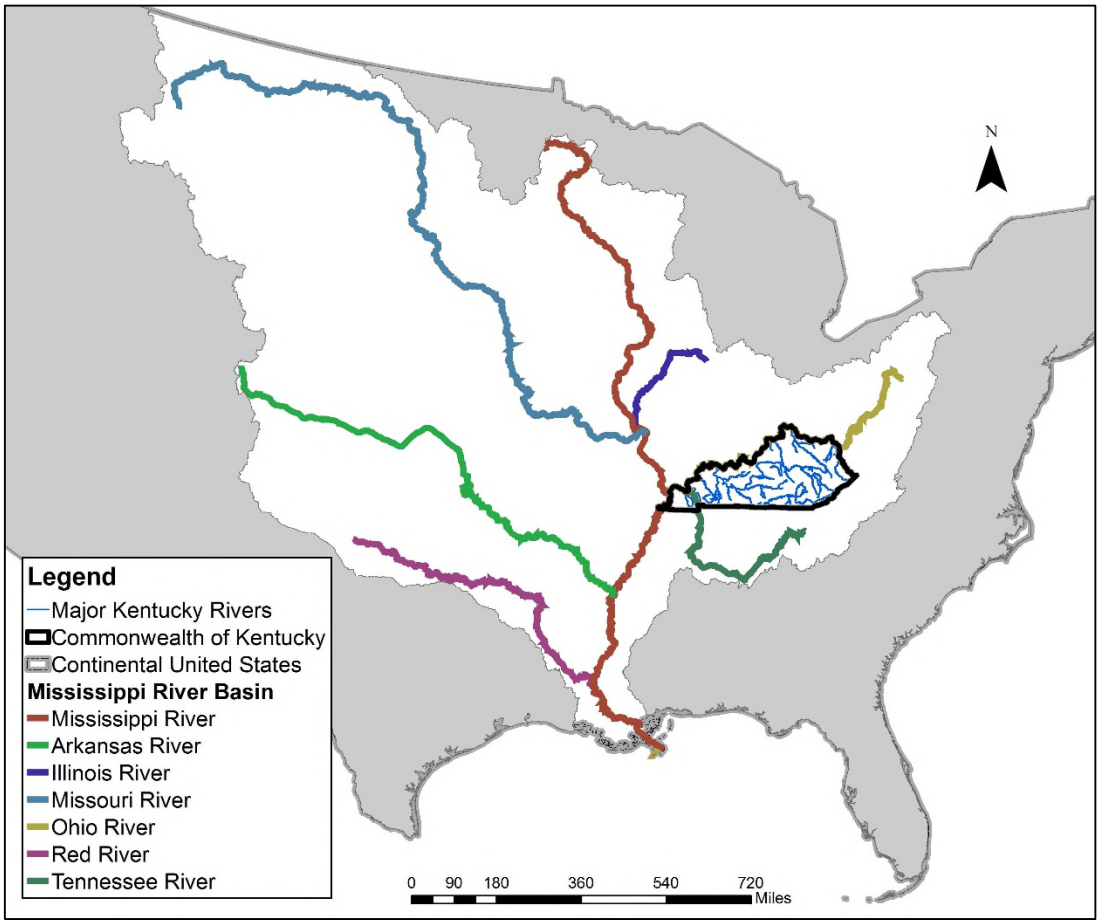


Figure 1 - Kentucky Hydrology and the Mississippi River Basin

The NRS Update is not a "one-size-fits-all" approach to nutrient pollution in Kentucky communities. Due to the long duration of nutrient cycling in the environment, the dynamic local relationship between land use and nutrients, and the substantial data required to quantify the two, this NRS Update provides an adaptive framework and next steps to improve water quality. Nutrient pollution is a problem decades in the making, requiring long-term commitments from public agencies, partners, and local communities to resolve.

1.1 Addressing Prior Stakeholder Comments

DOW received multiple comments on its 2014 NRS from stakeholders, which it addressed through nutrient reduction efforts since that time. Comments from the EPA (April 28, 2014) highlighted the need for tracking progress and tailored implementation to fit Kentucky's unique landscape. The EPA also encouraged additional interagency coordination with the Natural Resources Conservation Service (NRCS), the Kentucky Division of Conservation (DOC), and other stakeholders.

One way DOW responded to these suggestions has been through the Kentucky Nonpoint Source (NPS) Program. The NPS Program tracks multi-agency installation of nutrient reducing practices, called best management practices (BMP), through watershed-scale Geographic

Information Systems (GIS) mapping (see **Figure 2**). DOW also supports collaborative watershed planning and BMP installation using EPA Section 319(h) funds (319 Program). DOW provides technical assistance in partnership with the Kentucky Office of Agricultural Policy to maintain the On Farm Water Management Program. This partnership encourages water reuse, improves drought resiliency, promotes soil health, and improves water quality in the agricultural community. DOW frequently contributes to NRCS initiatives through the NRCS State Technical Committee, and collaborates with DOC on the Hypoxia Task Force and Kentucky Agriculture Water Quality Act Authority.

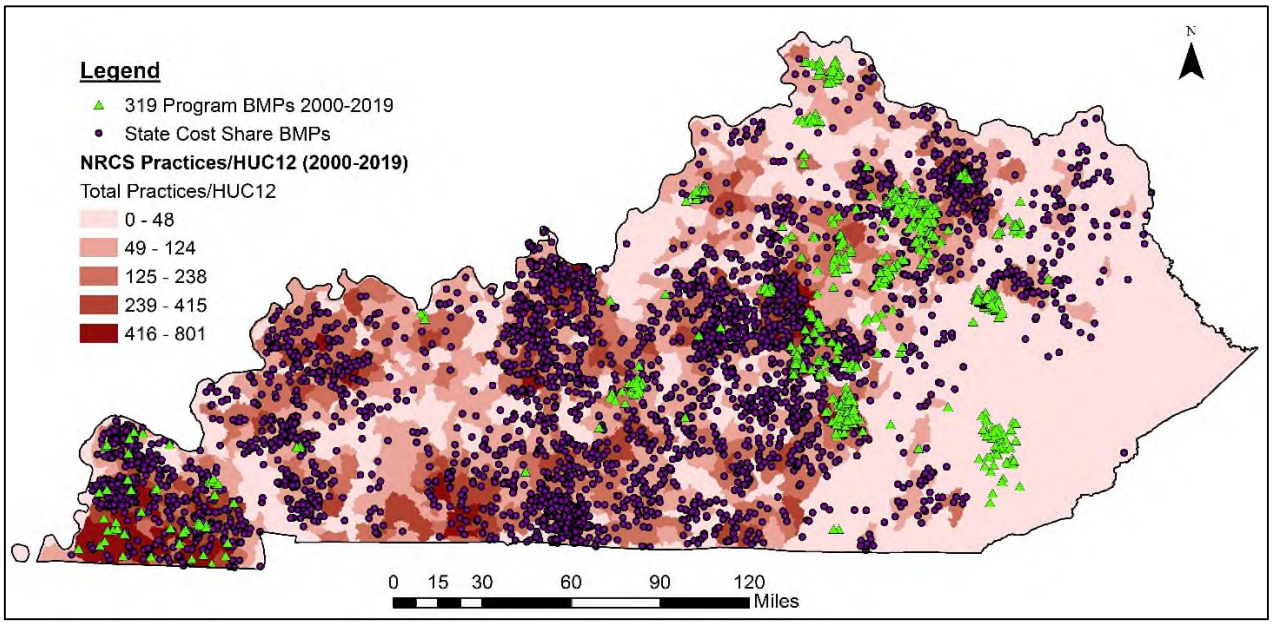


Figure 2 - Installed Best Management Practices Through 2019

EPA also recommended updating statistics referenced in the 2014 NRS. In response, DOW assessed statistics on agricultural land use changes (**Section 1.2**) and water quality loading trends (**Section 2.1**). DOW analyzed statewide Ambient Monitoring Network data through 2019 to develop an interactive map of rolling 5-year nutrient loads and yields, and regional impacts of installed 319 Program BMPs on local watersheds (see **Figure 10**). DOW evaluates this historic data with ongoing monitoring to track water quality improvements, and implement an adaptive management strategy (see **Section 5**).

Additional comments on the 2014 NRS identified an interest in a more refined analysis of the nutrient problem, specific reduction goals, and transparency in watershed prioritization. DOW relies on data driven metrics to identify nutrient contribution sources using water and air quality monitoring and USGS modeling (see **Section 2.1**), to analyze relative point source nutrient loading (see **Section 3**), and to track nutrients from nonpoint sources (see **Section 4.2**). DOW also provides pertinent agency analysis to the Agriculture Water Quality Authority and Hypoxia Task Force, such as its 2021 Nutrient Loads and Yields Study Update. As a result, this NRS Update outlines data driven implementation priorities (**Section 5.1**), while addressing data gaps and engagement needs through monitoring priorities (**Section 5.2**) and community outreach (**Section 7.3**).

1.2 Landscape Changes

Changes in Kentucky's aquatic nutrient outflow, population, and land use provide important context for the NRS Update outlined in **Sections 3-7**. Population statistics quantify community growth that puts pressure on aging wastewater infrastructure, increases the pace of land development, and elevates demand for agricultural products. Nutrient load data tells a complex story of flooding, drought, waste management, domestic and agrarian fertilizer use, sewage treatment efficiency, and nutrients in various stages of migration downstream. Agricultural statistics provide insight into land use changes, producer efficiency, and product demand. Combined, these three data sources provide an important perspective for the NRS Update.

DOW maintains a long-term, fixed ambient river monitoring network covering approximately 76% of the state drainage area, including receiving waters from urban and rural areas across Kentucky (see **Figure 6**). Water sampling data from DOW's ambient river monitoring network indicates an increasing trend for Total Nitrogen and Total Phosphorus loads from 2005 to 2019. Similarly, population growth from 2010-2019 increased, with a total estimated population increase of 3.0%, which is below the national average of 6.3% for the same period.

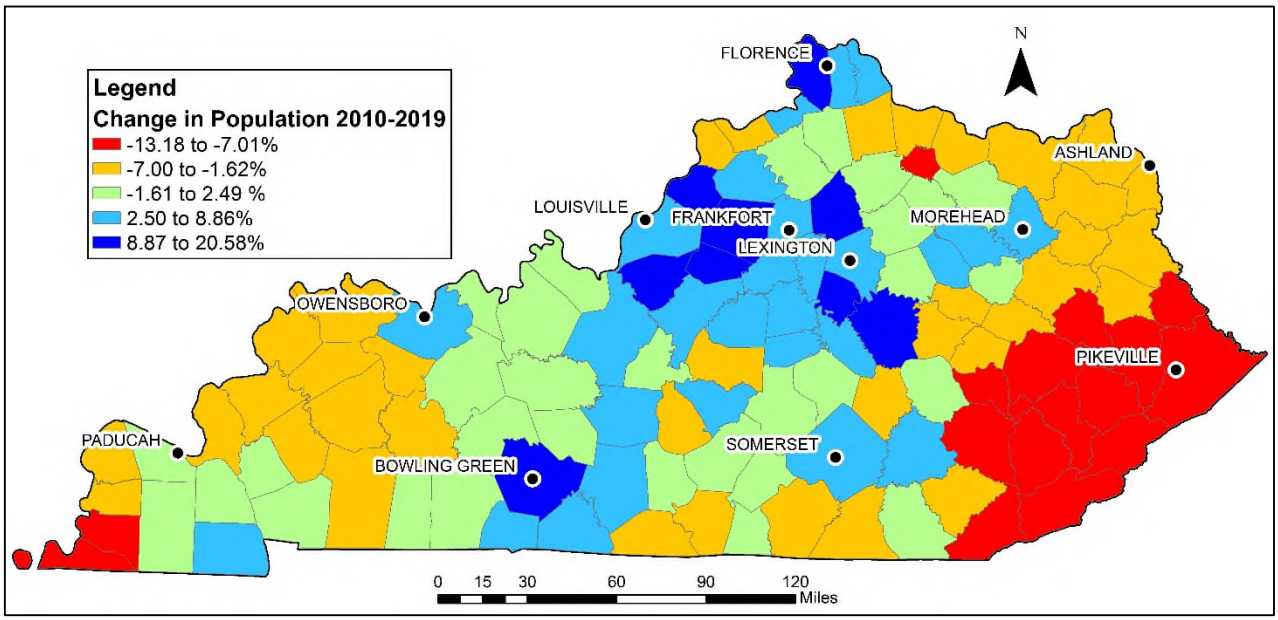


Figure 3 – Cumulative Population Change from 2010 to 2019
Data Source: U.S. Census

While these estimates indicate that statewide population and nutrient loads increased, regional changes indicated stronger population growth in areas around Lexington, Louisville, Florence, and Bowling Green (see **Figure 3**). Higher population growth areas in some of these Central and Northern Kentucky communities correspond with comparatively higher watershed concentrations of phosphorus (see **Figure 6**), and higher phosphorus loads from publicly owned treatment works (POTWs) which treat domestic wastewater (see **Figure 7**). However, Central and Northern Kentucky also have high levels of naturally occurring phosphorus in stream sediments due to underlying limestone bedrock (see **Figure 4**). Additionally, the declining

populations in rural western Kentucky do not appear to be driving the higher nutrient concentrations shown in **Figure 5** and **Figure 6**.

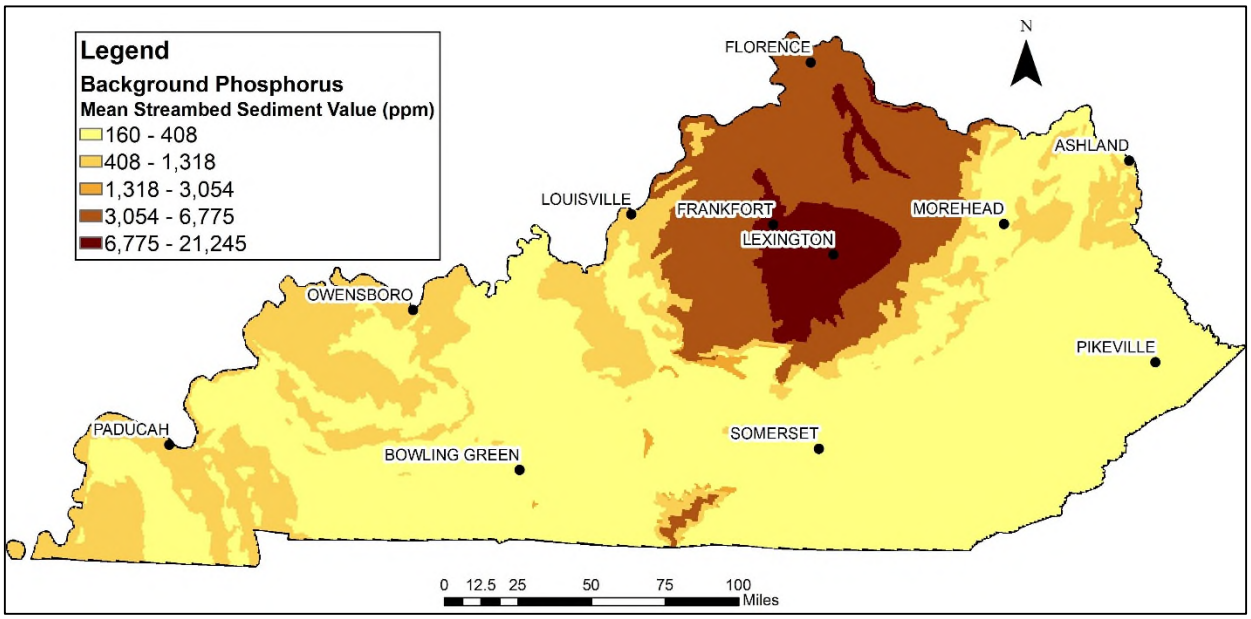


Figure 4 - Background Phosphorus Concentrations

Data Source: U.S. Geological Survey

Since nitrogen and phosphorus accumulate and persist in the natural environment many years after their release, historic farm statistics give context for nutrient loads in various stages of delivery to the Gulf of Mexico. Of Kentucky's 25.4 million acres, approximately 51% is farmland, with crop production and pastureland representing the largest agricultural land uses by acreage. According to farm census data from the USDA's National Agricultural Statistics Service (NASS), fertilizer was applied to just under 4 million acres of Kentucky farmland in 1997, before reaching a twenty-year peak of 4.2 million acres in 2007. Fertilizer application then decreased to 3.7 million acres in 2012 before slightly increasing to 4.1 million acres in 2017. These moderate annual changes indicate that Kentucky's fertilized acreage remains fairly consistent from year to year, and routinely constitutes approximately 30% of the total reported farmland acreage.

While fertilized acreage information is helpful, it does not quantify the concentration of nutrient inputs. During the twenty-year period from 1997 to 2017, fertilizer purchases increased from $194 million in 1997 to a high of $472 million in 2012. However, this 58.7 percent increase in total sales does not indicate a large increase in applied fertilizer volume because the cost per ton of various fertilizers also increased (59.7 - 77.1 percent) from 1997 to 2012.

NASS statistics show that the nitrogen application rate per fertilized acre (lbs/acre) for Kentucky's most common crops, corn and soybeans, vary from year to year. The rate for corn steadily increased from a low of 61 lbs/acre in 1964 until it peaked in 1999 at 178 lbs/acre. Since then, nitrogen application rates on corn decreased slightly to a 20-year low of 145

lbs/acre in 2014, and then rebounded to 173 lbs/acre in 2016. Phosphorus application rates on soybeans increased from 50 lbs/acre in 1977 to a high of 83 lbs/acre in 1998, before decreasing to a 30-year low of 53 lbs/acre in 2012. Fertilizer application rates for corn and soybeans appear to be declining from peaks in the 1990s, while fertilizer sales indicates that total fertilizer volume remains stable, if not declining. Prudent application and management of fertilizer using BMPs identified in the Kentucky Agriculture Water Quality Act (AWQA) can reduce nutrient losses from cropland into the environment (**Section 4.1**).

In Kentucky, pastureland is the second largest land-use category after cropland, according to federal NASS records. Pastureland decreased from 5.3 million acres in 1997 to 3.9 million acres in 2017. While land used for pasture decreased, the reported value of livestock and poultry increased significantly from approximately $1.5 billion in 1997 to $3.2 billion in 2017, driven largely by poultry production growth. In the past 20 years, reported inventory of chickens sold for meat increased 158% compared to inventories of beef cattle, which decreased nearly 11%. Poultry production is a growing agricultural land use and represents a potential source of nutrient inputs. Effective nutrient management using a Nutrient Management Plan will help livestock and poultry operations fulfill their obligations under the AWQA, and limit nutrient loss into the environment (**Section 4.1**).

2 Nutrient Reduction Progress

The 2014 NRS outlined DOW's initial steps to address nutrient loading into waters of the Commonwealth. Since then, DOW has made significant progress in the following areas:

a) Pursuing the latest science with partner agencies to identify baseline nutrient loading data and areas of highest nutrient loading;
b) Collaborating with other agencies and volunteer organizations to track HABs and reduce nutrient loads; and
c) Enhancing monitoring programs to better connect elevated nutrient levels to indicators of eutrophication.

2.1 The Latest Science

Kentucky pursues the latest science to identify the greatest needs and inform where best to focus limited funding sources. As a member of the Hypoxia Task Force, DOW leverages its long-term monitoring networks to understand Kentucky's nutrient contribution to the Gulf of Mexico, and works with local partners to identify and reduce nutrient impacts to springs, streams, rivers, and lakes.

2.1.1 DOW Loads & Yields Study (2005-2019)

To evaluate nutrient trends and guide updates to the NRS, DOW updated its Nutrient Loads and Yields Study[2] using the statewide ambient rivers monitoring network, and ORSANCO monitoring data. The study utilized 57 fixed stations in DOW's network, 5 ORSANCO stations, and associated USGS stream gages, to calculate loads and yields from 2005-2019. Loads help estimate the total nutrient mass flowing through a watershed (tons/year), while yields provide an understanding of nutrient concentrations in watersheds ((tons/year)/square mile).

Monitored watersheds in the 2021 Loads and Yields Study[2] represent approximately 82% of Kentucky's total land area. DOW stations monitor 54 watersheds, which capture approximately 76% of Kentucky's land drainage area, while ORSANCO stations monitor 5 Ohio River catchments that add 6% of non-overlapping drainage area. Estimated nutrient loading from monitored watersheds is generated by totaling non-overlapping basins. Monitored watersheds in DOW's updated Loads and Yields Study contribute an estimated 114,061 tons/year of Total Nitrogen, and 16,019 tons/year of Total Phosphorus downstream. Overall, "both nitrogen and phosphorus yields significantly increased at stations across the state" based on 5-year rolling means from 2005-2019.

The Study also compares nutrient loading against land use, similar to a prior USGS study of 1974-2004 DOW data. The DOW land use conclusions were consistent with the USGS study, which found that "estimated mean annual yields of TN (total nitrogen) at stations in agricultural basins were 107 percent larger than stations in the undeveloped land-use/land-cover drainage basins and 63 percent larger than stations in the mixed land-use/land-cover drainage basins"[3]. Both studies identified higher nutrient yields with agricultural and mixed uses, while the DOW study also establishes rolling watershed nutrient baselines. **Figure 5** and **Figure 6** depict

estimated mean annual loads and yields of TN and TP from DOW monitoring stations.

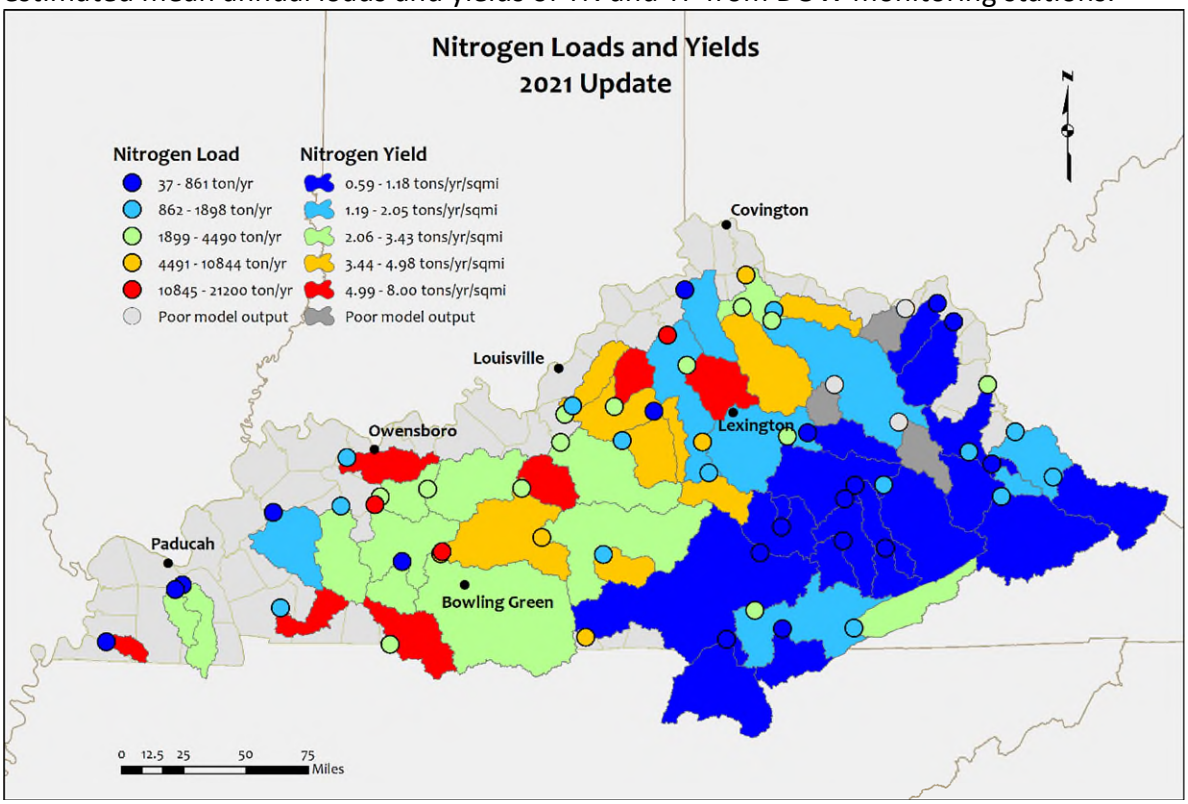


Figure 5 - Estimated DOW Mean Annual Nitrogen Loads & Yield by Watershed (2005-2019)

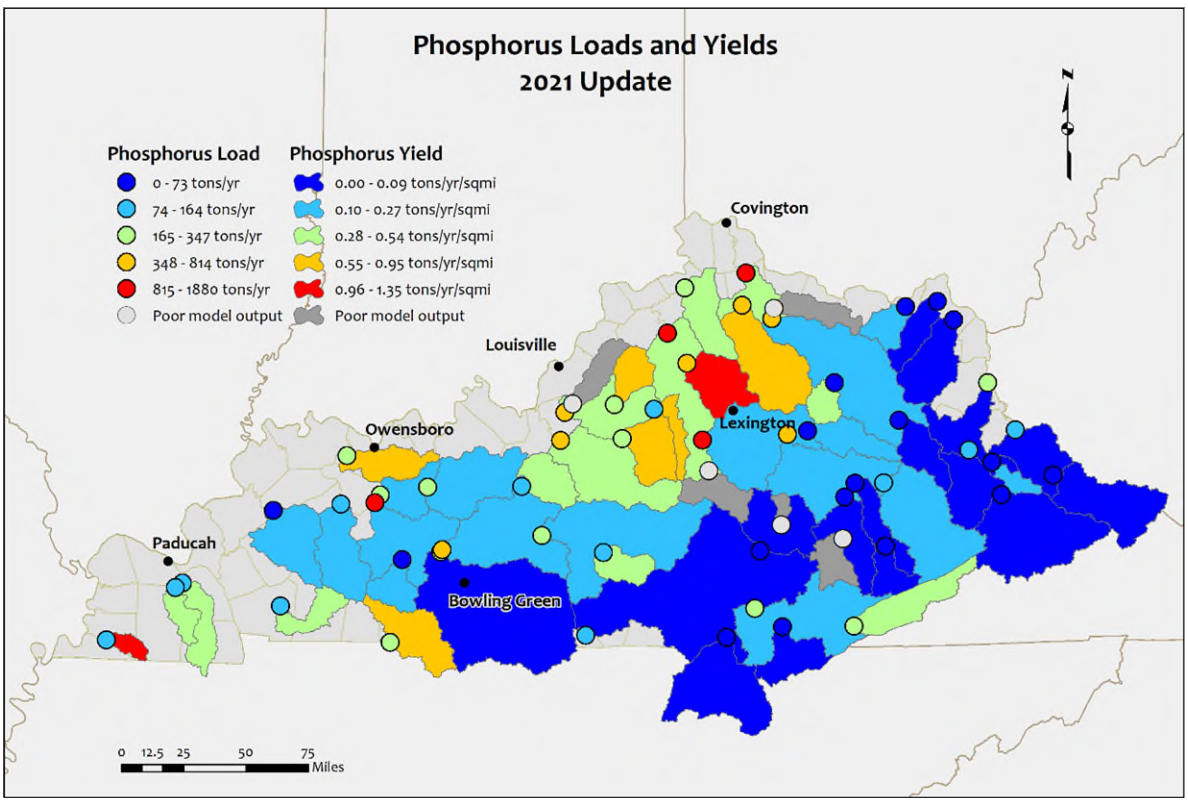


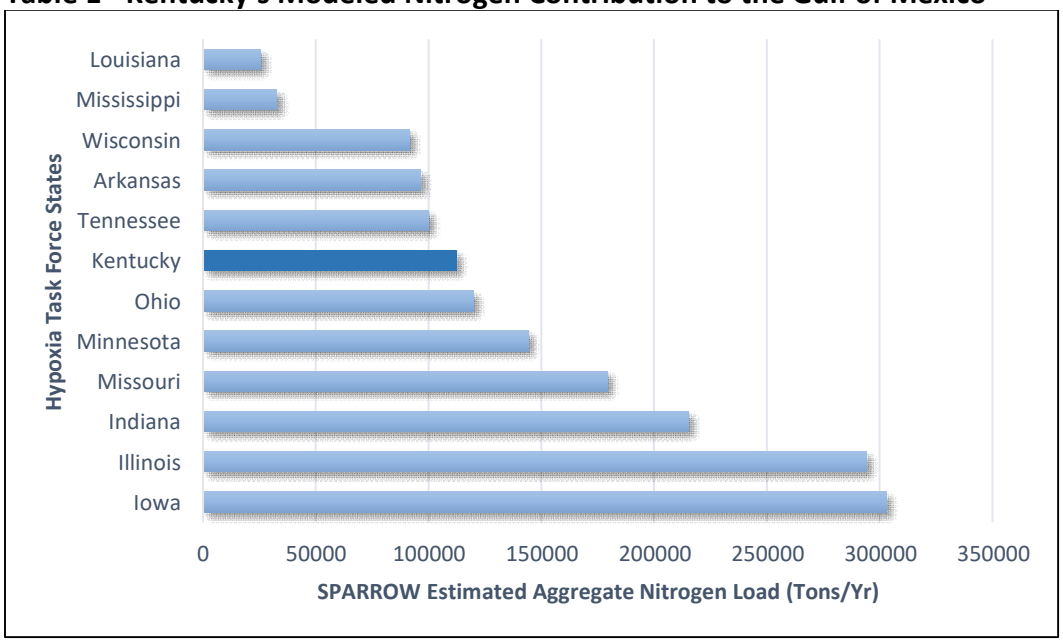
Figure 6 - Estimated DOW Mean Annual Phosphorus Loads & Yield by Watershed (2005-2019)

2.1.2 Kentucky's Nutrient Load Contribution

DOW and USGS nutrient studies reveal spatial gaps that require additional monitoring data or updated models to quantify Kentucky's annual total nutrient load contribution to the Gulf of Mexico (see **Section 4.2**). In lieu of a complete empirical representation of Kentucky's exported nutrient load, Kentucky compares its available data to models calibrated for the Mississippi/Atchafalaya River Basin (MARB) to arrive at an estimate of statewide nutrient loads and yields. A 2021 USGS study in the Journal of the American Water Resource Association calibrated the 2012 SPARROW (SPAtially Referenced Regressions on Watershed attributes) model for the MARB and compared estimated contributions between states[4]. The USGS study estimates that *Kentucky's total exported annual nitrogen load is 101,943,851 kg or 112,374 tons per year*, which places Kentucky at 7th highest among Hypoxia Task Force states (see **Table 1**).

The SPARROW model data broadly tracks with DOW's 2021 Loads and Yields Study[2], which estimates an annual nitrogen load from monitored watersheds of 114,061 tons/year across 82% of Kentucky's land. The DOW study also estimates that Kentucky's remaining unmonitored surface area (18%) contributes 15,942 tons per year, resulting in a statewide total of 130,003 tons/year, or slightly higher than the SPARROW estimate. However, when accounting for out of state nutrient contributions flowing through Kentucky, the DOW study estimates *Kentucky's total nitrogen load contribution is 94,208 tons per year*, which is slightly lower than the SPARROW modeled load.

Table 1 - Kentucky's Modeled Nitrogen Contribution to the Gulf of Mexico

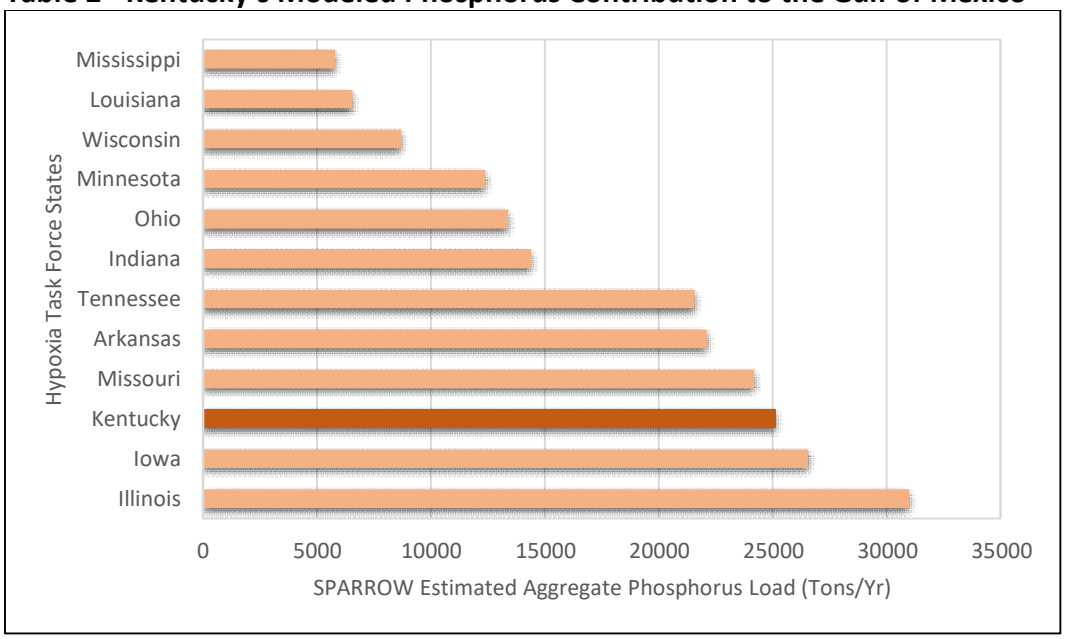


Data Source: Journal of the American Water Resources Association

The 2021 MARB SPARROW study also estimates *Kentucky's total exported annual phosphorus load at 22,785,212 kg or 25,116 tons per year*, which places Kentucky 3rd highest among Hypoxia Task Force states (see **Table 2**). SPARROW modeled phosphorus loads are higher than the DOW Loads and Yields Study *total phosphorus estimate of 10,506 tons/year*, although

some of this difference is because the DOW study removed Tennessee-originated loads (7,252 tons/year) from Kentucky load totals. While Kentucky's nutrient monitoring network captures large rivers, the nutrient contributions from smaller rivers in Western Kentucky and cities along the Ohio River are underrepresented. This spatial data gap will be a DOW priority for future collaboration and monitoring efforts (see **Section 5.2**). Any future MARB-calibrated SPARROW modeling will be evaluated in biennial NRS updates (see **Section 8**) against Kentucky's ongoing loads and yields analytics.

Table 2 - Kentucky's Modeled Phosphorus Contribution to the Gulf of Mexico

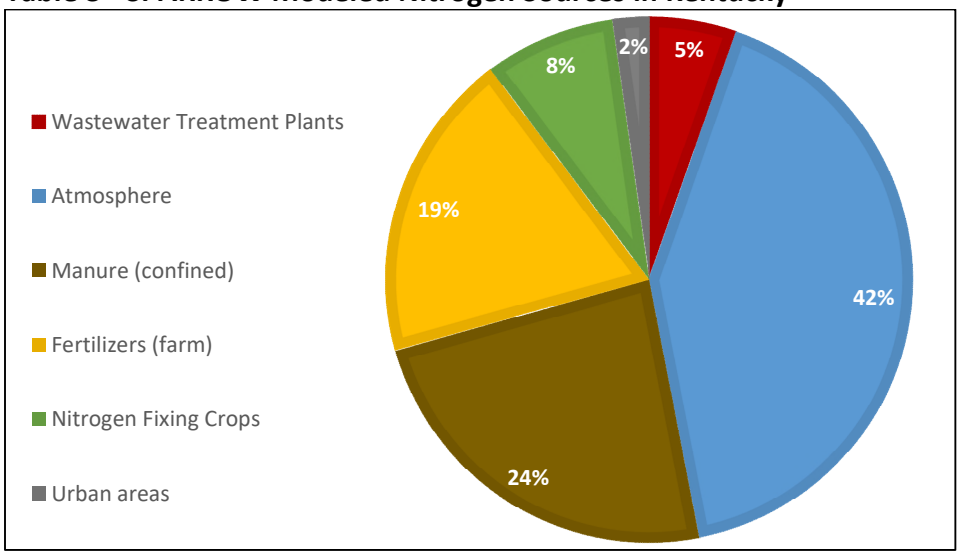


Data Source: Journal of the American Water Resources Association

2.1.3 Nutrient Sources & Progress

The SPARROW study estimates that atmospheric deposition is the greatest nitrogen contributor (42%), followed by manure (24%), and farm fertilizers (19%), with the remaining sources (nitrogen fixing crops, wastewater plants, urban areas) contributing less than 10% each[4] (see **Table 3**). Contributing phosphorus sources are estimated by SPARROW to include natural sources (41%), farm fertilizer (29%), manure (16%), wastewater plants (8%), and urban areas (6%)[4] (see **Table 6**). These SPARROW findings are consistent with the DOW 2021 Loads and Yields Study[2] and background phosphorus soil concentrations (**Figure 4**), which correlate agricultural land use and phosphorus-rich soils with higher nutrient yields.

Table 3 - SPARROW Modeled Nitrogen Sources in Kentucky

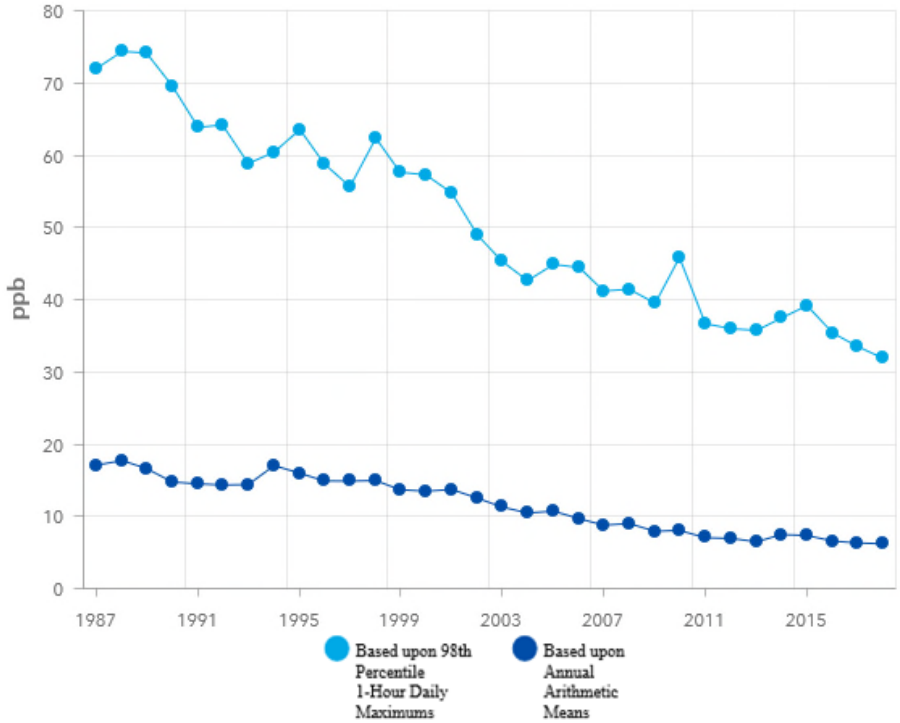


Data Source: Journal of the American Water Resources Association

The DOW 319 Program helps interested stakeholders reduce nonpoint source pollution in local watersheds by developing watershed plans and implementing BMPs. DOW estimates annual load reductions achieved through watershed plan implementation using EPA's Spreadsheet Tool for Estimating Pollutant Load (STEPL). From 2014 to 2019, DOW estimates that 319 Program-funded projects reduced nitrogen loads by 132.6 tons/year and phosphorus loads by nearly 25 pounds/year (see **Figure 10**). Cumulatively, DOW estimates that these projects removed 333.8 tons of nitrogen and 67.5 tons of phosphorus through federal fiscal year 2019. BMP projects provide long-term annual reductions beyond initial installation.

In addition to agricultural and wastewater sources of aquatic nutrient pollution, modeling data indicates that atmospheric deposition is a significant contributor to Kentucky's nitrogen load. The 2021 MARB SPARROW study indicates that atmospheric deposition accounts for approximately 42% of Kentucky's nitrogen load delivered to the Gulf of Mexico (see **Table 3**). Since 2002, the Kentucky Division for Air Quality (DAQ) made significant progress reducing nitrogen dioxide emissions. Nitrogen dioxide, an indicator pollutant for the nitrogen oxides pollutant group, precipitates through atmospheric deposition and pollutes Kentucky's waters. Statewide air monitors indicate the 98th percentile 1-hour daily maximum annual nitrogen dioxide average *decreased nearly 35%* from 48.9 parts per billion (ppb) in 2002 to 31.9 ppb in 2018 (see **Table 4**). These results put Kentucky ahead of the 41.8 ppb average for the Ohio Valley Central Region that EPA reported in 2018. DOW will continue tracking DAQ-reported trends in atmospheric nitrogen dioxide to provide a holistic perspective on nutrient sources in the Commonwealth.

Table 4 - Kentucky Statewide Nitrogen Dioxide Averages



Source: Kentucky Division for Air Quality 2019 Annual Report

2.1.4 Solutions through Applied Technology

DOW leverages mapping technology and citizen science networks to alert the public of water quality concerns, including harmful algal blooms (HABs). DOW collaborated with Watershed Watch in Kentucky to develop the Volunteer Lakes Monitoring Program, which provides an early warning system for suspected HABs. Citizen scientists report water quality observations and synchronize water transparency measurements (i.e. secchi depth) with bi-weekly NASA/USGS Landsat satellite flyovers so that DOW can compare satellite imagery with field measurements. Remote sensing models utilize these Landsat images to evaluate potential aquatic chlorophyll changes indicative of algal blooms. An interactive web viewer provides a public repository for these citizen scientist observations. This combination of local data collection, state modeling, and federal satellite imagery allows DOW to evaluate large areas quickly. Public awareness and participation in water quality protection is improving due to a high level of local interest.

DOW also provides support to communities through 319 Program funding of watershed studies. DOW's work with the Little River Water-Quality Consortium contributed to a USGS study[5] of bacteria, nutrient, and sediment sources in the Little River Basin of southwest Kentucky. The Little River Basin is a complex watershed – home to cropland, livestock, forestland, and the City of Hopkinsville – that results in one of the highest nitrogen yielding watersheds[2] in the state. The Little River study allowed stakeholders to focus their efforts on the most prominent sources of pollution in the watershed. The combination of innovative pollution source tracing,

community stakeholder involvement, and federal and state agency investment is a model for DOW's vision of data and community-driven solutions.

Training in the Loading Simulation Program in C++ (LSPC) and the Water Quality Analysis Simulation Program (WASP) will enable the DOW to develop greater capacity to address nutrient impairments in complex watersheds. With these tools, DOW can develop dynamic models that identify areas of high nutrient loading and simulate the effects of different management strategies. These modeling tools will assist development of Total Maximum Daily Loads (TMDLs) and other types of water quality restoration plans. In 2018-2019, DOW conducted intensive sampling to support the LSPC-WASP model development in two large watersheds with several nutrient impaired waters. Management actions informed by this model will help improve local waterways and reduce nutrient loads delivered to downstream waters.

2.2 Agency Coordination

DOW collaborates with non-profit organizations, and multiple state and federal agencies, to evaluate, monitor, and reduce nutrient pollution in waters of the Commonwealth. DOW partners with the Electric Power Research Institute (EPRI) to certify credits generated through the Ohio River Basin Water Quality Trading Project. Credits generated through installation and certification of agricultural conservation practices are sold to companies, non-profits and individuals for multiple purposes, including meeting corporate sustainability goals. Since 2014, these private investment practices kept over 21,895 lbs of nitrogen and 5,045 lbs of phosphorus on farms, and out of Kentucky waterways.

DOW also partners with the Kentucky Infrastructure Authority to administer the Clean Water State Revolving Fund (CWSRF), which added nutrient reduction scoring criteria for 2021 applicants. It also works with the Kentucky Division of Conservation (DOC) when project goals overlap between the 319 Program and the DOC State Soil and Water Cost Share Program (State Cost Share). After practices are implemented, DOW generates load reduction estimates and monitors water quality for these projects, while providing annual summaries of 319 program progress in the NPS Annual Report. DOW works with the state NRCS office, and State Technical Committee, to identify and prioritize sensitive water resources through the Mississippi River Basin Initiative, National Water Quality Initiative, and Source Water Protection Program. DOW also tracks interagency BMP implementation (statewide at the HUC12 scale) with information provided annually by the State NRCS Office and DOC.

Collaboration between DOW, DOC, and the UK Cooperative Extension Service promotes adoption of AWQA plans on farms across the Commonwealth. The Kentucky General Assembly passed the AWQA in 1994 (KRS 224.71-100 to 224.71-145) to protect water resources from agriculture and forestry activities. Required BMPs can receive partial funding from State Cost Share and NRCS programs to minimize nonpoint source pollution, and address reported water quality violations. Additional efforts to promote AWQA plans by DOW and DOC are discussed in **Section 4.1**.

DOW works with partner agencies to monitor and issue HAB advisories across the state. DOW regularly convenes a HAB Workgroup that includes the Department for Public Health, Department of State Parks, Department of Fish and Wildlife Resources, USGS, and US Army Corps of Engineers, and others to coordinate resource deployment, algal bloom investigation, and public advisories. DOW maintains and updates a HAB Viewer that allows Kentuckians to view HAB advisories and the status of local waters of interest. DOW also provides technical assistance to public water systems who rely on HAB-susceptible source water.

DOW addresses nutrient loads in wastewater effluent by identifying new technologies and ways to optimize facilities for enhanced nutrient removal. In 2015, the Division of Water assembled a team of universities, associations, and state and federal agencies, to conduct nutrient and energy efficiency audits for Kentucky wastewater facilities. This Wastewater Treatment Plant (WWTP) Optimization Program Team leveraged an EPA grant initiative to provide these audits at no cost to participating facilities. The WWTP Optimization Program Team members include representatives from the following:

- Division of Water
- Division of Compliance Assistance
- Division of Enforcement
- Office of Energy Policy
- KY Infrastructure Authority
- KY-TN Water Environment Association
- KY Rural Water Association
- University of Kentucky Industrial Assessment Center
- University of Memphis
- EPA Region 4

This Optimization Program provides free nutrient and energy audits, and creates analytical reports that make recommendations on how facilities can optimize nutrient treatment and minimize energy use. Each year from 2016 through 2018, three new facilities participated in the program. Facilities that implemented recommendations saw a decrease in energy demand costs, with some saving ~30% per month on utility bills. The December 2019 edition of Streamlines magazine highlighted optimization success at three Kentucky facilities. After a year of implementing optimization, the Lawrenceburg WWTP reduced total nitrogen discharge by 63% (18,600 lbs/yr), total phosphorus by 39% (1,000 lbs/yr), and realized a 16% cost savings in reduced energy demand. Additionally, the Princeton WWTP and Greenville WWTP reduced total nitrogen in effluent by 55% (30,000 lbs/yr), and 33% (12,700 lbs/yr), respectively (see **Table 5**). The optimization team continues working with facilities to track nutrient reduction through the program.

Table 5 - Wastewater Treatment Plant Optimization Efficiency Examples

	Lawrenceburg	Princeton	Greenville
Energy Cost Savings	$25,000/yr	$23,000/yr	$10,000/yr
	16%	15%	18%
Energy Reduction	410,000 kWh/yr	148,800 kWh/yr	110,000 kWh/yr
	22%	13%	13%
TN Reduction	18,600 lbs/yr	30,000 lbs/yr	12,700 lbs/yr
	63%	55%	33%
TP Reduction	1,000 lbs/yr	300 lbs/yr	-
	39%	9%	-
Chemical Cost Savings	$4500/yr	$0	-
Chemical Usage	-30%	0%	-

Source: Brendan Held, EPA Region IV

Additionally, DOW convenes a Clean Water Advisory Council (CWAC) which provides a forum for the wastewater community to discuss infrastructure funding, regulatory impacts, and other issues. This collaborative stakeholder group is comprised of public utility representatives providing wastewater treatment services to Kentucky citizens. The CWAC forum also provides DOW an opportunity to discuss permit changes, such as the DOW decision to require all municipal and sanitary sewer permittees to monitor and report nitrogen and phosphorus concentrations from influent (source) and effluent (finish) waters. As a result, regulatory decisions are more data-driven and transparent with the regulated community.

2.3 Water Quality Criteria Progress

In 2013, Kentucky updated its nutrient water quality criteria to clarify expectations for water quality protection. Most significantly, this update strengthened the definition of eutrophication to identify specific indicators of excess nutrients, such as large diurnal oxygen swings, algal blooms, and displacement of diverse aquatic communities with species known to tolerate nutrient enrichment. These changes enhanced DOW's ability to identify waters impaired by or threatened by excess nutrient loading. The impact of excess nutrients on stream communities is especially difficult to track, in part due to natural variation in local biota and geology. From 2013-2015 DOW conducted intensive stream monitoring in the Bluegrass Region, where phosphorus levels are naturally elevated, to identify nutrient enrichment biological indicators. These studies help translate narrative aspects of the nutrient criteria into region-specific goals for restoring impaired waters.

To improve data collection of nutrient enrichment indicators, DOW updated monitoring plans and incorporated additional staff training. Routine monitoring programs added nutrient enrichment observations, such as benthic algae in streams and algal blooms in reservoirs, to field data forms. Reservoir monitoring began incorporating remote sensing data to identify algal bloom development outside of regular monitoring visits. This mapping data supplements onsite water quality monitoring for 305(b) water quality assessments contained in DOW's Integrated Report to Congress.

EPA awarded DOW an Environmental Information Exchange Network (EN) grant to develop an in-house database application for Kentucky's 305(b) water quality assessments and TMDL Actions that also communicates with EPA's ATTAINS system. The Kentucky Assessment and TMDL Tracking System (KATTS) streamlines the workflow for assessments and stores assessment-related data in a way that can be easily queried and analyzed. DOW designed the system to capture detailed information on observed water quality indicators to assist in targeting future monitoring needs. Additional funding will expand the application to capture watershed restoration and protection activities, and enhance the ability to manage, track, and communicate efforts to improve water quality across the state.

3 Statewide Point Source Strategy

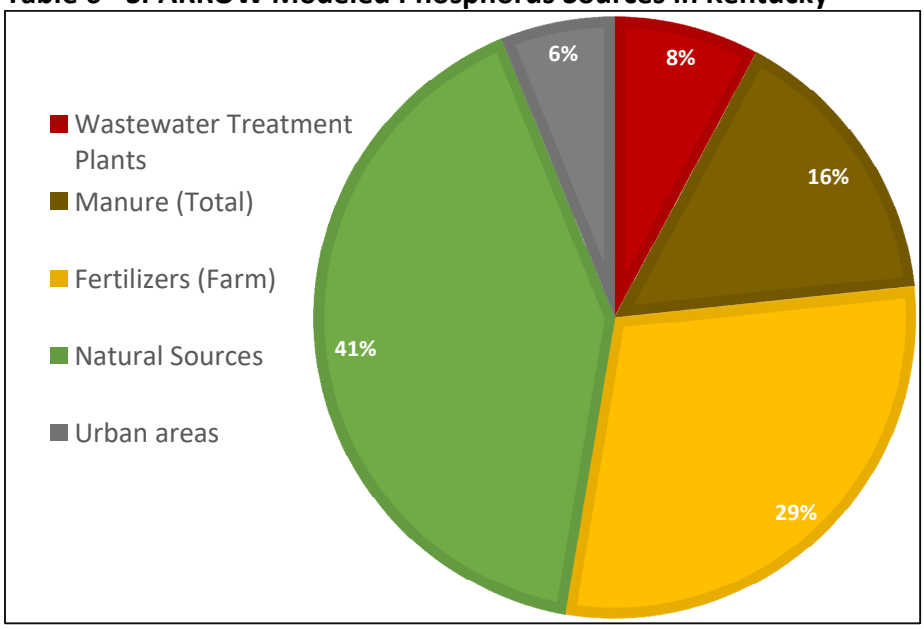
The NRS Update focuses on optimization treatment methods at wastewater facilities in order to reduce nutrient loading and improve operating efficiency, while also building upon 2014 NRS objectives to reduce nutrients from municipalities, septic systems and other permitted operations.

3.1 POTW Optimization

The 2002 MARB SPARROW model indicates that approximately 8% of Kentucky's phosphorus load comes from sewage point sources, while another 6% originates from urban land runoff (see **Table 6**). Combined, approximately 14% of Kentucky's modeled phosphorus load comes from wastewater systems and municipal stormwater.

DOW is pursuing facility specific nutrient reduction actions at POTW dischargers to address sewage point sources. Specifically, major POTW facilities that expand (i.e. POTW facilities with a design flow of 1.0 million gallons per day [MGD]) are required to meet a numeric phosphorus limit (see **Figure 7**). DOW is also developing facility-specific permit requirements for major POTW facilities renewing their KPDES permit that lack numeric nutrient limits. These facility-specific permit requirements can include numeric nutrient limitations or a study of optimization methods to reduce nutrient discharge.

Table 6 - SPARROW Modeled Phosphorus Sources in Kentucky



Data Source: Journal of the American Water Resources Association

Nutrient reduction optimization allows a POTW to identify the best combination of reduction strategies for its specific system. Nutrient reduction methods can include reducing phosphorus from influent sources, altering conventional treatment methods, reconfiguring existing treatment processes, or installing new treatment technologies. Phosphorus discharge data from Kentucky's Major POTW facilities indicates that achieving a 1.0 mg/l annual flow-weighted

average may cut the phosphorus loading from these facilities to Kentucky waterways *by up to 50%*.

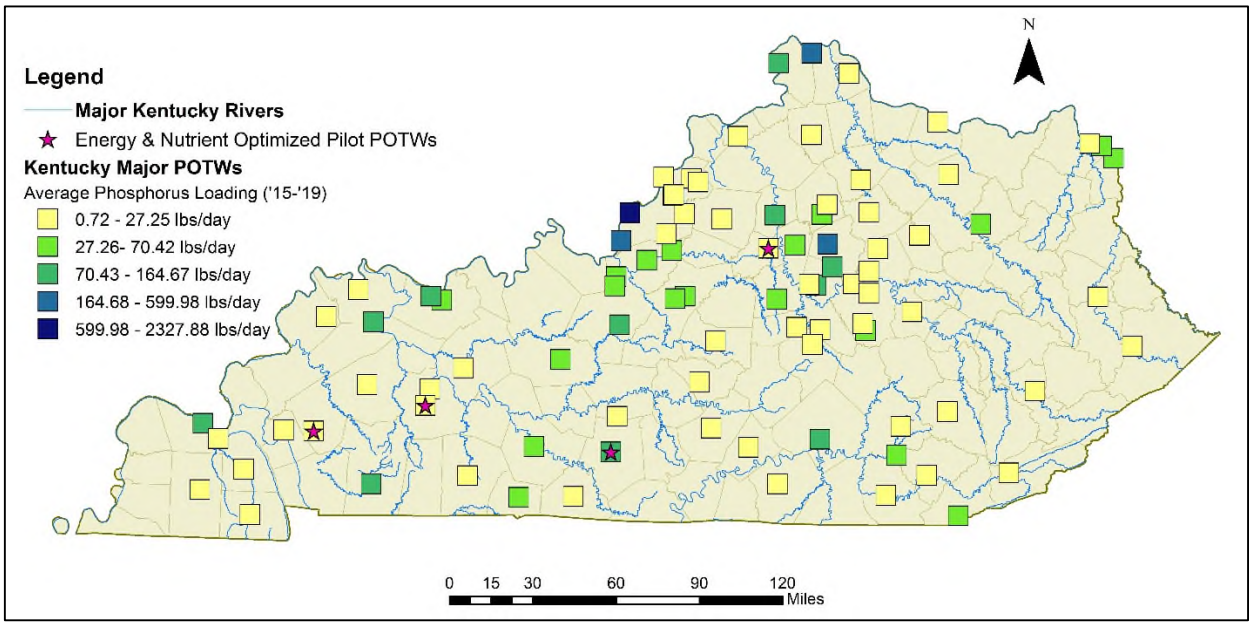


Figure 7- Major POTWs & Pilot Optimization Facilities

3.2 Other Statewide Point Source Efforts

While municipal stormwater systems are point sources of nutrient pollution, they require nonpoint source strategies to achieve reductions. For example, municipal separate sewer systems (MS4) in Kentucky discharge stormwater runoff from many discrete locations (point sources). Nutrient sources in this runoff can include lawn fertilizer applications, pet waste, and soil disturbance activities on private or public lands. Section 6.2.7 of the updated Kentucky Nonpoint Source Management Plan provides a list of educational resources for MS4 systems.

Kentucky individual and general MS4 permits require actions to control construction stormwater runoff, eliminate illicit discharges, foster public participation and awareness, inspect infrastructure, and even monitor nutrient discharges in large systems. DOW updated the general MS4 permit (KYG20) in 2018 to require a written plan that addresses illicit discharges and improved mapping of post-construction water quality BMPs. DOW will continue to review and update general and individual MS4 permits during permit renewal to further incorporate strategies for reducing the discharge of nutrients.

DOW encourages MS4 systems to adopt the most effective and practical stormwater BMPs for new construction, redevelopment, and retrofit activities. In collaboration with the Kentucky Water Resources Research Institute, the 319 Program funded the Kentucky Watershed Academy Urban BMP guide to enhance stormwater BMP planning by watershed coordinators and MS4 systems. DOW also promotes and trains MS4 Coordinators on nature-based solutions that leverage constructed features, such as rain gardens and stormwater wetlands, to mitigate

flooding and nutrient losses. In 2021, DOW collaborated with the Kentucky Association of Mitigation Managers on a nature-based solution training series to equip municipal staff with stormwater mitigation tools, including an interactive map of installed nature-based solutions.

Since 2014, Kentucky's CWSRF committed over $457 million to wastewater and stormwater infrastructure projects that improve wastewater treatment, alleviate stormwater impacts, and replace deteriorating infrastructure that can leach nutrients into the environment. From this 2014-2019 funding, CWSRF approved over $20 million for stormwater improvement projects for stormwater retention, green infrastructure, and flooding mitigation. Additionally, over $88 million of wastewater and stormwater projects were invited to participate in the 2020 CWSRF program. DOW annually updates the Priority System Guidance Document that ranks projects for CWSRF funding. Projects that use funds to reduce nutrient pollutants in a DOW priority watershed, address existing or proposed nutrient TMDLs, or provide green infrastructure with nutrient benefits, receive higher ranking.

Local funding for stormwater infrastructure also plays an important role in reducing nutrient loading, while mitigating flood risk. In 2018, a Western Kentucky University survey found that 11 of Kentucky's 106 MS4 communities have dedicated local funding for stormwater BMPs. As storm events increase in intensity and frequency, more local municipalities should consider dedicated stormwater funding to limit pollution and reduce flooding impacts to residents. Future NRS reports will outline progress on Kentucky's stormwater education and investment efforts.

4 Statewide Nonpoint Source Strategy

Nonpoint sources such as agriculture, atmospheric deposition, and sediment erosion provide the majority of nutrient loading to Kentucky waters. DOW's 2021 Loads and Yields Study[2] revealed a strong correlation between agricultural land use and nitrogen yields, while phosphorus rich soils in Central Kentucky contribute to high phosphorus yielding watersheds. This updated nonpoint source strategy focuses on new initiatives through the AWQA and expansion of existing programmatic efforts to reduce nutrient losses.

4.1 Kentucky Agriculture Water Quality Act

Protection and preservation of Kentucky waters from nutrient impairments is a long-standing commitment by citizens, agricultural producers, and public agencies, and not a new initiative. The AWQA requires farms with more than 10 acres to develop a plan and implement BMPs that are protective of water quality. The Kentucky Agriculture Water Quality Plan[6] identifies three concepts that form its backbone:

- Agriculture and silviculture producers are responsible citizens and good environmentalists with strong ties to the land and water in their operations.
- Agriculture and silviculture producers are primary consumers of well water for drinking, and surface water for recreational activities. It is therefore in their own interest to protect water resources in their operations.
- Kentucky supports educational programs that promote the voluntary adoption of BMPs to protect water quality.

To empower producers to protect local water quality, DOW and DOC developed water quality planning tools that simplify conservation planning, engage more producers, and connect producers with BMP funding sources.

4.1.1 AWQA Planning Tool Development & Implementation

Coinciding with the 25th anniversary of the AWQA, DOW received EPA funding (through the Hypoxia Task Force) to update the existing AWQA producer workbook into an electronic format. This new resource meets the needs of modern farmers by creating a user-friendly and adaptable decision-making tool. The AWQA planning tool incorporates the latest best management practices (BMPs), and improves producer access to future BMP updates. DOW, DOC, and active farming members of the AWQA Authority collaborated on development and testing of the tool prior to launch in 2021.

This electronic planning tool incorporates technical assistance features, photo examples (see **Figure 8**), and a water quality benefit rating to facilitate BMP selection and implementation. Additionally, the AWQA planning tool links to funding sources from DOC, NRCS, and the Kentucky Office of Agriculture Policy to facilitate financial planning. By further requiring an AWQA plan on file, some common funding sources, including State Cost Share and the County Agricultural Investment Program (CAIP), incentivize the development and implementation of AWQA plans.

Photo Credit: USDA ARS

Figure 8 – Alternative Waterer & Rotation Grazing BMPs

The AWQA planning tool helps producers protect local water sources from harmful algal blooms through nutrient mitigation measures. In late summer, stagnant or captive water bodies are particularly susceptible to algal blooms that can harm livestock or impair drinking water sources. Developing a robust AWQA plan helps farmsteads, livestock operations, crop producers, forestry operations and streamside properties minimize HAB risks. While research demonstrates the nutrient trapping benefits of small ponds, it is equally important to keep nutrients from migrating into these watering sources using filter strips, grassed waterways, and other BMPs.

4.1.2 AWQA Outreach & Messaging

In 2019, DOW, DOC, and other Energy and Environment Cabinet (EEC) officials initiated an AWQA outreach campaign with stakeholder and partner meetings to engage the agricultural community. EEC officials published AWQA articles in significant farming publications such as Kentucky Farm Bureau News, while partners published articles in periodicals such as the Kentucky Soybean Sentinel. Through these platforms, EEC officials and partners encouraged existing producers to update their AWQA Plans, while informing new producers of plan assistance available from local Conservation Districts, DOC State Cost Share funds, agriculture development programs through the Kentucky Office of Agriculture Policy (KOAP), and Farm Bill funding from the NRCS and USDA.

Figure 9 – Agriculture Water Quality Act Messaging

DOW, DOC, and partners are engaged in an AWQA outreach campaign through radio, print, social media, and direct engagement (see **Figure 9**), focusing on Nutrient Priority Areas with sensitive resources (see **Section 5.1.2**). These NRS Nutrient Priority Areas can also serve as AWQA "water protection priority regions", allowing the AWQA Authority to tailor conservation outreach, funding, and practice standards to address known water quality issues (KRS 224.71-120). The AWQA planning tool helps facilitate tailored planning, financial assistance, and partner engagement in the agricultural community.

The University of Kentucky (UK) Cooperative Extension Service developed a baseline inventory of known nutrient reduction efficiencies of livestock BMPs in Kentucky. This baseline document was made possible through the Hypoxia Task Force's partnership with land grant universities, and funding from the Walton Family Foundation. While row crop BMP efficiencies are the subject of significant research in other Hypoxia Task Force states, there is less research in Kentucky and surrounding states on the most effective BMPs for livestock. This baseline lays the groundwork for a more comprehensive State Science Assessment and establishes the need for additional research on livestock BMP nutrient reduction efficiencies. DOW will continue tracking livestock BMP research and incorporate available science in outreach with the AWQA Authority.

4.2 Other Statewide Nonpoint Source (NPS) Efforts

DOW evaluates nonpoint sources of nutrients through its role in the Hypoxia Task Force, management of the 319 Program, Watershed Planning, and TMDL pollution budgets for impaired waters. The work of the Hypoxia Task Force includes groundbreaking research on the delivery of loads and local contributions. Research commissioned through the Hypoxia Task Force Trends Workgroup includes a 2019 USGS Study that identified a small (1.58% from 2002-2012) reduction in nutrient loads to the Gulf of Mexico. The Hypoxia Task Force is collaborating with the National Great Rivers Research and Education Center (NGRREC) to study additional trends. DOW will continue analyzing watershed trends from Kentucky's ambient monitoring network (see 2021 Loads and Yields Study[2]) to compare with those identified by NGRREC.

The DOW NPS Program oversees statewide implementation of the EPA 319 Program, which provides funding for watershed plan development and implementation. Annual nutrient load reductions published in the NPS Program Annual Reports (see **Figure 10**) indicate local nutrient progress across the state. To improve outcomes, DOW refocused its resources to provide Basin Coordinators in all seven major river basins (see **Figure 19**). Basin coordinators facilitate development of new watershed plans and implementation projects (i.e., agriculture BMPs, septic system repairs, etc.) to reduce nutrients across the Commonwealth.

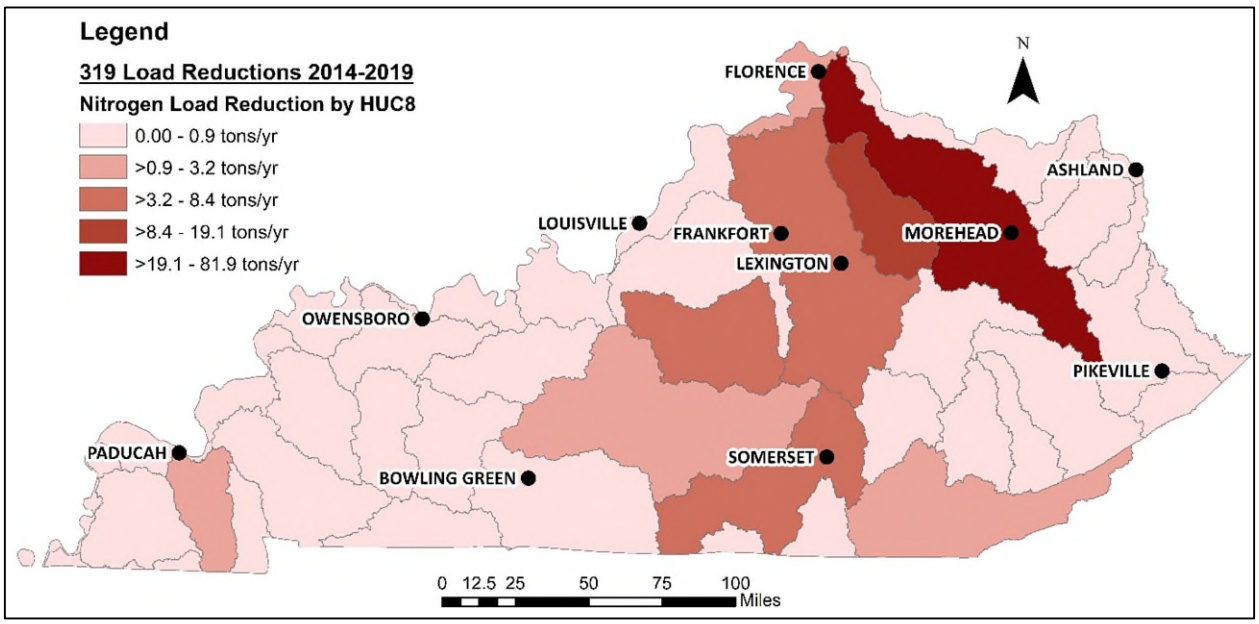
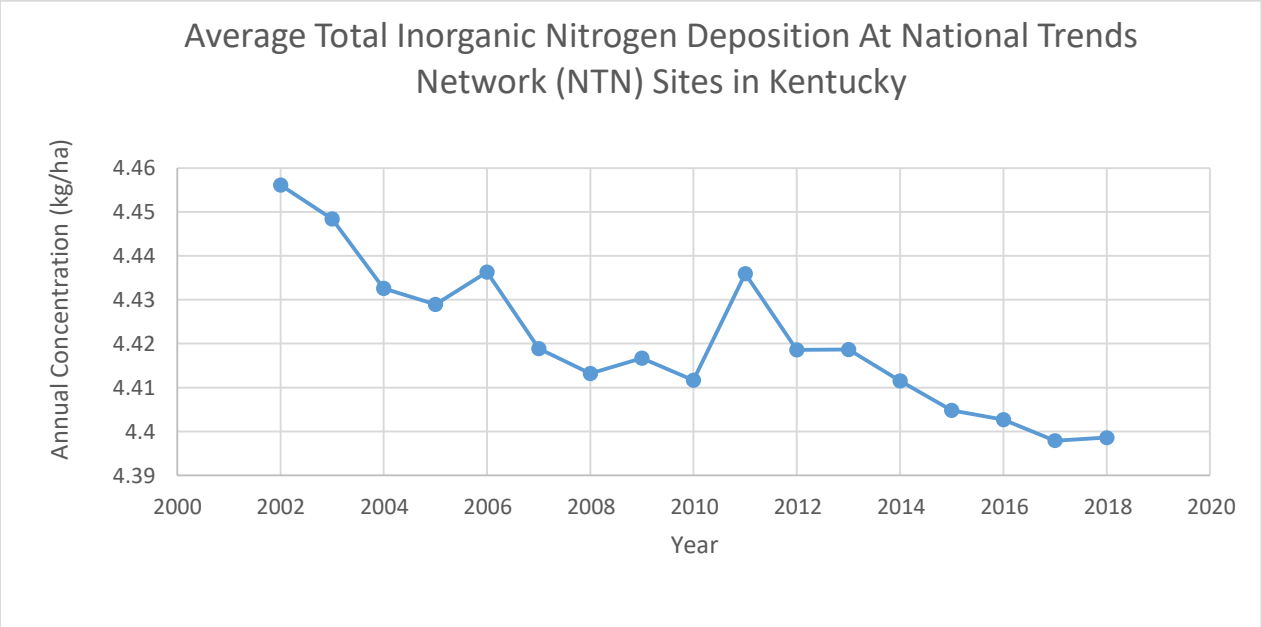


Figure 10 - 319 Program Nitrogen Load Reductions by 8-Digit HUC (2014-2019)

According to DOW's 2018/2020 Integrated Report, approximately 17% of assessed streams have nutrient-related impairments. The Clean Water Act requires detailed pollution budgets for these waters, known as Total Maximum Daily Loads (TMDLs). In recent years, EPA has promoted the use of alternative types of pollution reduction plans where they can achieve water quality restoration faster than the lengthy process to establish a TMDL. In the case of nonpoint source nutrient issues, these alternative restoration plans (i.e. "TMDL Alternatives") rely on a demonstration of local engagement, watershed planning, and follow-up monitoring to addresses the impairment and track progress. EPA accepted Kentucky's first TMDL Alternative for the Gunpowder Creek Watershed in northern Kentucky in 2018, prompting a search for additional alternative restoration plans. Watershed planning and local engagement keeps the Gunpowder Creek alternative plan on track for successful restoration, as evidenced by some of the highest 319 Program-funded load reductions reported in 2018 and 2019. Kentucky's TMDL and NPS programs will continue partnerships with local communities to reduce nutrient pollution and restore impaired waters through watershed planning.



Data Source: National Atmospheric Deposition Program's National Trends Network

Figure 11 - Average Atmospheric Deposition in Kentucky 2002-2018

Additionally, six air quality stations across Kentucky monitor nonpoint source atmospheric deposition of total inorganic nitrogen in the National Trends Network (NTN), through the National Atmospheric Deposition Program (NADP). The NADP recorded a steady decrease in nitrogen deposition from 2002 to 2018 (see **Figure 11**), reflecting decreasing nitrogen dioxide in Kentucky's ambient air monitoring (see **Section 2.1.3**). DOW will continue to monitor trends from this network for future biennial updates.

5 Nutrient Reduction Prioritization

Reducing nutrient pollution across Kentucky's varied landscape requires a data-driven focus with short-term and long-term goals. The proliferation of land uses, land types, and natural conditions requires collaborative efforts to attain short-term local water benefits that result in long-term improvements at the Gulf of Mexico. The following sections outline how public resources will be allocated for the most pressing and solvable problems, while reducing data gaps and tracking progress through monitoring. This two-part strategy will help achieve nutrient load reductions in the near-term, while also identifying future focus areas.

5.1 Implementation Priorities

Utilizing the flexibility afforded to states in the 2011 Memo from EPA Assistant Administrator Nancy Stoner, DOW is revising Kentucky's priority watersheds to reflect emerging concerns and insights from nutrient monitoring data. These Nutrient Priority Areas include the highest nutrient yielding watersheds, nutrient focused drinking water source areas, and reservoirs with confirmed HABs (see **Figure 12**). These areas will rank higher on 319 Program, CWSRF, and State Cost Share applications, receive a greater NRCS cost share on BMP funding, and receive funding prioritization for Volunteer Lake Monitoring (see **Section 7.2**). Funding sources such as the Gulf Hypoxia Program will prioritize conservation practice installation and technical assistance in Nutrient Priority Areas.

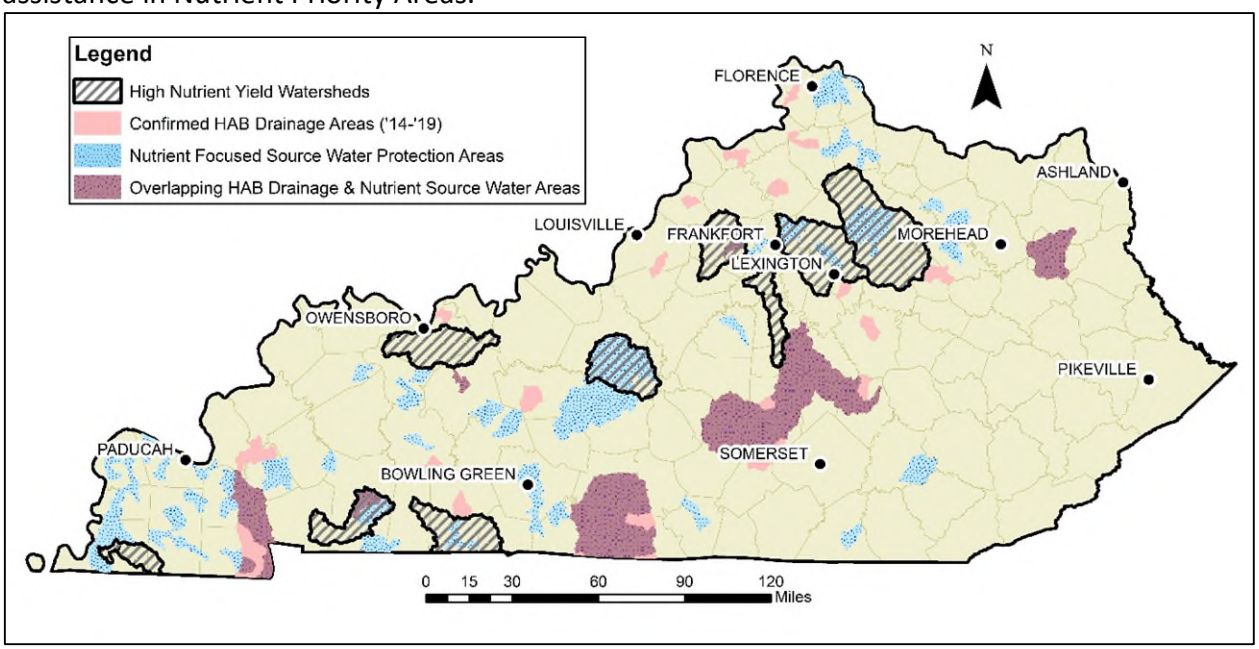


Figure 12 – Nutrient Priority Areas

DOW will track short-term progress through estimated load reductions from 319 Program and State Cost Share funded nonpoint source BMPs (see STEPL model), and through permit-driven changes in point source discharges of nutrients. DOW will gauge long-term progress in Nutrient Priority Areas using statewide monitoring networks to track basin-wide changes, while conducting intensive surveys of smaller watersheds for changes in habitat, macroinvertebrates,

and water chemistry (**Section 5.2**). Research on legacy nutrients guides this decentralized approach, which suggests large-scale nutrient reductions are limited by legacy nutrients that persist for decades once released[7]. DOW has demonstrated success with this approach through watershed planning, local engagement by basin coordinators, and collaborative funding of BMPs.

5.1.1 Collaborative Solutions

Partnerships are vital to achieving local nutrient reductions. Together, DOW and NRCS developed the Source Water Protection Priority Area component of Nutrient Priority Areas to protect drinking water. As a result of this collaboration, high cost-sharing from federal conservation funding expanded from 13% to 20% of the state (see **Figure *13***). Preliminary data suggests enhanced NRCS funding and technical assistance between 2020 and 2022 will benefit over 432,000 acres of farmland. These protection areas reflect overlapping funding priorities between DOW's protection of drinking water sources under the Safe Drinking Water Act, and NRCS's commitment to fund agriculture BMPs that protect source waters under the 2018 Farm Bill.

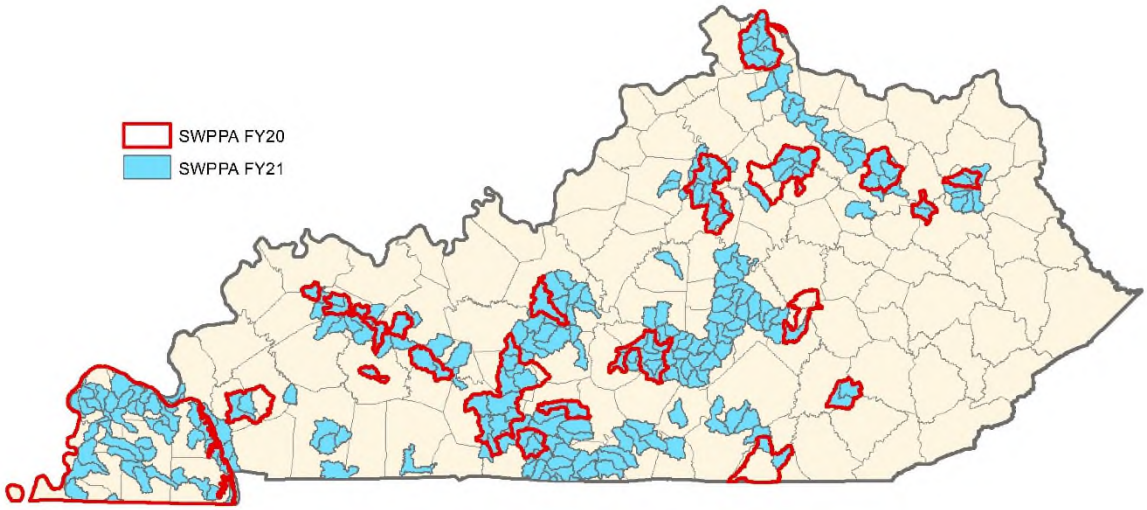


Figure 13 - Increased coverage of NRCS Source Water Priority Protection Areas

The well-established partnership between DOW and DOC funds agriculture BMPs in 319 Program watershed planning areas. DOC funds practices such as exclusion fencing and waterers that keep livestock out of streams, while watershed planners develop community support and adoption of these BMPs. This collaborative approach often results in higher adoption of BMPs in a given watershed. Between 2011 and 2019, State Cost Share funded approximately 302 BMPs in DOW watershed planning areas. This collaboration will improve the number of conservation practices in Nutrient Priority Areas, which overlap with 21 existing or pending watershed planning areas.

Additionally, in 2020 and 2021, DOW and DOC partnered to estimate annual load reductions for the State Cost Share Program using the same modeling platform (STEPL) used by the 319 Program. Between 2020 and 2021, total phosphorus load reduction improved by nearly 40%,

while combined investments in 2021 kept an estimated 50,000 tons of sediment out of waterways (see **Figure 14**). By comparing data from both programs, state managers can compare annual impact, quantify progress, and explore ways to reduce landscape nutrient losses.

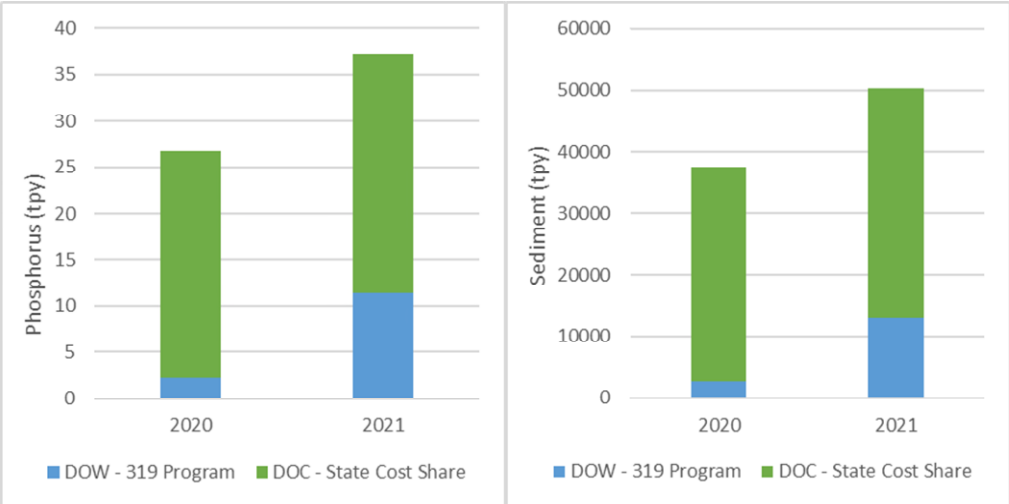


Figure 14 - Annual Phosphorus and Sediment Load Reduction by Program

DOW is already making progress with its partners in specific Nutrient Priority watersheds. Eight of the thirteen Kentucky NRCS 2020 Priority Work Units are located in Nutrient Priority Areas. The Lake Linville watershed is one such work unit estimated to receive up to $572,000 in BMP funding from the Kentucky NRCS Office, supported by DOW Basin Coordinators' community engagement. DOW is also providing water quality monitoring associated with NRCS's National Water Quality Initiative (NWQI), and providing planning input for the Mississippi River Basin Healthy Watersheds Initiative (MRBI). DOW will continue collaborating with NRCS on these projects to maximize funding and staff resources.

5.1.2 Project Promotion

Kentucky's AWQA provides a unique platform for collaboration in Nutrient Priority Areas. The AWQA planning tool (**Section 4.1.1**) and associated BMP guides link landowners with federal, state, and local programs that provide technical assistance and help fund BMP installation. Kentucky is a diverse state of mountains, rolling hills, springs, lowlands, and sloughs that requires specialized planning by those most familiar with the land. Local soil conservations districts can help landowners identify the best BMPs for their property. Funding for selected BMPs is available through DOC's State Cost Share program, NRCS's EQIP, 319 Program watershed planning, and KOAP. AWQA outreach activities will focus on Nutrient Priority Areas to enhance existing projects in these areas. As funding allows, DOW will prioritize AWQA marketing resources in Nutrient Priority Areas.

5.2 Monitoring Priorities

Four monitoring strategies highlight DOW's commitment to gauge progress in nutrient priority areas, and identify future nutrient projects. Specifically, DOW is committed to **Harmful Algal**

Bloom Tracking, Watershed Nutrient Load Tracking, Statewide Monitoring and Assessment, and Nutrient TMDLs & Alternative Plan Development. Each of these monitoring priorities improves understanding of nutrient impairment sources and loading. Collectively, these priorities represent an adaptive management strategy that identifies nutrient-impaired waters, elevates them to Nutrient Priority Areas, and tracks long-term progress.

5.2.1 Harmful Algal Bloom Tracking

DOW's Ambient Lakes Monitoring Program monitors approximately 67 reservoirs and lakes on a rotating basis to assess eutrophication from nutrient sources, among other concerns. The U.S. Army Corps of Engineers monitors an additional 18 reservoirs in Kentucky. DOW also trains Watershed Watch volunteers to monitor eutrophic indicators in lakes (see **Section 7.2**). These volunteers provide an early warning system to DOW scientists of eutrophic conditions and potential algal blooms. DOW and Watershed Watch are deploying nutrient test kits with volunteers to monitor the tributaries that feed these lakes, and help identify which tributaries contribute higher nutrient concentrations. DOW also uses satellite imagery and bloom reporting to identify potential harmful algal blooms (HABs) and coordinate HAB response with partners, such as the U.S. Army Corps of Engineers, and the Ohio River Valley Water Sanitation Commission. DOW provides information on reported blooms and recreational public health advisories on its HAB Viewer. Lakes with repeated HABs receive greater consideration for inclusion as Nutrient Priority Areas (see **Section 5.1**).

5.2.2 Watershed Nutrient Load Tracking

Kentucky uses the Ambient River Monitoring Network (see **Figure 15**) and the USGS stream gage network to estimate watershed nutrient loading. This long-term monitoring network provides important nutrient data on most major Kentucky river systems going back to 1976. DOW periodically reassesses USGS stream gage locations funded by the EEC, and works with USGS to maintain this network for multiple programmatic needs. To facilitate stakeholder engagement in these monitoring efforts, DOW developed an interactive story map that presents nutrient loads and yields trends, and allows users to explore the connection between land use, loading, and DOW efforts to reduce nutrient loss. These watershed trends guide agency decisions on BMP investment, Watershed Plans, and other monitoring initiatives.

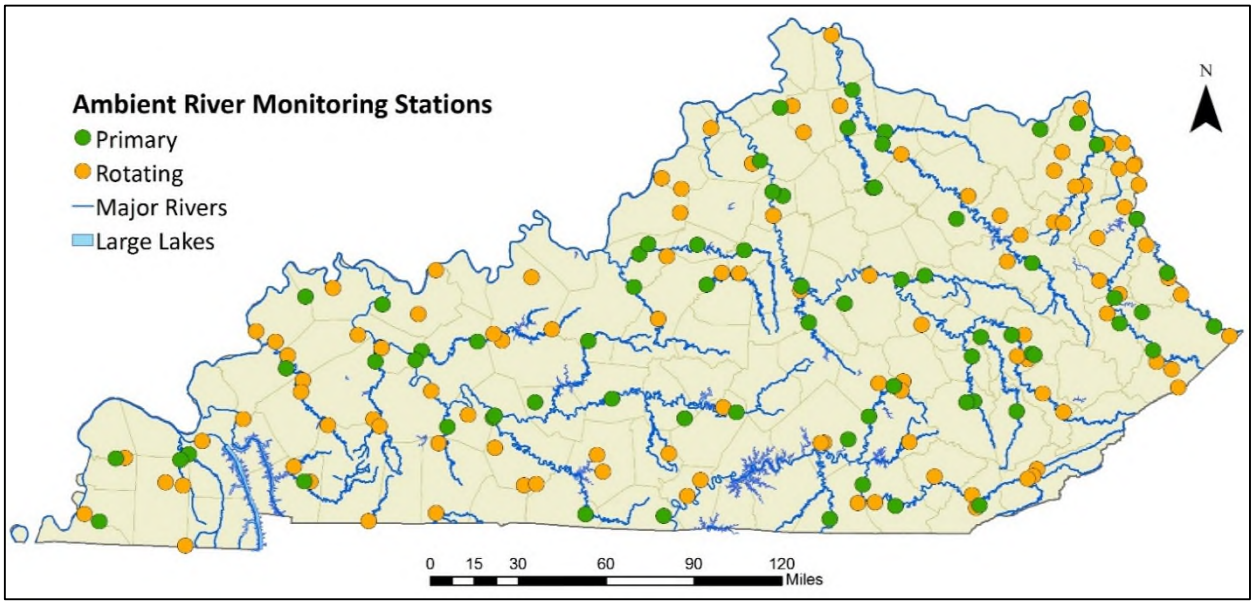


Figure 15- DOW Ambient Rivers Monitoring Network

5.2.3 Statewide Monitoring and Assessment

DOW monitors water quality to identify impaired and healthy waters, support the development of TMDLs and other pollution reduction plans, issue advisories, and evaluate the success of watershed management actions (i.e., BMPs) across the state. A diverse set of monitoring programs sample streams, rivers, springs, and lakes at fixed, targeted, or probabilistically chosen stations to assess water quality. These programs provide most of the data used for assessments and listings. Every two years DOW publishes the Integrated Report to Congress on the Condition of Water Resources in Kentucky, which updates the 305(b) List of assessed waters and the 303(d) List of impaired waters that require a TMDL. Water quality assessments contributing to the 305(b)/303(d) lists follow the procedures identified in DOW's Consolidated Assessment and Listing Methodology (CALM).

When DOW lists an impaired water on the 303(d) List, additional water quality monitoring helps identify impairment sources and nutrient reduction needs. This monitoring is critical for the development of TMDLs in these waters, and for tracking progress in implementation. Other types of water quality restoration plans also rely on intensive monitoring. In the case of Watershed Plans, these intensive surveys quantify baseline conditions before 319 Program funded BMPs are installed. After implementing 319 Program, State Cost Share, or NRCS funded BMPs, additional intensive surveys can confirm the extent of water quality improvement. These monitoring efforts expand the understanding of nutrient sources and the effectiveness of remedial activities, including those in Nutrient Priority Areas.

To compliment these monitoring efforts, DOW developed a drinking water operator survey to identify where nutrients may be affecting source water quality, and consequently drinking

water treatment. This information will assist prioritization of future monitoring and water quality assessments for the domestic water supply designated use.

5.2.4 Nutrient TMDLs & Alternative Plan Development

Kentucky's 2018/2020 Integrated Report indicates that excess nutrients is among the leading causes of impairments to aquatic life designated uses (warm or cold-water aquatic habitat) in streams, rivers, and lakes. Nutrient impairments, like many others, required development of a TMDL, including a detailed analysis of nutrient sources, calculation of a nutrient budget, and allocation of nutrient loads to sources. Interested parties can pursue alternative plans before TMDL development if local engagement and funding sources provide capacity to restore water quality more quickly. In many instances, Watershed Plans associated with nutrient impaired streams are good candidates for these alternative restoration plans (i.e. "TMDL Alternatives"). Where an alternative plan alleviates the nutrient impairment to the point of meeting water quality standards, the waterbody can be delisted from the 303(d) list and forego a TMDL.

Kentucky's 303(d) Vision priorities (2016-2022) outline the long-term focus for both TMDLs and alternative plans to address 303(d) listed waters for all types of impairments. Nutrient impaired streams identified as 303(d) Vision priority waters in 2016 include those associated with the Gunpowder Creek TMDL Alternative (2018) and the Sulphur Creek TMDL Alternative (2022). Future DOW updates to the 303(d) Vision will take into account Nutrient Priority Areas when finalizing 303(d) priorities.

6 Nutrient Water Quality Criteria

Kentucky's nutrient water quality criteria established in 401 KAR 10:001 and 401 KAR 10:031 focus on nutrient-driven eutrophication that results in algal blooms and impacts aquatic life. Eutrophic conditions also pose threats to drinking water systems and recreation. DOW is committed to effectively implementing Kentucky's narrative nutrient criteria, while exploring additional opportunities to refine or update this approach.

6.1 Building on Narrative Criteria

Implementation of Kentucky's narrative nutrient criteria involves expanded testing and analysis of eutrophic indicators (see **Figure 16**) in a number of monitoring programs. DOW is developing regional nutrient screening values for streams to determine which streams require a more thorough investigation for eutrophication. These values provide a threshold above which eutrophic conditions are more likely to occur. When water samples exceed screening values, additional sampling or evaluation will assess potential stream impairments, in keeping with the DOW Consolidated Assessment and Listing Methodology (CALM).

Figure 16-Eutrophic Indicators Include Algal Mats

6.2 Numeric Criteria Advancements

Establishing numeric criteria for nutrients requires a keen understanding of the impacts of excess nutrients on all designated uses across waterbody types and geographic regions. This relies on extensive data collection to determine regional background nutrient levels and enrichment indicators.

Most DOW monitoring programs have added or expanded nutrient data collection in recent years. DOW has completed several studies to identify region-specific nutrient thresholds based on biological indicators. Additional data collection and studies targeting response indicators continues to be a priority of the agency. In addition to informing efforts towards numeric criteria development, this information will assist Kentucky's application of narrative criteria in the 305(b) assessment process, setting watershed planning and TMDL targets, improving understanding of natural nutrient variability, and identifying where biological indicators are sensitive to nutrients.

In August 2021, EPA released its final national recommendation criteria for lakes and reservoirs. DOW will consider the recommended approaches for future updates of Kentucky's water quality standards.

7 Education and Outreach

Developing stakeholder and partner equity to reduce nutrient pollution is a prominent objective of the NRS Update. Because nutrient loading in Kentucky ties directly to local land use, significant partnerships and stakeholder involvement are required to make progress. DOW will improve partnerships and stakeholder engagement initiated under the 2014 Strategy.

7.1 Partner Engagement

To kick off the NRS Update, DOW convened partners in the summer and fall of 2019 to solicit early input and gauge statewide nutrient reduction progress since the 2014 NRS. DOW works with the AWQA Authority, DOC, and UK Cooperative Extension Service to identify barriers to statewide BMP implementation. Voluntary installation of innovative BMPs on private lands is vital to Kentucky's nutrient reduction efforts, and requires all federal, state, and local partners. DOW works with commodity groups, farmers, and advocacy groups through the AWQA Authority to promote BMP adoption for agriculture operations across the state.

DOW and DOC engage federal partners, through the Federal Water Subcabinet of the Hypoxia Task Force, to streamline innovative BMP adoption and address funding for nutrient monitoring. DOW also contributes to multiple working groups with the Hypoxia Task Force Coordinating Committee and to regular updates available on the EPA website. In 2019, the EPA awarded DOW a $100,000 grant to develop the AWQA planning tool (**Section 4.1.1**) and provide lake monitoring training resources to volunteers (**Section 7.2**). EPA provided an additional $100,000 grant in 2020 to support outreach initiatives. Any additional funding through the Hypoxia Task Force and EPA will support BMP implementation, monitoring, and outreach in NRS Nutrient Priority Areas. DOW updates funding opportunities and awards for nonpoint source pollution projects on its 319 Program Grant Webpage.

7.2 Stakeholder Engagement & Training

DOW can engage stakeholders in watersheds across the Commonwealth through listening sessions, public meetings, public comment periods, and education events. Of these public interactions, few are as meaningful and enduring as water quality monitoring efforts between citizen scientists and DOW. Through the non-profit Watershed Watch in Kentucky, DOW collaborates with citizen scientists to monitor local springs, streams, rivers, and lakes. DOW provides technical assistance and training resources that help stakeholders identify, monitor, and report local water quality conditions that also guide DOW success monitoring efforts. Through this program stakeholders not only learn about, but are also equipped to protect, their watersheds.

DOW continues to receive robust interest in citizen scientist water monitoring efforts, especially regarding the Volunteer Lakes Monitoring Program. The pilot program began in 2017 at Herrington Lake, Lake Barkley, and Kentucky Lake to equip citizen scientists in early detection of HABs and nutrient pollution that impact drinking water sources and recreation (**Figure 17**).

Figure 17 –DOW Staff Train Volunteers on Secchi Depth Measurements

DOW prepared the technical references for this program, and DOW Basin Coordinators conduct trainings with interested stakeholders. Volunteers are encouraged to schedule field observations with the remote sensing Landsat Path and Row flyover calendar (**Figure 18**). DOW staff then process the Landsat satellite imagery to evaluate potential water quality changes in large lake areas. Citizen scientist observations can help calibrate DOW image processing and improve early detection of HABs. As this program expands statewide, DOW hopes to improve HAB detection and public notification, while educating citizens about the factors that degrade drinking and recreational waters.

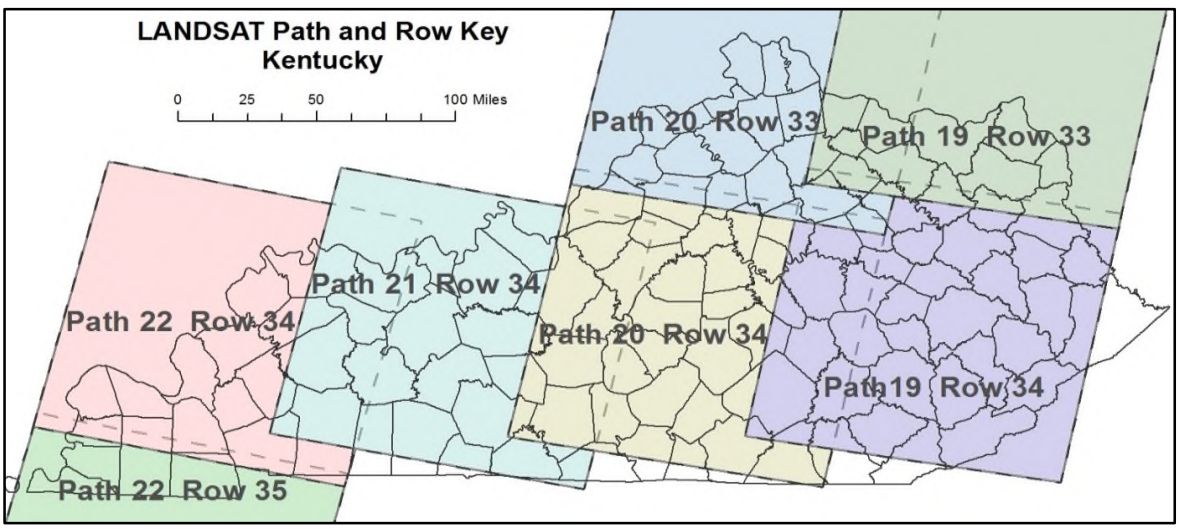


Figure 18 - Landsat Imagery Path and Row Used by Volunteers to Schedule Observations

To improve stakeholder engagement, a portion of EPA's HTF grant to Kentucky will fund additional training resources for the Volunteer Lake Monitoring Program, focusing on Nutrient Priority Areas (**Section 5.2.1**). Through Watershed Watch in Kentucky, DOW is also deploying a Nutrient Monitoring Program that will enable stakeholders to track nutrient concentrations in their local waters. Volunteers can combine Nutrient Monitoring Program and Lakes Monitoring resources to identify the concentration and flow of nutrients into lakes where algal blooms are a concern. DOW collaborates with its partners to track reported and potential HABs through the DOW HAB Viewer, an interactive map of reported algal blooms and associated recreational health advisories. DOW improved HAB viewer data transparency in 2019 to refine the location of reported blooms, the presence or absence of toxic algae based on lab testing, and locations where toxic algae concentrations met advisory criteria.

7.3 Local Capacity Development

Local engagement is the backbone for nutrient reduction success in Kentucky. DOW Basin Coordinators and local Watershed Coordinators foster local coalitions and provide a direct link to state and federal funding. Each of Kentucky's Basin Coordinators work in one of seven major watersheds across the state (see **Figure 19**), and promote watershed planning in nutrient-impaired waters to improve water quality. Watershed planning allows communities to access grants for wastewater system repairs, stormwater improvements, installation of innovative conservation practices on agricultural land, and deployment of educational and water monitoring resources.

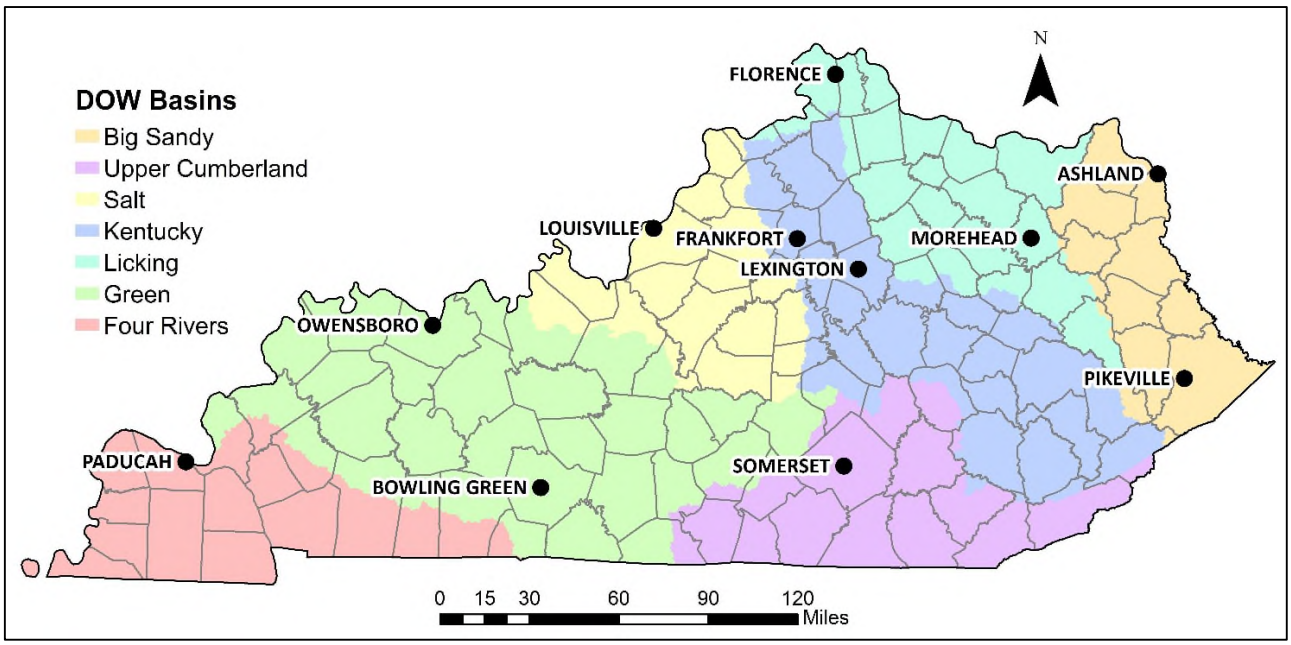


Figure 19 - Basin Coordinator Work Areas

Access to grant funding is particularly important for disadvantaged communities which represent nearly 40% of the population located in, or serviced by, drinking waters systems in Nutrient Priority Areas. DOW is working to improve access to watershed resources for

disadvantaged communities through streamlined processes that minimize barriers to entry. One example is the 319 Reporter portal which allows applicants to pull watershed data for the 319 grant application in one, convenient report. The Energy and Environment Cabinet also developed an information hub to facilitate community engagement on environmental justice.

Basin Coordinators play an integral role in the NRS Update by building local capacity for projects and BMPs in Nutrient Priority Areas (see **Figure 12**). Collaborative partnerships with DOC, NRCS, UK Cooperative Extension Offices, and Soil Conservation Districts are key to achieving statewide nutrient progress sought by the NRS Update.

8 Reporting

Nutrient pollution is a problem decades in the making that requires long-term commitment to achieve improvement on a statewide scale. Current research[7] indicates that nutrients can persist in the environment for decades before water monitoring shows nutrient reductions. The NRS will only be successful if statewide and national audiences understand the level of ongoing commitment needed by both volunteer and professional stakeholders, continued capital investments, and local consensus on goals. DOW is committed to building a nutrient stakeholder network, and tracking the wide range of nutrient reduction efforts through programmatic reporting and NRS progress reports.

Current program progress reports include annual Nonpoint Source Pollution, 319 Program Success Stories, the biennial Integrated Report, and regular updates to the HAB Viewer. Reductions in nonpoint source nutrient loads from the 319 Program are quantified using the EPA Spreadsheet Tool for Estimating Pollutant Load (STEPL) and summarized in the Loads & Yields Study story map. Successful projects, such as those at Stoner Creek and Fleming Creek, demonstrate that local water quality improvements require considerable time, investment, and community participation to be successful. DOW will continue building the nutrient network of stakeholders and telling Kentucky's nutrient story.

DOW will also continue monitoring long-term trends through nutrient analysis of ambient monitoring stations. DOW's Kentucky Nutrient Reduction Strategy webpage serves as a hub to communicate nutrient trend analysis (Loads & Yields Study), nutrient progress, and highlight partner engagement. Future biennial NRS updates will provide progress of the tracked elements in **Appendix A: NRS Update Management Goals, Objectives and Actions**. DOW will continue building a stakeholder network that drives an iterative nutrient strategy, while leveraging available funding such as the Gulf Hypoxia Program to invest in training and implementation.

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Appendix A: NRS Update Management Goals, Objectives and Actions

Nutrient Reduction Strategy Update Goals, Objectives, and Actions							
Goal 1: Reduce point source nutrient loading through KPDES permitting programs				Targeted Completion			
Objective 1:	Incorporate nutrient reduction initiatives into Publicly Owned Treatment Works (POTW) permits.			2023	2024	2025	2026
	Action 1:	Incorporate nutrient removal optimization BMPs into Major POTW permits.					
		Tracking measure:	Track the number of nutrient optimization studies conducted at permitted facilities.	X	X	X	X
		Tracking measure:	Track number of permits with nutrient discharge limits.	X	X	X	X
Objective 2:	Continue programmatic point source activities with nutrient reduction benefits.			2023	2024	2025	2026
	Action 1:	Continue CWSRF funding for infrastructure with nutrient benefits					
		Tracking measure:	Track CWSRF funding recipients and identify those with nutrient benefits.	X	X	X	X

Goal 2: Reduce nutrient loading through Kentucky Agriculture Water Quality Act (AWQA) tool development & BMP installation.				Targeted Completion			
Objective 1:	Create tools to help producers develop and implement AWQA plans.			2023	2024	2025	2026
	Action 1:	Create AWQA planning tool and associated enhancement tools, along with how-to tutorials for Plan development.					
		Tracking measure:	Track AWQA planning tool trainings for local conservation and extension staff.	X			
	Action 2:	Promote statewide messaging on most needed best management practices.					
		Tracking measure:	Track EEC participation in AWQA outreach events, and contribution to educational materials on agriculture BMPs.	X	X	X	X
Objective 2:	Continue programmatic nonpoint source activities with nutrient reduction benefits.			2023	2024	2025	2026
	Action 1:	Pursue regional nutrient reduction through the Hypoxia Task Force.					
		Tracking measure:	Record EEC participation in Hypoxia Task Force meetings, publications and initiatives.	X	X	X	X
		Tracking measure:	Report on project achievements funded by the Gulf Hypoxia Program.	X	X	X	X
	Action 2:	Continue nonpoint source support of nutrient initiatives.					
		Tracking measure:	Annually quantify nutrient load reductions in 319 Program watersheds.	X	X	X	X
		Tracking measure:	Quantify annual statewide nutrient load reductions from State Cost Share Program.	X	X	X	X
		Tracking measure:	Monitor trends in the recorded atmospheric deposition of nitrogen from the National Trends Network.	X	X	X	X

Goal 3: Provide focused NRS support where statewide efforts alone are unlikely to improve nutrient impairments.				Targeted Completion			
Objective 1:	Identify implementation priorities where partner/ stakeholder infrastructure exists to achieve success, where nutrients threaten public drinking water and where high yielding watersheds indicate a need for BMPs.			2023	2024	2025	2026
	Action 1:	Reduce nutrient loads in Nutrient Priority Areas where interagency resources or local commitments can deliver results.					
		Tracking measure:	Quantify nutrient load reductions from Gulf Hypoxia Program initiatives.	X	X	X	X
		Tracking measure:	Track load reductions from permitting efforts at POTWs.	X	X	X	X
		Tracking measure:	Track NRCS implementation in source water protection watersheds.	X	X	X	X
Objective 2:	Identify monitoring priorities to evaluate sources of nutrient impairments and quantify nutrient loads.			2023	2024	2025	2026
	Action 1:	Monitor HAB and nutrient impacted waterbodies.					
		Tracking measure:	Track the number of volunteer monitored lakes with a history of HABs or nutrient impairments.	X	X	X	X
		Tracking measure:	Report the location and status of reported or confirmed HABs through DOW's HAB Viewer.	X	X	X	X
	Action 2:	Quantify watershed nutrient loads.					
		Tracking measure:	Provide nutrient loading trends in each biennial report and additional internal/external data that the meets data quality criteria for inclusion.		X		X

Goal 3: Provide focused NRS support where statewide efforts alone are unlikely to improve nutrient impairments.				Targeted Completion			
Objective 2:	Identify monitoring priorities to evaluate sources of nutrient impairments and quantify nutrient loads.			2023	2024	2025	2026
	Action 3:	Assess nutrient impairments and list nutrient impaired waters.					
		Tracking measure:	Track the number of waters with a nutrient-related cause of water quality impairment in the Integrated Report.		X		X
		Tracking measure:	Track nutrient improvements/progress in assessed, listed streams through monitoring.		X		X
	Action 4:	Develop TMDLs and facilitate alternative restoration plans (TMDL Alternatives) with nutrient impacts					
		Tracking measure:	Track progress of TMDLs and alternative restoration plans completed for nutrient impaired waters.		X		X

Goal 4: Pursue the latest science on nutrient criteria.				Targeted Completion			
Objective 1:	Build on Kentucky's narrative nutrient criteria (401 KAR 10:001, 401 KAR 10:031) to better protect surface waters.			2023	2024	2025	2026
	Action 1:	Improve implementation of narrative criteria by updating monitoring and assessment methodologies for nutrient impairments.					
		Tracking measure:	Report on narrative criteria implementation in biennial NRS updates		X		X
Objective 2:	Identify potential enhancements to nutrient criteria.			2023	2024	2025	2026
	Action 1:	Evaluate options for developing numeric nutrient criteria for lakes and reservoirs.					
		Tracking measure:	Report on numeric nutrient progress in biennial NRS updates		X		X

Goal 5: Develop stakeholder and partner equity in the Nutrient Reduction Strategy (NRS)				Targeted Completion			
Objective 1:	Improve engagement with agency partners to develop collaborative solutions prior to major investments.			2023	2024	2025	2026
	Action 1:	Use listening sessions with partner agencies, agricultural producers and water infrastructure industry to refine strategy efforts as part of an iterative process.					
		Tracking measure:	Maintain a record of stakeholder outreach events for the NRS Update and biennial reports.	X	X		X
		Tracking measure:	Maintain a record of comments received on the NRS Update and biennial reports.	X	X		X
Objective 2:	Engage stakeholders through citizen science training and monitoring.			2023	2024	2025	2026
	Action 1:	Create and deploy volunteer training resources with strategic partners such as the Watershed Watch program.					
		Tracking measure:	Maintain a record of volunteer lakes monitor trainings through Watershed Watch and DOW.	X	X	X	X
Objective 3:	Develop local capacity to address nutrient impairments through Watershed Plans.			2023	2024	2025	2026
	Action 1:	Foster stakeholder and partner support in watersheds with insufficient local involvement to address nutrient pollution through Basin and Watershed Coordinators.					
		Tracking measure:	Report the number of watershed plans developed in Nutrient Priority Areas.		X		X
		Tracking measure:	Regularly update EPA's Nonpoint Source Watershed Projects Data Explorer with approved watershed plans through EPA's Grants Reporting and Tracking System (GRTS).	X	X	X	X
		Tracking measure:	Report on Basin & Watershed Coordinator trainings & outreach events in Nutrient Priority Areas.		X		X