Promoting Clean and Safe Water in Lake Erie:

Ohio's Domestic Action Plan 2020 to Address Nutrients

In accordance with
the Great Lakes Water Quality Agreement

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Introduction

A healthy Lake Erie is essential for a strong economy and high quality of life in Ohio; it is the source of drinking water for nearly 3 million Ohioans in shoreline communities. Large parts of the Lake Erie watershed that drain directly to the lake are in Ohio. This includes most of the land area in the Maumee River watershed, the largest tributary to the lake.

Ohio has a long history of identifying problems and developing solutions regarding nutrient enrichment and harmful algal blooms (HABs) in Lake Erie. To summarize, after a lengthy but successful fight to reduce historically high nutrient levels in Lake Erie, algal blooms had abated in the 1980s. In the mid-1990s, toxin-producing blue-green algal blooms began to appear in the western basin of Lake Erie. A particularly massive bloom occurred in 2003 and blooms of varying intensity have recurred most years since then. Satellite imagery of the algal blooms was used to assess recreational use of Lake Erie as "impaired" under the Clean Water Act in 2018[1], retroactive to 2016[2].

Lake Erie has also had a consistent area of low oxygen in the bottom waters of the central basin of the lake which impairs habitat for fish. While this is a naturally occurring annual event, nutrient enrichment increases the size and brings it nearer to the shoreline drinking water intakes.

The state of Ohio has been in the forefront of developing a response to algal blooms and low oxygen in Lake Erie. Building on the work of the Ohio Phosphorus Task Force, Ohio participated in efforts at the federal level through the Great Lakes Water Quality Agreement of 2012 (GLWQA) to link the harmful algal blooms and low oxygen levels to specific amounts of nutrients measured in the tributary rivers.

The governors of Ohio and Michigan and the premier of Ontario committed to a goal of reducing phosphorus loadings to Lake Erie by 40 percent through the signing of the western basin of Lake Erie Collaborative Agreement (Collaborative), first in 2015 and again in 2019. The Collaborative was intended to serve as the precursor to the Ohio Domestic Action Plan (DAP). Ohio's DAP will advance efforts toward the proposed nutrient reduction targets put forth in the GLWQA under Annex 4 (Nutrients). The DAP expands on the Collaborative implementation initiatives and includes the central basin as well as the western basin of Lake Erie.

Adaptive Management

The Ohio DAP is subject to change following the adaptive management philosophy. As defined by the U.S. Department of the Interior, this involves "…exploring alternative ways to meet management objectives, predicting the outcomes of alternatives based on the current state of knowledge, implementing one or more of these alternatives, monitoring to learn about the impacts of management actions, and then using the results to update knowledge and adjust management actions."[3] It is an approach intended to achieve objectives in systems that are responsive to management actions where there is uncertainty. It is useful in the management of natural systems, because the detailed workings of such systems may not be fully known, but many policy and program alternatives exist.

Efforts are underway at the Annex 4 level as well as in Ohio to define uncertainties, list the actions to take, implement, and then evaluate the results of various actions to reduce nutrient loads to Lake Erie and clean up the algae blooms in the lake. Each water year that passes offers an opportunity to learn more about system response and adjust actions if necessary.

H2Ohio

In March 2019, Governor DeWine introduced H2Ohio[4], a water quality initiative to invest in targeted, long-term solutions to ensure clean and safe water in Lake Erie and throughout Ohio. The H2Ohio Fund will provide the resources necessary to plan and implement targeted long-term water solutions. There are three strategies that are key to H2Ohio: land-based protection, water-based restoration, and science-based monitoring and research.

[1] ***https://www.epa.ohio.gov/dsw/tmdl/OhioIntegratedReport#1798510016-report***.
[2] ***https://epa.ohio.gov/Portals/35/tmdl/2016intreport/2016OH_IR_Amendment_May2018.pdf***.
[3] See ***http://www.doi.gov/ppa/upload/Chapter1.pdf***.
[4] ***http://h2.ohio.gov***.

Through collaboration among the Ohio Department of Natural Resources (ODNR), Ohio Environmental Protection Agency (Ohio EPA), Ohio Department of Agriculture (ODA), and Ohio Lake Erie Commission (OLEC), H2Ohio will address critical water quality needs and support innovative solutions to some of the state's most pressing water challenges.

H2Ohio is a statewide initiative. However, it has been designed, in part, to address the specific needs of Lake Erie. Strategies adopted and funded as part of H2Ohio for nutrient reduction specific to Lake Erie will be detailed within Ohio's Domestic Action Plan. The primary focus of H2Ohio for the purposes of the DAP will be on implementation of agricultural best management practices (BMPs), wetland restoration, and improvements to wastewater infrastructure. Actions supplementing H2Ohio goals have been incorporated throughout the DAP.

Goals of the Ohio Domestic Action Plan

The cornerstone of an adaptive management process is the goals that are established. The management objectives the State is trying to achieve in the Ohio DAP were defined through an interagency collaboration under Annex 4 (Nutrients) of the GLWQA[5] and are summarized here:

- Achieve a 40 percent total spring load reduction in the amount of total and dissolved reactive phosphorus (TP and DRP) entering Lake Erie's western basin from the Maumee River by the year 2025[6]. A spring (March – July) Flow-Weighted Mean Concentration (FWMC) of 0.23 mg/l TP and 0.05 mg/l DRP and a target of 860 metric tons (1.9 million lb) total phosphorus and 186 MT (410,000 lb) dissolved reactive phosphorus in the Maumee River is predicted to be a 40 percent reduction from the base year of 2008.
- Achieve a 40 percent total spring load reduction in the amount of total and dissolved reactive phosphorus (TP and DRP) entering Lake Erie's western basin from the Portage and Toussaint Rivers by the year 2025.
- Achieve a 40 percent total spring load reduction in the amount of total and dissolved reactive phosphorus (TP and DRP) entering Sandusky Bay from the Sandusky River to protect water quality in Sandusky Bay.
- Achieve a 40 percent total annual load reduction in the amount of total phosphorus entering Lake Erie's central basin by the year 2025. This goal applies to priority tributary watersheds to the central basin of Lake Erie in Ohio, which include the Maumee, Toussaint, Portage, Sandusky, Huron, Vermilion, Cuyahoga and Grand Rivers[7].

Ohio's phosphorus efforts have generally focused on TP, which includes both particulate and dissolved fractions. The majority of dissolved phosphorus is DRP. This is the most biologically active fraction of TP. Because of DRP's changeability, tracking phosphorus using mass balance methods is done using TP. Also, many phosphorus reduction implementation actions or BMPs have been studied looking only at TP.

While efforts have historically focused on TP, Ohio has supported projects to improve the understanding of DRP sources and transport. These studies will help quantify the "sinks" and "sources" of all phosphorus forms. Sinks include accumulation of sediment and organic material in slow moving waterbodies (i.e., lakes and reservoirs), floodplains, and drainage ditches. An example of an additional source being further studied is phosphorus entering waters from bank erosion. This work will allow Ohio to include DRP in a more rigorous fashion in future iterations of the Ohio Domestic Action Plan.

Major Sources of Phosphorus in Ohio

Understanding Nutrient Sources

Nonpoint sources include agricultural, urban or rural community runoff and natural sources. Agricultural sources of phosphorus are due to runoff of fertilizers (commercial and manure) and soil into waterways. The extent of fertilizer application throughout the Lake Erie watershed is not tracked. Because of this, a distinction between agricultural sources of phosphorus cannot be made at this time. This runoff is carried overland and via subsurface drainage

[5] See Annex 4 Subcommittee Objectives and Targets Task Team recommended targets technical report (***https://binational.net//wp-content/uploads/2015/06/nutrients-TT-report-en-sm.pdf***).

[6] The dates for these goals are from the Western Basin of Lake Erie Collaborative Agreement. ***https://lakeerie.ohio.gov/Portals/0/Ohio%20DAP/Western_Basin_of_Lake_Erie_Collaborative_Agreement-2015-06-13.pdf***.

[7] The spring load targets for the Maumee, Toussaint and Portage Rivers will also serve to reduce phosphorus to the central basin of Lake Erie.

networks (field tiles). Farm management practices can affect this drainage, which is also related to non-manageable factors including field slope, soil properties, and local climate.

Community-based sources of phosphorus are population-related sources that result from non-agricultural land uses; they are generally from human and industrial waste. Most community-based sources are managed through the National Pollutant Discharge Elimination System (NPDES) permitting program at Ohio EPA. These include municipal wastewater treatment plants, industrial facilities, municipal separate storm sewer (MS4) communities, and combined sewer overflows (CSOs). Home sewage treatment systems (HSTS; often referred to as septic systems) are a community source that is only partially regulated by the NPDES program. Phosphorus runoff from developed land that is outside of an MS4 community is another community source not regulated by the NPDES program. Ohio EPA's 2018 Nutrient Mass Balance Study[8] calculated TP loadings for these sources, excluding MS4 communities. Figure 1 shows the wastewater treatment (including CSOs) and HSTS contributions in Ohio's largest Lake Erie Annex 4 priority tributaries. Appendix E contains detailed information about community sources.

The National Center for Water Quality Research (NCWQR) at Heidelberg University has been monitoring phosphorus in Ohio's key Lake Erie watersheds for over 40 years. These data are collected at a high frequency and provide a robust basis for understanding where and when phosphorus moves through these key tributaries.

In 2018, Ohio EPA used these data in a nutrient mass balance study to evaluate major sources of total phosphorus (Figure 1). The study covered select watersheds across the state, including four of the Annex 4 priority watersheds in Ohio (Maumee, Portage, Sandusky and Cuyahoga). This study calculated mass balance amounts for several nutrients including total phosphorus (TP; which includes particulate and dissolved fractions) and dissolved reactive phosphorus (DRP; a more biologically reactive fraction), as well as nitrogen. For a complete discussion of all the findings for all nutrients studied, please see the report.

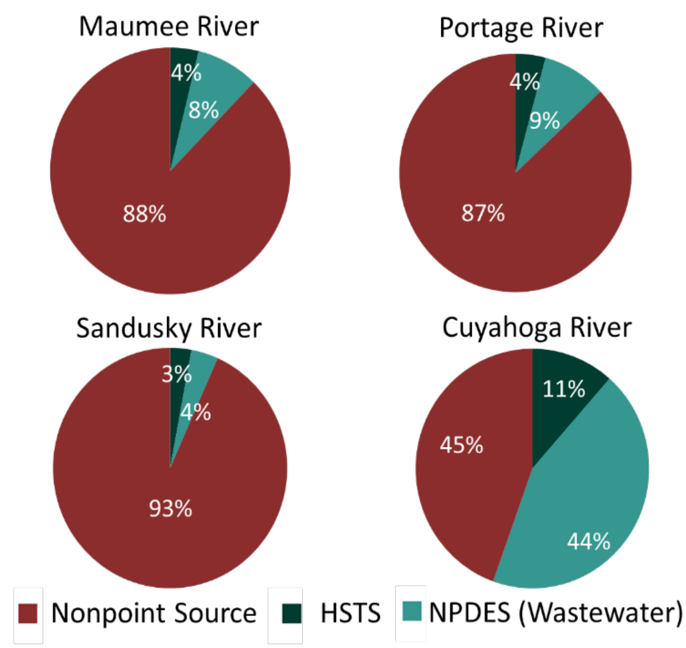


Figure 1: Proportions of total phosphorus averaged over water years 2013-2017. Maumee River includes entire watershed in Ohio, Michigan and Indiana. Nonpoint source includes both agricultural and urban nonpoint sources. HSTS: home sewage treatment systems. NPDES: National Pollutant Discharge Elimination System. Data from Ohio EPA Nutrient Mass Balance Study.

Sources of Phosphorus in the Maumee River Watershed

The Maumee River watershed is the top priority area in Ohio to address excessive nutrient impacts to Lake Erie due to its large size, soil type and land use. Springtime (March 1 to July 31) phosphorus loads from the Maumee River watershed have been identified as the most critical to reduce the occurrence of HABs in the western basin of Lake Erie. Table 1 provides a comparison of the Maumee River and the three next largest Ohio Annex 4 priority tributaries.

Figure 1 shows that 88 percent of the Maumee's phosphorus load is from nonpoint sources (average result from 2013-2017 water years). These are diffuse sources that cannot be attributed to a discharge pipe. Runoff from agricultural fields and developed areas are examples of nonpoint sources. For the Ohio portion of the Maumee River's watershed a more detailed accounting of these nonpoint sources has been conducted. (Details of this work are explained later in this section.)

[8] The following source discussion is extracted, in part, from the Nutrient Mass Balance Study. For more details and a complete set of figures, see document at ***http://epa.ohio.gov/Portals/35/documents/Nutrient%20Mass%20Balance%20Study%202018_Final.pdf***.

Table 1 - Geographic and nutrient comparison for the four largest Lake Erie tributaries in Ohio. Discharge and total phosphorus loads showing the annual average of the 2013 through 2017 water years.

River	Area (mi^2)	5-Year Avg Discharge[9] (avg daily cfs)	5-Year Avg TP (metric tons)	Agricultural Land Use
Maumee	6,568	6,346	2,212	77%
Portage	585	436	184	81%
Sandusky	1,420	1,346	513	80%
Cuyahoga	808	1,089	309	15%

Figure 2 shows the results of this analysis for the 2008 Annex 4 baseline year. Of the portion of the load that originates in Ohio, 85 percent is attributed to agricultural sources; or 63 percent of the total load is from Ohio agricultural lands.

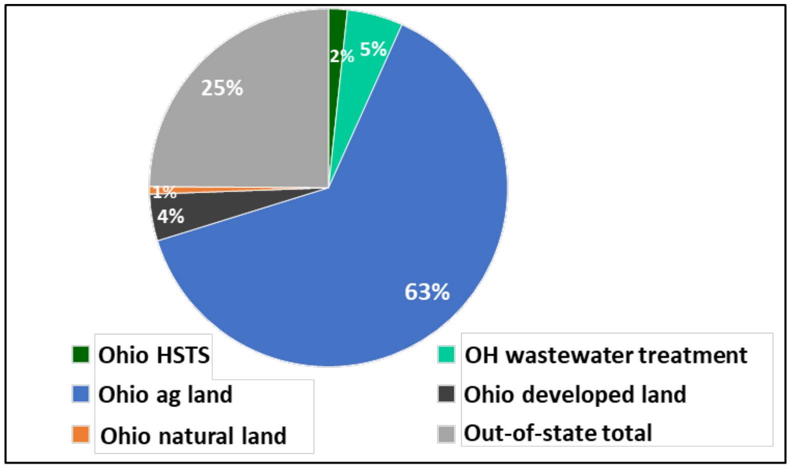


Figure 2: Maumee River watershed 2008 (Annex 4 baseline year) sources of total phosphorus. All sources except for "out-of-state total" are from Ohio contributions.

Sources of Phosphorus in Other Annex 4 Priority Tributaries in Ohio

In addition to the Maumee, Figure 1 shows the total phosphorus loading sources to the Portage, Sandusky and Cuyahoga rivers. These are all Annex 4 priority Lake Erie tributaries. The source contributions to the Portage and Sandusky River watersheds are similar to the Maumee. The Cuyahoga River watershed is much more urbanized and, therefore, has a more even split between wastewater treatment and nonpoint sources of total phosphorus. The Ohio Nutrient Mass Balance report contains further details on these watersheds' nutrient sources.

The remaining Annex 4 priority watersheds are the Huron River, Vermilion River and the Grand River. These tributaries have smaller contributing loads (an order of magnitude less than the Maumee River load – approximately 100-200 metric tons annually (MTA) each). Because these are a low proportion of Ohio's total load, the initial focus remains on the larger tributaries, especially the Maumee River.

[9] Discharge for each watershed is measured at the most downstream U.S. Geological Survey streamflow gage, not the entire watershed. cfs = cubic feet per second.

Distributing Maumee River Springtime Loads to Subwatersheds

New to this version of the Ohio Domestic Action Plan is a finer scale geographic distribution of the TP load from various sources within the Maumee River watershed and further division by landscape source. This will enable local governments, watershed organizations, and farmers to implement actions that are meaningful in terms of field and instream projects and local land management decision making. This work will also allow for improved projections, tailoring of specific practices to conditions and locations, and accountability.

The method is a modified form of the Ohio EPA Nutrient Mass Balance Study methodology. It breaks the 4 million (plus) acre watershed into approximately 26 square mile (17,000 acre) geographic units corresponding to the U.S. Geological Survey Hydrologic Unit Code 12-digit subwatersheds (HUC12s). This method provides targets that can be used within each HUC12 as part of the watershed planning process (explained in a later section). Appendix A details the methods used for this load breakdown and the results for each HUC12.

Figure 3 shows the results from this effort expressed as the landscape phosphorus yield (or pounds of phosphorus runoff per acre) for each HUC12 in the Maumee River watershed for the 2008 Annex 4 baseline spring loading season. Landscape sources are those from agricultural, development, and natural areas plus HSTS. This method breaks out the load for each of these three landscape sources individually by HUC12 as well.

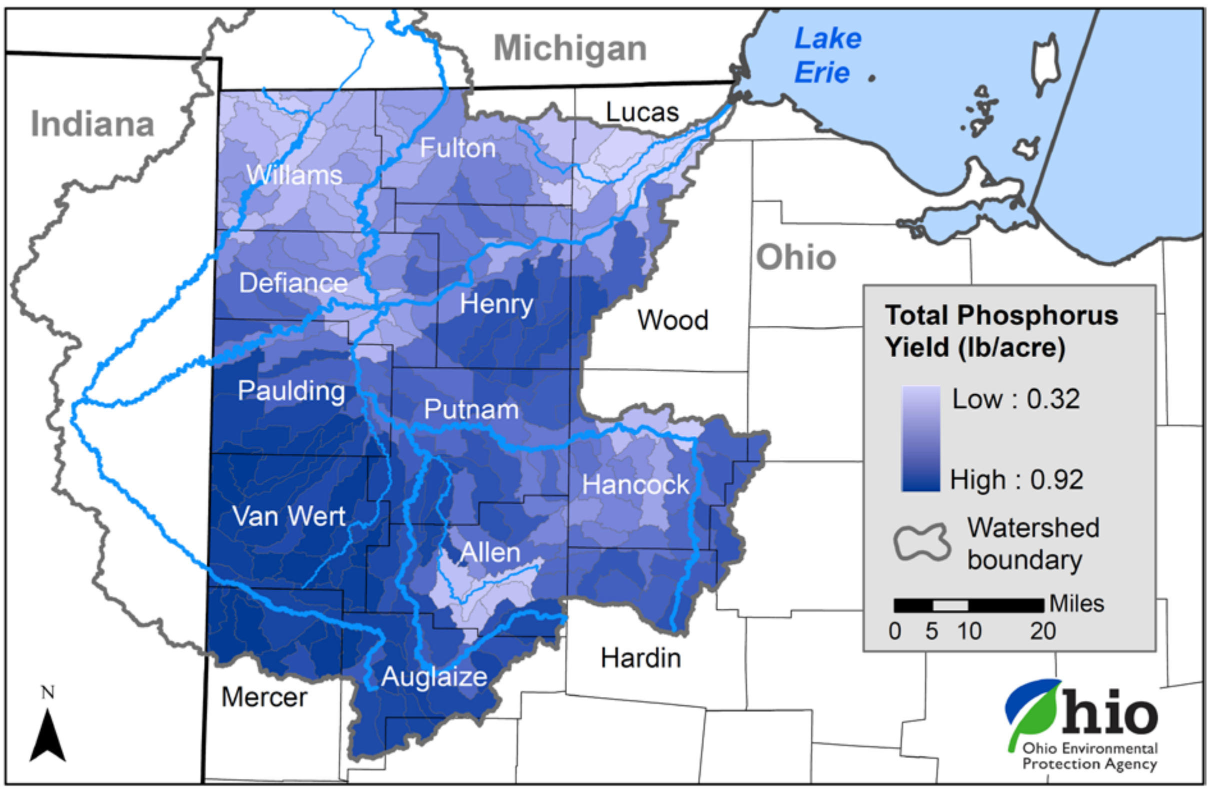


Figure 3: Total phosphorus yield from the landscape (agricultural, developed and natural lands runoff plus HSTS) by HUC12 in the Maumee River watershed for the spring 2008 base condition. See Appendix A for details.

Strategies and Implementation Actions

Overarching Strategies

There are four overarching strategies that Ohio will use to reduce nutrient loss. First, we will focus on agricultural land management since this has been identified as a significant source of phosphorus. Second, we will be restoring wetlands to recover their function in removing nutrients from the waterways. Third, we will be addressing community sources including HSTS and wastewater treatment infrastructure. Fourth, we will be continuing to encourage the use of watershed planning at the county and local level to assist with placing nutrient reduction practices on farm fields and in-stream to maximize nutrient reduction potential.

Addressing nutrient loss from agriculture will occur through State policies and programs primarily run through the ODA, but also in partnership with county soil and water conservation districts (SWCDs), watershed coordinating groups, the Ohio Agriculture Conservation Initiative (OACI), and private agribusiness firms. Wetland restoration and enhancement will be run through ODNR. Ohio EPA will oversee reductions from community sources, including funding from H2Ohio for HSTS remediation as well as innovative water and wastewater treatment technologies. Watershed planning, which will assist in finding suitable locations for structural projects, will continue to be a joint effort between Ohio EPA, ODA, and SWCDs and/or watershed coordinating groups. The OLEC will continue planning and implementation oversight including coordination between the agencies and the governor's office as needed.

H2Ohio will fund some new programs in addition to programs and policies already established through prior actions. Under Ohio's budget bill (HB 166), the Ohio General Assembly authorized $172 million in state funding to support water quality improvements in the Lake Erie basin and other areas of the state under the Ohio DAP. It is the intent to request additional state funding from the General Assembly in forthcoming budget requests to support the long-term objectives of H2Ohio in improving water quality in the Lake Erie basin and in other areas of the state.

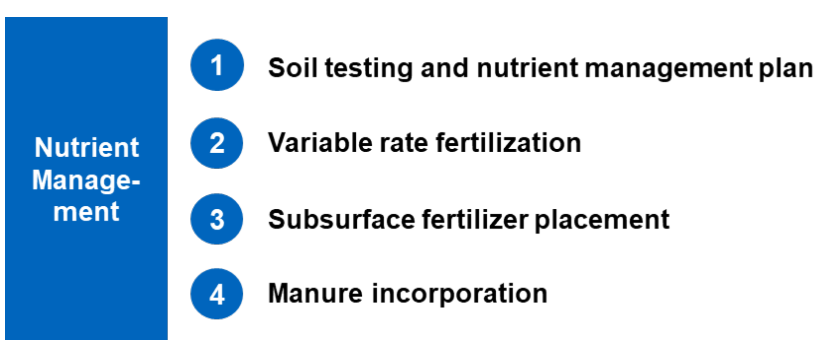
Actions to Address Nutrient Loss from Agriculture

Based on the source analysis above, most of the actions required to achieve the load reduction goals in Ohio will need to come in the form of agricultural nonpoint source controls also known as BMPs. Funding to implement these BMPs will come from State programs such as H2Ohio and Senate Bill 299 (see below for more information); federal programs such as U.S. Farm Bill programs, section 319 Clean Water Act funds, and the Great Lakes Restoration Initiative; and private-public partnerships with interested corporations and nongovernmental organizations.

Agricultural Land Management with H2Ohio

To focus this effort, ODA and Ohio EPA developed a robust list of over 100 agricultural BMPs that very specifically address nutrient loss, with an emphasis on total phosphorus reduction (see supporting files[10] for complete list). This list was narrowed down to ten cost-effective practices to focus the H2Ohio effort (Appendix B). Cost effectiveness was developed using a marginal abatement cost curve approach (Appendix C). These BMPs can be grouped into three broad categories: nutrient management, erosion management, and water management.

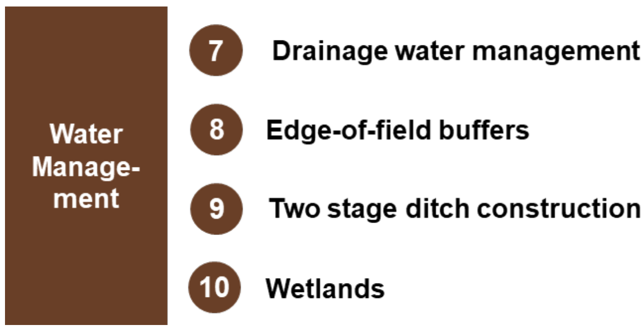
Nutrient Management is a generalized term for planning nutrient application events on the agricultural landscape. These characteristics are generally related to the popular 4R's of Nutrient Management — using the **right** nutrient source at the **right** rate and **right** time in the **right** place. There are four selected practices in this category:



[10] Posted at https://lakeerie.ohio.gov/LakeEriePlanning/OhioDomesticActionPlan2018.aspx

Erosion Management seeks to slow or stop the loss of soil-attached nutrients by reducing soil disturbance and increasing soil health. There are two selected practices in this category:

Water Management includes practices that slow water flow, settle sediments, and absorb nutrients. There are four selected practices in this category:



As part of the H2Ohio initiative, additional funding to incentivize the adoption of the top ten priority agricultural BMPs will be provided to growers. Initially, these programs will focus on the counties in the Ohio portion of the Maumee River basin. In future years, H2Ohio will expand to the entire western Lake Erie basin followed by the rest of the state.

Many of the conservation practices specific to nutrient reduction will require nutrient management planning at the farm and field scale (Practice #1). SWCDs in cooperation with ODA (as part of H2Ohio programs), Certified 4R Retailers, and U.S. Department of Agriculture - Natural Resource Conservation Service (USDA-NRCS) are equipped to complete nutrient management planning and identify the need for conservation practices at the field and farm scale. SWCDs are also important partners in watershed planning efforts that link these field and farm scale actions to watershed-based outcomes. These planning processes will be used to recommend BMPs for individual farms. The State expects to support and work closely with the SWCD conservationists to provide resources to producers to implement conservation practices across the western Lake Erie basin.

To most effectively reach growers, SWCDs operate at the county level as primary contacts. They will provide technical assistance, direct efforts to recruit growers, and collect and aggregate practice implementation actions by county.

The OACI is an innovative, collaborative effort of the agricultural, conservation, environmental and research communities to improve water quality by establishing a baseline understanding of current conservation and nutrient management efforts while building farmer participation in a new certification program. OACI will assess farm practices in Ohio to better understand current on-farm conservation and nutrient management efforts; and create a new, voluntary certification program for farmers to promote continuous improvement and increase adoption of BMPs to improve water quality in the western Lake Erie basin.

A comprehensive package of programs that deliver resources for agricultural land management under H2Ohio has been developed (Appendix D, also see http://h2.ohio.gov/agriculture/).

Senate Bill 299 Programs

In addition to support through H2Ohio, SB 299 provides roughly $36 million in funding toward a variety of programs, including $3.5 million to support county SWCDs in the western Lake Erie basin for staffing and to assist in soil testing, nutrient management plan development, enhanced filter strips, and water management and other conservation support and up to $20 million for ODA programs.

ODA will continue two programs to support practices funded through SB 299: the Ohio Working Lands Small Grains Program and Voluntary Nutrient Management Plans through Certified 4R Retailers.

Some BMPs are suited for specific sensitive areas in the watershed that may have already been identified by producers working with SWCDs and other agricultural professionals. In addition to support through H2Ohio, ODA will continue to incentivize these practices across the western Lake Erie basin watershed through programs such as the Ohio Working Lands Hay Buffers program funded through SB 299. For more details on SB 299 programs, see the fact sheets on the ODA Western Lake Erie Basin Programs website[11].

Lake Erie Conservation Reserve Enhancement Program

The ODA Division of Soil and Water Conservation is also making additional funding available to farmers through the Lake Erie Conservation Reserve Enhancement Program (CREP). CREP is the country's largest private-land conservation program. Administered by the USDA Farm Service Agency in partnership with ODA and local SWCDs, CREP targets high-priority conservation areas in exchange for removing environmentally sensitive land from production. In return for establishing permanent resource-conserving plant species, farmers are paid an annual rental rate along with other federal and state incentives as applicable per each CREP agreement. Participation is voluntary, and the contract period is typically 15 years.

- Beginning in 2019, the state of Ohio is providing a $200 bonus for all newly enrolled filter strip and riparian area practices. For current CREP participants with expiring contracts, re-enrolling and expanding the width of filter strips or riparian areas will earn bonus dollars on additional acres.
- The Lake Erie CREP is available in 27 Ohio counties including: Allen, Ashland, Auglaize, Crawford, Defiance, Erie, Fulton, Hancock, Hardin, Henry, Huron, Lucas, Lorain, Marion, Medina, Mercer, Ottawa, Paulding, Putnam, Richland, Sandusky, Seneca, Shelby, Van Wert, Williams, Wood and Wyandot counties.

Agricultural Regulatory Programs

ODA administers laws and rules in partnership with SWCDs, Ohio EPA, ODNR and others to ensure agricultural operations in Ohio are supported with clear standards and expectations for environmental stewardship. The following regulatory framework (Table 2) includes a permit program for the largest producers of livestock and authority to resolve pollution complaints involving non-permitted operations through technical consultation, fines, and ultimately, referral to the permit program. Specific rules also apply to farms operating in the western basin of Lake Erie. Changes to these regulatory programs would require legislative action.

Table 2: Agricultural Regulatory Programs

Program	Description	Ohio Revised Code (ORC)	Ohio Administrative Code (OAC)
Concentrated Animal Feeding Facility Permit to Operate	Assures the proposed facility has developed appropriate best management plans in the areas of manure management, insect and rodent control, animal mortality and emergency response.	***903***	***901:10***
Concentrated Animal Feeding Facility Permit to Install	Assures the proposed building, its facilities and location will adequately support such an operation.	***903***	***901:10***
Agricultural Pollution Abatement	Establishes rules and complaint-based enforcement to prevent sediment and manure runoff from non-permitted agricultural operations.	***939***	***901:13-1-18***
WLEB Manure Management	Establishes additional manure application rules related to weather conditions for operations within the Western Basin of Lake Erie.	***939.08*** ***939.09***	***905.326***
Livestock Management Certification	Assures livestock managers and manure applicators receive training and are informed about utilizing livestock waste according to regulations and best practices.	***903.07***	***901:10-1-06***

Since the transfer of Division of Soil and Water Conservation from Ohio Department of Natural Resources to Department of Agriculture in 2016, these authorities have been enhanced and administrative procedures have been strengthened. The Division of Soil and Water Conservation can now assess civil and administrative penalties for

[11] ***https://agri.ohio.gov/wps/portal/gov/oda/divisions/soil-and-water-conservation/resources/wleb_programs.***

violations of the Agricultural Pollution Abatement Program rules and laws. This new authority penalizes the individual for the violation that occurred, deters future acts of agricultural pollution, and minimizes the economic benefit that may have been gained by polluting waters of the state.

Actions to Restore Wetlands

A wetland is an area of land that has unique characteristics because it is either seasonally or permanently covered by shallow water. Wetland ecosystems are home to specialized plant species adapted for life in saturated soil conditions, and wetlands provide critical habitat to a wide variety of animal species, from amphibians to waterfowl. Swamps, marshes, bogs, and similar areas— situated inland, along streams, or along the coast are all considered different types of wetlands.

Beyond wildlife habitat, the additional ecosystem services that wetlands perform are critical to the wider Great Lakes environment because wetlands slow the movement of water across the landscape. Intercepting and slowing runoff reduces the risk of flooding and erosion on stream corridors and downstream infrastructure and improves water quality by capturing or removing sediment and nutrients. This water-filtering capability is why wetlands are sometimes referred to as 'nature's kidneys.'

Historically, wetlands were not highly valued by society for these functions. Over the last few centuries, wetlands in Ohio have decreased in number and acreage, primarily due to agricultural and urban development, water level fluctuations, shoreline stabilization, and other modifications to drainage patterns. The 2006-2007 National Wetland Inventory identified 47,323 individual wetlands in Ohio's Lake Erie watershed, totaling 289,447 acres. By comparison, the total acreage of the Lake Erie watershed is approximately 7.5 million acres. The large-scale water quality issues addressed by the Ohio Domestic Action Plan can be attributed, in part, to the widespread loss of the ecosystem services provided by wetlands that once existed in northwest Ohio.

ODNR is the lead state agency working to restore, enhance, and create coastal, riparian, and inland wetlands, and promote the use of forested buffers to improve water quality and fish and wildlife habitat. ODNR has developed a strategic approach focused on investing in natural infrastructure to provide nutrient reduction and water quality benefits to Lake Erie. These projects will be implemented using sound science, landscape conservation design principles, and robust monitoring to measure progress in achieving water quality improvement goals.

Most of ODNR's initial wetland efforts are focused in northwest Ohio. These areas include: 1) the mouth of the Maumee River; 2) the Lake Erie coastal region between the Maumee River and the Toussaint River; 3) the Sandusky Bay region; and 4) the Maumee and Sandusky River watersheds. These areas have been identified as either primary sources of phosphorus and/or are primary phosphorus pathways into Lake Erie. Each wetland project is designed to maximize surface water nutrient reduction capability. Projects that are currently under development by ODNR are listed in Appendix F.

Wetland ecosystems provide a relatively low-cost, natural mechanism for nutrient reduction with many environmental benefits. ODNR is committed to creating and restoring thousands of wetland acres over the next decade in the Lake Erie watershed.

Actions to Reduce Community Sources

Every community in Ohio's Lake Erie watershed has already played a significant role in reducing nutrient loads. Future actions outline opportunities for communities to participate in additional nutrient reduction that will continue to improve conditions in local receiving streams as well as downstream in Lake Erie. The following provides an overview of the implementation actions addressing HSTS and wastewater treatment plants -- community-based sources of nutrients. See Appendix E for an extended discussion on these sources. The appendix also includes details about CSOs and storm water sources.

Community-Based Nutrient Reduction - HSTS

Ohio Department of Health (ODH) rules for sewage treatment systems require that all new and existing systems are issued an operation permit with an identified maintenance schedule, and for discharging systems, a sampling schedule to ensure the system is meeting discharge standards. As of Jan. 1, 2015, all new and modified systems are issued an operation permit by the local health department. Local health departments are currently conducting inventories and issuing operation permits to existing systems and addressing system problems or nuisance conditions.

ODH will continue to work with local health departments to ensure implementation of their Operation and Maintenance Tracking Programs for sewage treatment systems as required in the Ohio Administrative Code, and provide options and resources for implementing operations and maintenance tracking including identification of failing sewage treatment systems within targeted watersheds[12].

Upon identification of a failing system, local health departments will establish specific action plans and timeframes for correction of the nuisance conditions. These plans may include repair, alteration or replacement of the sewage treatment system or connection to public sewers, where available.

Starting with the passage of the American Recovery and Reinvestment Act in 2009 and continued with funding support from Congress, Ohio EPA, in coordination with ODH, has provided between $1 million and $15 million annually (over $35 million) to local counties and health departments to repair or replace failing HSTSs for low to moderate income homeowners. Since 2016, Ohio EPA has awarded almost $50 million to Ohio local health departments to direct to eligible homeowners.

Ohio EPA offers three options for directing funding assistance to homeowners for improvements to failing HSTS. These include, development of a linked deposit program; a local loan capitalization program; and principal forgiveness loans to local health departments. Because the principal forgiveness option provides funding similar to grants, it is the most popular of the three options.

Ohio EPA provides additional funding through the H2Ohio initiative for infrastructure projects that improve water quality. The initial project announced in the Lake Erie watershed entails the construction of new wastewater collection and a treatment system in the unincorporated area of Kunkle, Ohio, Williams County (Maumee River watershed). H2Ohio funds will be combined with a U.S. Army Corps of Engineers grant and Ohio EPA funding for this project covering the overall cost of $3.5 million. About 90 homes with failing HSTSs will be taken offline reducing phosphorus by 168 pounds per year. The cost per pounds of phosphorus reduction will not be uniform since each infrastructure project involves a unique mix of circumstances. Therefore, the phosphorus reduction will be calculated for each individual applicable H2Ohio project.

Local health departments continue to work with state and local government agencies and local public sewage treatment providers to facilitate extending sewers to areas of concentrated failing HSTS. Local health departments are required to report to ODH all operation permits issued.

Community-Based Nutrient Reduction – Wastewater Treatment (Final Outfalls)

Removing phosphorus from municipal sewage wastewater treatment facilities and applicable industrial facilities has been ongoing in the state. Ohio continues to include phosphorus optimization language in NPDES permits issued to major dischargers within the lake basin. This language requires the permittees to investigate source reduction, operational improvements, and minor facility modifications to reduce current effluent concentrations cost effectively. Appendix E outlines point sources and the efforts to reduce phosphorus discharges.

[12] Located on the "Information for LHDs" page (***https://odh.ohio.gov/wps/portal/gov/odh/know-our-programs/sewage-treatment-systems/INFORMATION-FOR-LHDS/***) under an expandable heading titled "Operation and Maintenance Tracking Program Resources for Local Health Districts".

The state of Ohio has invested in these nutrient reduction efforts by offering financial assistance to communities with NPDES permits for wastewater treatment plant upgrades and combined sewer separation projects. Through its Water Pollution Control Loan Fund, Ohio EPA has provided Lake Erie communities with over $2.6 billion in wastewater resource infrastructure project loan funds between 2009 and 2018. Over 300 projects are included in this group with at least one project in 28 of the 33 Ohio Lake Erie counties. Nearly $83 million of these funds have been provided as principal forgiveness. These funds all contribute to projects that in some manner result in nutrient reductions. Table 3 breaks down this funding by Lake Erie basin.

Table 3: Ohio EPA Water Pollution Control Load Fund wastewater upgrade project amounts from 2009 through 2018.

LE Basin Ultimately Receiving Treated Wastewater	Loan Values for Projects	Principal Forgiveness Provided with Loans
Western Basin	$626,066,245	$43,815,086
Sandusky Basin	$44,290,549	$3,052,542
Central Basin	$2,011,940,052	$35,769,391
Total	$2,682,296,846	$82,637,019

Using Watershed Planning to Aid Practice Placement

Several agricultural BMPs, such as nutrient management plans, are broadly applicable and county conservationists can promote these directly with growers. However, we know from modeling research (Martin et al. 2019[13]) that placement of structural practices is important in meeting the load reduction target efficiently. One way to determine the best placement is through a local watershed planning effort. Therefore, along with other county efforts, Ohio will continue to encourage the development of watershed plans for the most effective placement of structural practices.

The primary purposes of watershed plans are to identify critical areas, organize stakeholders, set local goals and objectives for conservation practice implementation, identify implementers and funding sources, and most importantly, develop ready-to-go projects and conservation practice adoption and activity. Ohio's Nonpoint Source Pollution Implementation Strategy (NPS-IS)[14] is the framework to develop nine-element watershed plans and establish project eligibility for federal funding. This framework will also be used, in part, to determine placement for projects funded through H2Ohio.

The nine-element plans written for a 12-digit Hydrologic Unit Code (HUC12) watershed, which are typically about 26 square miles in area, are a key mechanism for analyzing load reduction opportunities. Each nine-element plan is developed to explicitly list the load reduction targets that must be met in each unique HUC12 watershed. These load reduction goals added across all HUC12 watersheds are designed to meet the far-field Lake Erie Annex 4 targets.

We have started HUC12 far-field load reduction planning efforts (Figure 5). The intent is to focus on completing the southern portion of the Maumee River watershed, and then include the remainder of the Maumee, Portage, Sandusky and Cuyahoga River watersheds as time and funding become available. None of the existing nine-element watershed plans in the Lake Erie watershed have a far-field nutrient reduction component that were developed for this version of Ohio's DAP, so a coordinated effort to work with regional stakeholders to update the existing plans is needed.

Agricultural Land Management Tools for 9-Element Watershed Plans

While agricultural conservation practices are implemented on farms or in fields, watershed planning can be used to identify critical areas and help organize and prioritize projects and actions across many farms within a community.

In addition to providing the local planners with target loads at the HUC12 level, we are providing a suite of recommended practices based on best available knowledge about the nutrient reduction benefits of these tools as described in the Strategies section above (Appendix B). This list of BMPs includes recommended practices that local SWCDs, watershed groups, local governments, farmers and others can implement on their own or with state and

[13] Martin, J.F., Kalcic, M.M., Aloysius, N., Apostel, A.M., Brooker, M.R., Evenson, G., Kast, J.B., Kujawa, H., Murumkar, A., Becker, R., Boles, C., Redder, T., Confesor, R., Guo, T., Dagnew, A., Long, C.M., Muenich, R., Scavia, D., Wang, Y., Robertson, D., 2019. Evaluating Management Options to Reduce Lake Erie Algal Blooms with Models of the Maumee River Watershed. Final Project Report – OSU Knowledge Exchange. Available at ***http://kx.osu.edu/project/environment/habri-multi-model***.

[14] Nine-Element NPS-IS in Ohio: ***https://www.epa.ohio.gov/dsw/nps/index#120845160-9-element-nps-is***.

federal support. Local watershed stakeholders are encouraged to use the list of recommended BMPs to facilitate discussions during the planning process.

A new tool that is becoming available in Ohio for planning in agricultural landscapes is USDA's Agricultural Conservation Planning Framework (ACPF). The ACPF uses a watershed approach to locate practices within a HUC12 using GIS tools designed to find conservation opportunities across different agricultural landscapes. While not a comprehensive tool for siting all possible practices, it will be useful in this context because of its focus on water retention in agricultural landscapes. The ACPF has been piloted in a few watersheds in the western Lake Erie basin (WLEB) and efforts are underway at NRCS and Ohio universities to expand its coverage.

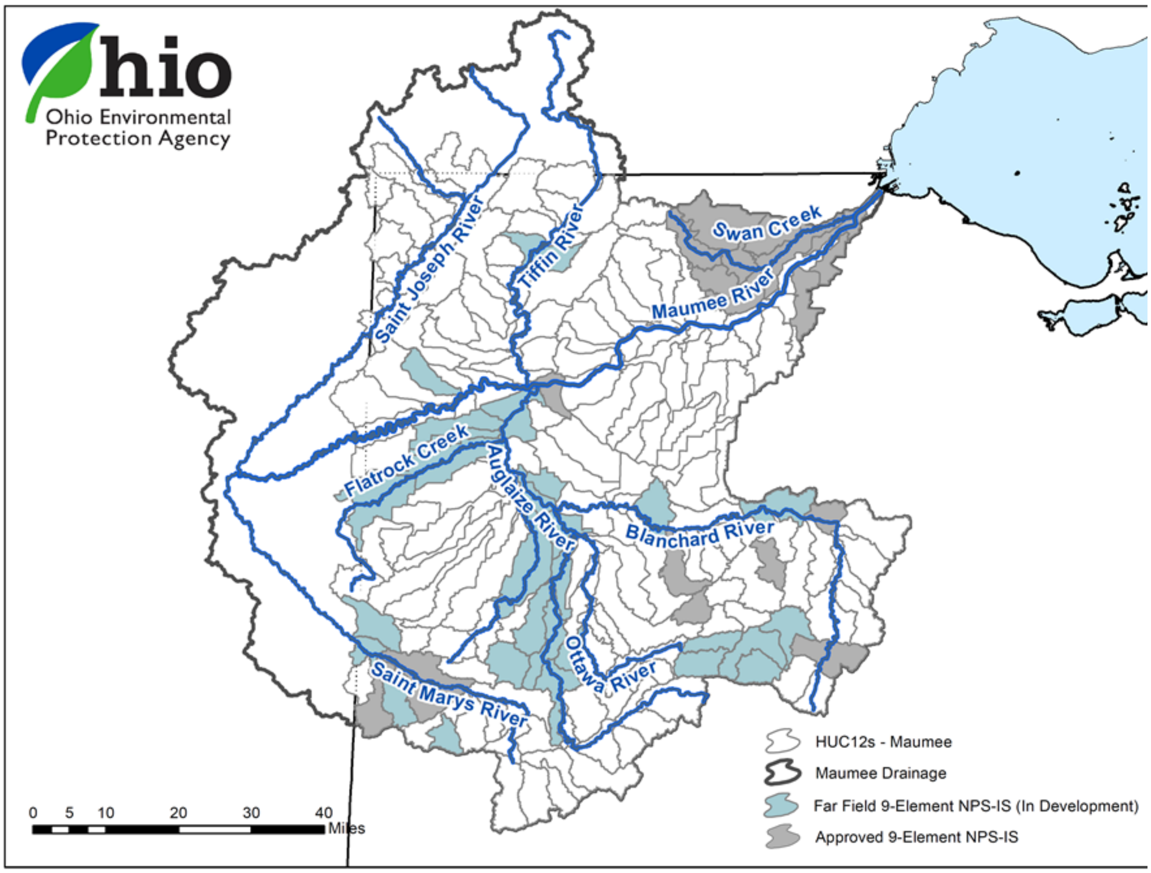


Figure 5: Watershed planning for HUC12s in the Maumee River watershed -- existing NPS-IS and plans under development.

Community Based Tools for 9-Element Watershed Plans

Although the focus for planning will be on agricultural practices, plans can have practices such as stream restoration that address urban nonpoint sources (e.g. non-permitted storm water) as well as HSTS sources of nutrients.

Ohio communities face many challenges with aging storm water management infrastructure, combined sewer overflows, impervious surfaces, and continued pressure to reduce the rate and amount of runoff that is entering Ohio streams from the urban and suburban landscape. Peak discharge volume reduction decreases overall volume of discharge which is directly related to loading reduction. Loading is also reduced because improved retention of urban runoff also incrementally reduces erosional stressors on streambanks; and reduces stream bed scour which can disconnect streams from floodplain access where sediment and nutrients are readily processed.

Ohio is encouraging, and communities are embracing, green infrastructure and Low Impact Development (LID) practices. Some examples that are consistent with Ohio's Nonpoint Source Management Plan (2014) and the Ohio Balanced Growth Program[15] include:

- Storm water retention practices (detention ponds, wet ponds and wetlands);
- Storm water infiltration and filtration practices (rain gardens, bio-retention, infiltration basins, grassed swales, permeable pavement/pavers);
- Increase permeable surfaces (green parking areas & roofs, eliminate curbs and gutters); and
- Restoration of channelized streams, riparian buffers and floodplains.

Ecosystem Services Tools for 9-Element Watershed Plans

Loss of wetlands, increased agricultural drainage, and floodplain disconnection along with the modification of in-stream channel and habitat conditions are the highest magnitude causes of aquatic life use impairment in Ohio streams. The nine-element watershed plans are designed to restore attainment of aquatic life use within each HUC12 by implementing practices such as stream restoration, streambank restoration, floodplain restoration, wetland restoration, riparian restoration, and others. These "ecosystem service" conservation efforts can be used to achieve far-field nutrient load reduction targets by increasing nutrient assimilation in streams and wetlands, encouraging floodplain deposition of silt and sediment, reducing stream bank erosion, and overall discharge (volume) reduction.

Process and Timeline

With a possible 194 HUC12s in the Maumee River watershed alone, we recognize that it will take some time for a significant number of nine-element watershed plans to be completed or revised. The SWCDs will likely decide how many and which of their HUC12s need this degree of analysis and on what schedule would allow their practice placement goals to be met. The initial 26 new plans underway using the far-field targets are expected to be completed in 2020 with funded projects to follow in 2021. Additional funding for watershed plans is currently being sought by the State, but is not currently available. While this is a key action, it is not the only action that will be taken, nor is it necessary to limit actions to areas with approved nine-element watershed plans.

Other Actions

Total Maximum Daily Loads

The Total Maximum Daily Load (TMDL) program focuses on identifying and restoring polluted rivers, streams, lakes and other surface waterbodies that are identified as impaired on the Section 303(d) list in the Integrated Report that Ohio EPA maintains. A TMDL is a written, quantitative assessment of water quality problems in a waterbody and contributing sources of pollution. It specifies the amount of pollutant reduction needed to meet water quality standards, allocates pollutant load reductions, and provides the basis for taking actions needed to restore a waterbody. Each TMDL report includes an implementation plan that lists these actions.

None of the existing Ohio TMDLs in the Lake Erie watershed have factored in phosphorus load allocations based on proposed Annex 4 phosphorus targets for Lake Erie. Rather, those TMDLs have recommended actions to address local near-field nutrient impairments. An analysis of the load reductions detailed in the existing phosphorus near-field TMDLs indicates that while helpful, these reductions will not be enough to achieve load reductions needed for far-field (Lake Erie) purposes[16]. These TMDLs can be found here: ***https://epa.ohio.gov/dsw/tmdl/index***.

Ohio EPA is assigning a high priority to Lake Erie's western shoreline, western open water, and islands shoreline assessment units for impairments of public drinking water supply (algae) and recreation (algae), and committing to develop a far-field TMDL over the next two to three years. See the 2020 Integrated Report[17] for more information.

[15] See ***https://balancedgrowth.ohio.gov*** for more information about program recommendations and resources.
[16] Methodology for Connecting Annex 4 Water Quality Targets with TMDLs in the Maumee River Basin. Task Order Number EP-B175-00001 (Aug. 9, 2018). ***https://www.epa.gov/sites/production/files/2018-10/documents/annex4_methodology_with_appendices_20180809-508.pdf***.
[17] ***https://epa.ohio.gov/dsw/tmdl/OhioIntegratedReport***

Private Organizations Actions Summary
Meeting the targeted phosphorus reductions will include efforts from nongovernmental organizations and the private sectors. A supplement of actions in the Lake Erie basin by nongovernmental and private actors is included as a supplemental table on the web page with the final version of the Ohio DAP.

Dredge Material Open Lake Placement Ban

Each year, harbors on Ohio's north shore must be dredged to keep the shipping channels open so commodities can move in and out of the ports. Nearly 1.5 million tons of material are dredged annually. Historically, much of the dredged material was dumped in the open waters of Lake Erie. However, with passage of Senate Bill 1, that will no longer be an option after July 1, 2020. Diverting this material to other uses or locations will improve Lake Erie water quality by removing a source of phosphorus.

Monitoring and Tracking

Monitoring Program

In an Adaptive Management framework, monitoring of system response and tracking towards goals is a necessary function to evaluate actions being taken so that necessary adjustments can be made.

It remains imperative to track reduction progress, preferably tied to reduction practices, in specific watersheds through a comprehensive and long-term water quality monitoring program. It is the goal of the overall water quality monitoring strategy in Ohio to include monitoring data from edge of field, sub-watershed, Annex 4 priority watersheds, and Lake Erie in order to provide a total picture of nutrient sources and the nutrient delivery system. The primary indicator of progress will be water quality monitoring and associated load calculations at the key downstream station on each of the Annex 4 priority watersheds in Ohio.

The state of Ohio and its federal and institutional partners have restructured the pre-existing river monitoring network to better inform tracking towards the Annex 4 nutrient reduction targets (Appendix G). Ideally water quality monitoring would be on a continuum and is able to provide data beginning at edge of field, continuing at the sub and major watershed levels, and ultimately the open water of Lake Erie. While it is not possible to monitor at every HUC12 outlet, the current network of sites has been established to cover key locations and provide data that are more useful in evaluating different practices and improving surveillance of areas with higher potential for nutrient loss.

Ohio EPA is required by law to develop a nutrient mass balance report every two years. The objective of the study is to determine nutrient (phosphorus and nitrogen) loads and relative proportions of point and nonpoint sources. The study highlights differences between the watersheds, both as total loads and relative contributions from different sources in the watersheds. This effort requires a regular and complete summary of all the nutrient monitoring data in subject watersheds. The next nutrient mass balance study will be published in 2020 and will include all Annex 4 priority tributaries.

ODNR will support extensive wetland monitoring work, especially in the WLEB and Sandusky Bay. In addition to identifying key water quality thresholds that will eliminate HABs, we are developing pre-construction baseline datasets to compare the "flow-thru" and other wetland restoration projects once completed through post-construction monitoring.

In addition, ODNR is working cooperatively with partners (Cleveland Water Alliance, city of Sandusky, Bowling Green State University, and others) to develop a low-cost sensor network to monitor water quality within Sandusky Bay and at the Old Woman Creek National Estuarine Research Reserves. ODNR anticipates that once developed, this sensor technology would be applied to assist with monitoring upgraded coastal wetland systems along the western basin shoreline as well.

Through the NPDES permit program, discharging entities monitor and report nutrient concentrations and flow volume via a dedicated database. Ohio EPA maintains this database and utilizes it for permit compliance.

Ohio EPA regulates public drinking water systems in Ohio. The Agency requires cyanobacteria and cyanotoxin monitoring on a regular basis from all plants using surface water. Monitoring requirements are adjusted based on various schedules assigned to plants. Plants with historic cyanotoxin detections in finished drinking water or with high source water susceptibility and limited treatment options are moved to a more frequent monitoring schedule. The Division of Drinking and Ground Waters tracks all HAB monitoring data from public water systems via a database and maintains an interactive map where the public can assess these data[18]. Surface water data for beaches and other water bodies is available via BeachGuard[19].

Tracking Actions and Responses

Tracking BMP, Wetland, and Community Actions

As a part of the H2Ohio initiative, agricultural BMP projects routed through Soil and Water Conservation Districts will be tracked via a digital platform already in use (Beehive). Metrics reported from data posted to this platform are under further development and could include extent of adoption of agricultural BMPs (number of acres enrolled, number of acres completed, funds committed, funds disbursed). H2Ohio tracking systems will also be able to track and report on number and type of completed wetlands projects, number and type of OEPA infrastructure projects completed (HSTS and water treatment/wastewater treatment infrastructure) and progress towards the actual phosphorus load targets for the Maumee River in Ohio. Tracking of all projects by watershed down to the HUC12 is possible, but is time consuming for SWCD staff entering agricultural BMP projects and thus has been given a low priority during the start up phase. Most of these metrics will be reported out in the aggregate by county or type of project (ie. by BMP, HSTS, etc.).

The ODA Division of Soil and Water Conservation is responsible for distributing the water quality funding from SB 299. This funding includes the Soil and Water Phosphorus Programs and additional financial support for SWCDs in the WLEB watershed. The Soil and Water Phosphorus Programs pay financial incentives for the utilization of BMPs. The Division will track the extent and location of these practices and will report relevant metrics (ex: dollars spent, number of practices installed, acreage, location of practices by HUC12) to OLEC.

USDA Farm Service Agency administers the Lake Erie Conservation Reserve Enhancement Program, which includes tracking and reporting number of contracts, payments, practices and acres enrolled in the program. ODA also tracks state incentive funds contributed to the program and produces an annual report.

Ohio EPA has existing systems for tracking nutrient levels for NPDES permitted entities and those data will continue to be collected and utilized for the Nutrient Mass Balance Study and other program purposes.

Tracking Watershed Planning Implementation

The state of Ohio intends to develop and implement a tracking mechanism that will summarize project lists from multiple HUC12 watersheds in one spreadsheet or database to streamline project and conservation practice implementation. This system will be similar to the already successful Areas of Concern Management Actions project tracking system — *Maumee AOC Data Management & Delisting System 3.0*. U.S. EPA is providing a technical assistance grant to Ohio EPA, part of which is being used to develop a tracking methodology.

Potential projects that are developed as part of the NPS-IS process are developed with explicit associated estimates of nutrient and sediment load reductions that are based on modeling and some limited performance research. Once the NPS-IS plans are approved and the tracking lists are created, we should be able to begin to develop some project-based and overall conservation practice implementation-based estimates of anticipated load reductions. This will not be a definitive way of determining whether these projects will achieve their targets, due to the uncertainty involved in developing the estimates. However, this can serve as a check on watershed model estimates and water quality monitoring-based tracking.

Tracking Progress Toward Nutrient Reduction Targets

Major benchmarks are the loading and concentration targets pinned to specific times and places. Benchmarks for Ohio apply to selected western basin tributaries to address HABs (Table 4) and to those tributaries plus additional central basin tributaries to address hypoxia (Table 5). Ohio will use the same springtime benchmark for the Sandusky River to control HABs occurring in Sandusky Bay.

[18] http://wwwapp.epa.ohio.gov/gis/mapportal/HAB_Monitoring.html.
[19] https://ohio.gov/wps/portal/gov/site/residents/resources/beachguard.

Table 4: Targets to address HABs

Priority Tributary	Spring Values (March 1-July 31)				
	2008 Baseline			Targets under 40% Reduction by 2025	
	Discharge (km^3)	Load metric tons	FWMC* mg/L	Load Metric tons	FWMC mg/L
Maumee River	3.76	1,414 TP 302 DRP	0.38 TP 0.08 DRP	860 TP 186 DRP	0.23 TP 0.05 DRP
Portage River**	0.436	195 TP 37DRP	0.45 TP 0.08 DRP	117 TP 22 DRP	0.27 TP 0.05 DRP
Sandusky River	0.963	367 TP 69.1 DRP	0.38 TP 0.07 DRP	230 TP 43 DRP	0.23 TP 0.05 DRP

*FWMC – Flow-weighted mean concentration.
** Portage River baseline and targets are calculated based on the 2011 spring season. See Appendix H for further explanation.

Ohio EPA is monitoring the streamflow and water quality in the Toussaint Creek watershed. These data start in 2017 and collection continues. The data are not collected at the same frequency as other monitoring points in the region. However, after data collection in 2019, we will be able to describe the loading dynamics in the Toussaint as compared to the Portage or other nearby watersheds.

Table 5: Targets to address hypoxia (metric tons annually - MTA)

Priority Tributary	2008 Annual Load*	40% Reduction Amount	Target Load by 2025
Maumee River	3,812	1,525	2,287
Portage River	237	95	142
Sandusky River	1,100	440	660
Cuyahoga River	452	181	271

*Annual load estimates based on Maccoux, 2016 values, except for the Portage River: Portage River baseline is calculated based on the 2011 water year, see Appendix H for further explanation.

The remaining Annex 4 Priority Watersheds, the Toussaint, Huron, Vermilion and Grand Rivers, are not included in this table because of their relatively small annual load totals (less than 150 MTA each). This represents less than 100 MTA of total reduction. Hence these watersheds, while important, are a lower priority for Ohio and will be considered for specific actions and load reductions in the future.

Ohio water resource agencies, Heidelberg University and USGS are all involved in tributary nutrient monitoring throughout the Lake Erie watershed. This monitoring includes sampling of key tributary pour points, like the Maumee River at Waterville, which are used to track the Annex 4 nutrient reduction targets. In the Maumee and Sandusky River watersheds there are additional upstream monitoring locations. More than 20 monitoring stations are in the Maumee River watershed alone. These include a monitoring station near the mouth of every major Maumee River tributary. Due to the great size of the Maumee River watershed, monitoring on its major tributaries will be used to track nutrient trends over time at a more manageable scale than just at Waterville. Additionally, several monitoring stations in the Maumee and Sandusky watersheds are located on much smaller tributaries that drain less than 50 square miles. These stations monitor "sentinel watersheds" and are key to understanding the success of nutrient reduction implementation practices. Appendix G outlines this monitoring program in greater detail.

We will continue to engage our stakeholders throughout this process and report to other governments and the citizens of Ohio on our continued strategies, investments and tracking toward goals.

Reporting

Ohio is committed to working with U.S. EPA to coordinate and provide progress tracking information in a consistent and timely manner. That includes participating in the ErieStat online platform, annual webinars, and other public forums such as the Great Lakes Public Forum which is held every three years. Ohio also provides information used in the GLWQA Triennial Progress Report of the Parties which is published every three years. The current Triennial Progress Report was issued in June 2019 and the next report will be issued in 2022.

Ohio EPA is responsible for publishing a biannual Ohio Integrated Water Quality Monitoring and Assessment Report[20]. Part of this report satisfies the Clean Water Act's Section 303(d) requirement for a prioritized list of impaired waters. Lake Erie assessment units are included in this report. The next Integrated Report will be released in 2020.

Ohio has also produced an annual Water Monitoring Summary and an associated Expanded Lake Erie Tributary Nutrient Load Monitoring Report that tracks monitoring results against the Annex 4 targets. These are available for download on the OLEC website[21].

As a part of the H2Ohio initiative, progress will be reported to the public at regular intervals via a dashboard, which may be either static (periodic reports or infographics) or online interactive (aspirational). Metrics reported via this dashboard could include extent of adoption of agricultural BMPs (number of acres, number of adopters), number and type of completed wetlands projects, number and type of Ohio EPA infrastructure projects completed (HSTS, lead removal) and progress toward the actual phosphorus load targets. Most of these metrics will be available cumulatively by county. Data for tracking by watershed are being collected and could also be made available in aggregate form.

The state agencies will continue to highlight key phases and successful projects through news releases.

Additional reporting mechanisms may be developed with stakeholder input as described below in the section on Public Involvement.

Research

Research is a critical part of Adaptive Management. In a system as complex as Lake Erie and its watershed, there are many uncertainties. In addition to exploring fundamental questions around nutrient fate and transport in the watershed, nutrient cycling in the lake, toxicity and algal biology, there are also critical research questions about protecting public health and the magnitude and timing of system response to management actions.

A primary source of research direction and funding in Ohio has been the work of Ohio's Department of Higher Education (ODHE). The chancellor of ODHE has been and will continue to work through representatives from the University of Toledo, Ohio Sea Grant, and The Ohio State University to solicit critical needs and knowledge gaps from state agencies. ODHE is now providing funding through the Harmful Algal Bloom Research Initiative (HABRI)[22] for applied research at Ohio universities. Many HABRI projects seek to understand both how phosphorus and other elements like nitrogen affect algal blooms, and how runoff can be reduced without negative impacts on farmers and other industries. Other projects focus on the public health impacts of toxic algal blooms, ranging from drinking water issues to food contamination.

Watershed models are a critical part of the Adaptive Management cycle. Existing models have been valuable in evaluating alternative practices and scenarios upon which nutrient reduction strategies can be based. Having multiple models of the same watersheds available has increased confidence in the results. The state of Ohio is also using H2Ohio funding to expand the existing rain gaging network in northern Ohio. The data collected from these rain gages will improve existing watershed modeling and research. Details about this work are included in Appendix G.

Survey research can provide insight into incentives for adoption of practices as well as projecting likely adoption rates. Demonstration projects, such as working farms in the Blanchard River watershed, have also been useful to encourage adoption of BMPs.

State agencies will continue to support a comprehensive and cohesive research program along with our university partners. Efforts will continue to ensure there is coordination of research priorities between the various state agencies, including the ODHE Research Collaborative, universities, foundations and the private sector that address issues specific to the Ohio DAP.

[20] ***https://epa.ohio.gov/dsw/tmdl/OhioIntegratedReport***.
[21] ***https://lakeerie.ohio.gov/Home.aspx*** and ***https://lakeerie.ohio.gov/LakeEriePlanning/OhioDomesticActionPlan2018.aspx***.
[22] See resources at ***https://ohioseagrant.osu.edu/research/collaborations/habs***.

Public Involvement and Advisory Mechanisms

The Western Basin of Lake Erie Collaborative Framework and the initial Ohio DAP were developed with input through meetings and conversations with various stakeholder groups and state agencies, individually and collectively. This revised Ohio DAP brings in the new H2Ohio initiative as well as additional calculations and research intended to improve the ability to quantify expected nutrient reductions, which should also improve the accountability for actions being taken, in response to public comment on these previous versions.

Ultimately, the state agencies have responsibility to achieve the water quality goals. However, this will only be accomplished through the involvement, input, implementation, use of science and accountability of a multitude of interests and resources. We would also like to recognize and include major efforts underway by private interests such as nongovernmental organizations and industry. Therefore, it is important to have a strategy for public involvement.

There are several potential options for public involvement with the Ohio DAP:

Concept #1: Advisory Board

The Advisory Board would have named members from a range of organizations. Meetings would be open to the public. The Advisory Board would be able to create work groups to address specific topics. Meeting frequency would be a minimum of once a year. More frequent meetings would depend on the capacity of Advisory Board members to administer additional meetings.

A formal advisory group will not be established at this time.

Concept #2: Annual Conference

Something similar to the Great Lakes Public Forum, a one-day conference with a plenary to discuss progress and tracking, followed by breakout sessions on subtopics within the DAP such as watershed planning, agricultural land management, monitoring strategy, etc.

The state will continue to explore the feasibility of holding occasional conferences specifically to address the Ohio DAP actions and outcomes.

Concept #3: Ad Hoc

OLEC would hold ad-hoc meetings with stakeholders, either on request by the stakeholder group, or by a public notice of meeting. Topics would depend on the need for coordination and input.

The state will continue to engage interested stakeholders through ad hoc meetings. Meetings will cover a range of topics related to meeting the goals of the Ohio DAP, and stakeholders should provide recommendations to the Ohio Lake Erie Commission about specific questions or issues that should be discussed in a broader group setting.

Conclusions and Projections

Accountability

Accountability means ensuring compliance with rules and laws, establishing clear areas of responsibilities, and making and keeping the commitment toward achieving the goals. Ohio has recommitted to the goals of the Collaborative Agreement to reduce nutrients by 2025 as well as to the goals set by the GLWQA.

Distributing the loads should enable us to improve our estimates of what is needed to achieve the targeted reductions, in terms of how widespread, where, what exact projects or practices are needed, and in tracking, verifying and accounting for progress.

We have improved our ability to quantify the actions that the State will be taking to address nutrient reduction. We are adding a tracking component so that funding and project installation and performance can be better quantified and results more readily shared.

Model Projections

The Adaptive Management process includes making predictions about expected outcomes based on proposed actions. Watershed modeling efforts have shown that implementation levels for proposed actions will have to increase basin wide to achieve the 40 percent load reduction target from Annex 4.

A multi-university team of modeling experts has developed, calibrated and validated six watershed computer models to determine which conservation practices are most likely to lead to target reductions in phosphorus runoff from the Maumee River watershed into Lake Erie (Scavia et al., 2016 [23], Martin et al. 2019[24]). The models were then used to evaluate how adoption of conservation measures over time would impact overall water quality. Meaningful engagement of a diverse advisory group provided important guidance for the project.

Some of the scenarios tested approach the total phosphorus target load. Recommended practices to reduce phosphorus runoff can be mixed and matched to work with farmer preferences and opportunities. Widespread adoption of practices will be necessary, as many scenarios required multiple management practices across at least half the farm fields in the Maumee watershed, so this mix-and-match approach will be essential to achieving the 40 percent reduction goal.

Separately, the NRCS 2016 Conservation Effects Assessment Project (CEAP) report[25] estimated that 95 percent of cropland acres would have to be affected by a suite of BMPs to achieve a 43 percent reduction in total phosphorus. This work showed that no single conservation solution will meet the needs of each field and farm. Rather, comprehensive field-scale conservation planning and systems are needed to accommodate the differences across farm fields. Another key finding from this work was that additional progress in nutrient and erosion control will depend on advancements in precision technologies.

These modeling efforts clearly show that every farm throughout the watershed has a role to play in achieving the load reduction targets. There are different ways to reach the target loads, but in all cases the adoption rates of the nutrient reduction practices will need to be widespread. We will work towards improving the models to better match expected actions based on the Ohio DAP, in order to better predict what we expect to happen and how long it will take.

Managing Expectations

The Lake Erie watershed in Ohio consists of over 7 million acres. The Maumee River alone has over 4 million acres in Ohio. While some progress has been made in the four years since the Collaborative Agreement was first signed, monitoring data in the rivers (see Water Monitoring Summary 2017, 2018) and satellite data showing the lake (see National Oceanic and Atmospheric Administration HAB products for Lake Erie and Ohio 2018 Integrated Report) indicate that there is a long way to go to meet the targets that have been set.

While the marginal abatement cost curve approach provides a guide to focus funding on relatively cost-effective practices, there is uncertainty in this model. Not all practices have been studied extensively. There is a lack of data for DRP reduction and that is why the analysis focuses on tracking TP even though DRP (or bioavailable P) are better indicators of HAB development. It is also difficult to determine the degree that the overlap of practices reduces overall effectiveness.

We anticipate that the response in the rivers and lakes will continue to be slow because of the need for widespread changes. The installation of physical structures and creation of natural features such as wetlands takes time to move through the proposal, design and construction phases. Education and outreach and the changes in behavior that they are intended to promote also take time to roll out.

In addition to the time needed to make these changes, it remains uncertain whether the installation of practices and changes in land management will result in immediate effects, or if there is some lag time for nutrients already moving through the system to be removed. This is an area of ongoing research.

[23] Scavia, D. et al. 2016. Informing Lake Erie Agriculture Nutrient Management via Scenario Evaluation. Water Center, University of Michigan. ***http://graham.umich.edu/water/project/erie-western-basin***.

[24] Martin, J. et al. 2019. ibid.

[25] USDA NRCS, 2016 Effects of Conservation Practice Adoption on Cultivated Cropland Acres in Western Lake Erie Basin, 2003-06 and 2012. ***https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcseprd889806.pdf.***

Despite these challenges, the state of Ohio feels that the new resources and focus provided by H2Ohio should accelerate the progress we have been making toward achieving the Annex 4 and Ohio DAP goals for nutrient reduction, and ultimately, a healthier Lake Erie.

Appendix A: Developing Far-Field Targets for the Maumee River Watershed

Distribution of baseline loads by sources and assigning target loads

A1 Introduction

At over 4 million acres, the Maumee River watershed is not a practical size to plan nonpoint source nutrient reduction. The efforts need to be based on individual actions by farmers, property owners and local officials at a finer scale, for example at the size of an agricultural field. Therefore, to be effective, it is necessary to bridge the gap between the total phosphorus (TP) loadings from the entire Maumee River watershed and smaller HUC12 subwatersheds. Loads are needed at the HUC12 scale to develop 9-element Nonpoint Source Implementation Strategies (NPS-IS) to guide actions in the absence of NPS-IS. These plans are the critical link between Maumee River watershed loading targets and implementable projects developed by local stakeholders.

A2 Methods

Ohio EPA completed a Nutrient Mass Balance Study in 2016 and 2018 that broke down existing TP loads into three broad categories: nonpoint source, point source [covered by National Pollutant Discharge Elimination System (NPDES) permit], and household sewage treatment systems (HSTS) (Ohio EPA, 2016 and 2018). At the statewide level this information has served to broadly define the role of the landscape runoff and wastewater treatment facilities in phosphorus loading. However, the study did not break down landscape to define the role of agricultural, developed and natural areas in total loading. The following methods are the evolution of what Ohio EPA used in the Nutrient Mass Balance Study. This refined method details a way to first identify the role of different components of nonpoint sources in the Nutrient Mass Balance Study and then to distribute those loads to the smaller HUC12 watershed units.

In addition to the new information added in the method, the components have been renamed to better reflect their legal definitions. The component that is identified as nonpoint source in the Nutrient Mass Balance Study includes loads from municipal separate storm sewer systems (MS4) that are legally defined as point sources. Similarly, the component that was named NPDES did not contain all sources covered by the program. To make the components of the mass balance consistent with these legal definitions different terminology is used in this modified nutrient mass balance method. The component previously named nonpoint source is called "landscape" loading because it is indexed to the different land uses in the Maumee River watershed. The component previously named NPDES is going to be named "wastewater treatment" (WT).

A2.1 Pour Point Load Estimation

Central to this modified nutrient mass balance method is a monitoring point, herein the pour point, where near-continuous data is collected by the National Center for Water Quality Research (NCWQR; see Works Cited section for a data download link). The pour point on the Maumee River is at Waterville, OH (USGS Gage No.: 04193490). Data are collected one to three times daily, resulting in the ability to calculate an accurate annual load at that location.

The load calculated at this point is the sum of daily loads based on the product of United States Geological Survey (USGS) daily flow and NCWQR daily nutrient concentrations. Flows were missing on some dates within the period of record. To address these gaps, flows were estimated using linear interpolation if the time period was less than three days; otherwise that period was excluded from the initial estimate. The dates when concentration data was missing (for example, ice cover) were excluded from the initial load estimate. To account for the days that were missing load (due to either flow or concentration gaps), a ratio of the USGS annual flow to sum of daily flow reported with NCWQR monitoring is used to adjust the annual nutrient load.

A2.2 Overall Loading Calculation

Equation 1 shows the overall loading calculation. The load discharged by wastewater treatment facilities are within the regulatory authority of Ohio EPA and represented as WT in equation 1. In addition to waste treatment facilities, loads from combined sewer overflows (CSOs) are also regulated by Ohio EPA. HSTS contributions are estimated separately. The landscape derived loads are separated into two categories: load calculated upstream (UPST) from the pour point and load calculated downstream (DST) of the pour point. The landscape loading terms include loads from agricultural, developed and natural lands. These components of loading are presented schematically in Figure A1. Details of how all these sources were determined are explained in the following sections of this report.

$$Total\ Load = WT + CSO + HSTS + Landscape_{UPST} + Landscape_{DST}\ (1)$$

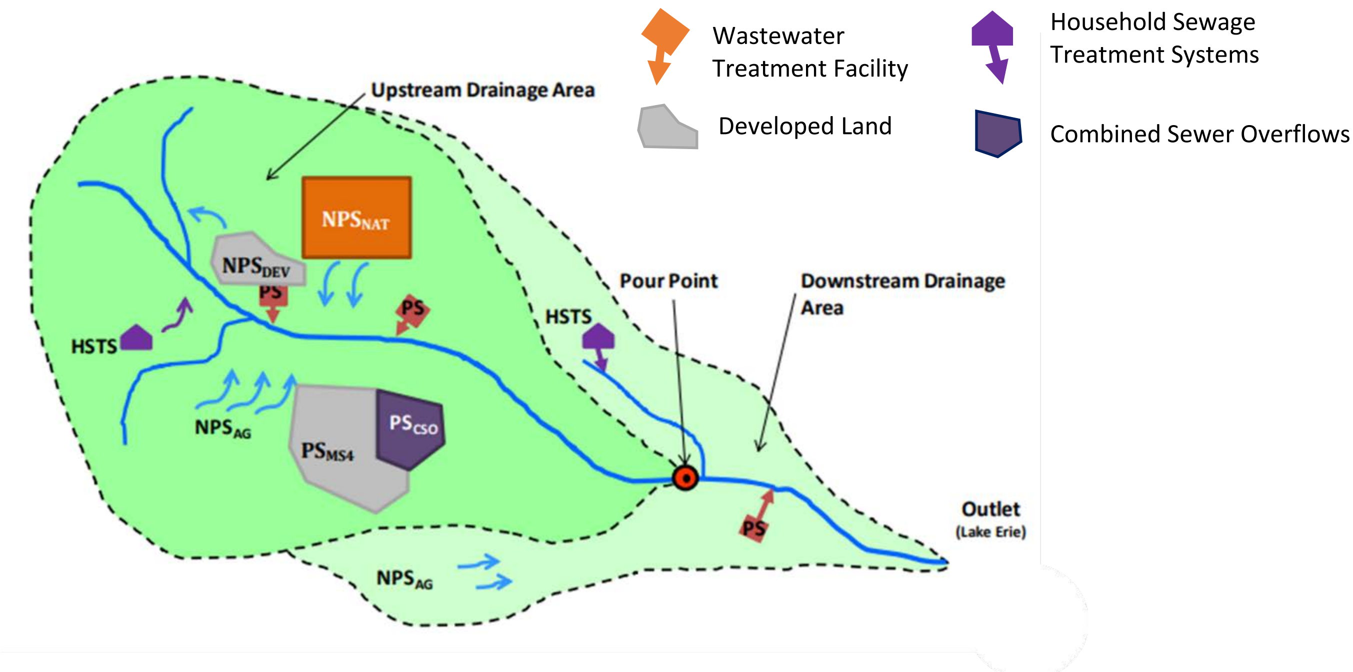


Figure A1: Schematic of sources represented in modified nutrient mass balance.

A2.3 Loads from Wastewater Treatment Facilities

Wastewater treatment facilities report operational data to Ohio EPA. All facilities are required to report flow volume. Phosphorus is reported at each facility dependent on factors such as its reasonable potential of elevated concentrations and facility size. The varied reporting from different facilities requires that loads be estimated using a method which is flexible and can account for missing data. Equation 2 estimates the generic loading from a wastewater treatment facility.

$$Annual\ Load = Q(in\ MG) * [TP] * cf\ (2)$$

In Equation 2, Q represents a facility's flow volume in million gallons (MG). The *cf* term, equal to 3.78451, is a conversion factor used to convert the product of MG and milligrams per liter into kilograms.

The TP concentration denoted [*TP*] in Equation 2, must be estimated from either reported data or assumptions based on similar facilities. Within the Maumee River watershed, wastewater treatment facilities are generally accounted for in two categories: public facilities and industrial facilities. The public facilities are further broken down into subcategories: major (≥1.0 million gallons per day facility design flow (mgd)), significant minor (≥0.5 mgd and <1.0 mgd), minor (≥0.1 mgd and <0.5 mgd), package plant (<0.1 mgd) and controlled discharge lagoons (any size).

To estimate the phosphorus concentration, each facility is placed into one of four groups depending on the type of plant and available phosphorus monitoring data. The groups and approaches for calculating phosphorus concentrations are: 1) industrial facilities reporting phosphorus concentrations – use the median concentration of phosphorus reported during the calculation period; 2) industrial facilities not reporting phosphorus concentrations – use similar facilities or other means to estimate phosphorus concentrations; 3) sewage treatment facilities reporting phosphorus concentrations – use the median phosphorus concentration from the calculation period; and 4) sewage treatment facilities not reporting phosphorus concentrations – use the median phosphorus concentration from similar facilities. Nutrient concentrations estimated for five classes of municipal effluent and are presented in Table A1.

Table A1: Facility classes by design flow.

Group	Type	Design Flow (mgd)	Median Concentration of Group (mg/L)
Industrials	All Industrial Permits	--	N/A
Major Municipal	Sewage Treatment	≥ 1.0	0.54
Significant Minor Municipal	Sewage Treatment	0.5 to 1.0	1.72
Minor Municipal	Sewage Treatment	0.1 to 0.5	2.07
Controlled Discharge	Sewage Treatment	Varies	1.92
Package Plant	Sewage Treatment	< 0.1	3.54

Wet-weather events often result in increased wastewater flows within collection networks, either by design in combined sewer communities or inflow and infiltration. The result of increased flows is reduced treatment at the plant (usually a bypass of secondary treatment), wastewater bypasses at the plant headworks (raw bypasses), overflows of combined sewers (CSOs) and overflows of sanitary sewers (SSOs). SSOs typically report occurrences but not volume. Therefore, SSOs are excluded from the analysis unless flow volumes are reported. This report uses a wet weather loading nutrient concentration of 0.73 mg/L for TP, the median concentration of 131 samples reported from September 2014 to August 2017 by two Ohio sewer districts that are required to monitor TP at select CSO outfalls in their NPDES permit. When bypasses go through primary treatment, 15 percent removal is assumed by Ohio EPA to account for settling and sludge removal. This value is set to be greater than the 6 percent removal from septic tanks but not as high a removal rates observed when fine solids are removed via extended settling and/or anaerobic digestion.

The Maumee River watershed includes wastewater treatment facilities that are outside of the state of Ohio. Data on monthly loads were available from the Integrated Compliance Information System (ICIS) maintained by U.S. EPA. These monthly loads were summed for each facility within the watershed and are reported in the lumped out-of-state (OOS) load. Facilities identified as controlled dischargers were excluded from the OOS analysis because using the data maintained in ICIS results in a gross overestimation of discharge volume. This is because ICIS averages the discharge of only days a discharge occurred. No associated count of days that discharge occurred is reported. Due to this being a very small fraction of the OOS wastewater load, it is more practical to not include this source. This load contains a CSO load estimate where the overflow volumes are reported, and combined sewer systems were assumed to have the same concentration as those within Ohio.

A2.4 HSTS Loads

The population served by HSTS is estimated using a spatial analysis of census data (U.S. Census Bureau, 2010), combined with an assessment of populations that are likely served by sewer systems of NPDES permitted facilities. The populations served by NPDES permitted wastewater treatment facilities are estimated using two methods. The first method is that census designated places (CDPs) are assessed as sewered or not. The second method is applied to NPDES permitted sewage treatment facilities that are not associated with a CDP. In this case, the population served by the facilities is estimated by determining the average flow for facilities associated primarily with households and then dividing by 70.1 gal/day/person (Lowe et al., 2009). Facilities serving mobile home parks and subdivisions were included in the latter approach while facilities serving highway rest stops and recreation facilities were excluded. The HSTS population is then estimated to be the remaining population when NPDES served CDP population and non-CDP NPDES served population are subtracted from the total population of the watershed.

Equation 3 explains this overall method.

$$Load_{HSTS} = Pop_{HSTS} * Nut_{Yield} * \left[percentPop_{\text{onsite, working}} * DR_{\text{onsite, working}} + percentPop_{\text{onsite, failed}} * DR_{\text{onsite, failed}} + percentPop_{discharge} * DR_{discharge} \right] \quad (3)$$

where,

Pop_{HSTS} = Total population served by HSTS in watershed (persons)

$\text{Nut}_{\text{Yield}}$ = Annual yield of nutrient per person $\left(\frac{\frac{\text{lb}}{\text{year}}}{\text{person}}\right)$

$\text{percentPop}_{\text{onsite, working}}$ = percent of population served by onsite working HSTS

$\text{DR}_{\text{onsite, working}}$ = nutrient delivery ratio for onsite working systems

$\text{percentPop}_{\text{onsite, failed}}$ = percent of population served by onsite failing HSTS

$\text{DR}_{\text{onsite, failing}}$ = nutrient delivery ratio for onsite failing systems

$\text{percentPop}_{\text{discharge}}$ = percent of population served by discharging HSTS

$\text{DR}_{\text{discharge}}$ = nutrient delivery ratio for discharging systems

The per capita nutrient yield in household wastewater was determined by literature review. A study by Lowe and others (2009) reported a median nutrient yield as 0.511 kg-P/capita/year. In a similar effort to this mass balance study, the Minnesota Pollution Control Agency (MPCA) estimated the annual per capita nutrient yield to be 0.8845 kg-P/capita/year (Wilson and Anderson, 2004). The MPCA study used estimated values based on different household water use activities while the Lowe study reported statistics on data measured on actual systems. The Lowe study median concentrations were used because the methodology uses actual sampling data of septic tank effluents.

Phosphorus delivery ratios for three different system types were also estimated by literature review. One system type is properly operating soil adsorption systems. In these systems, wastewater percolates through the soil matrix where physical, chemical and biological processes treat pollutants. Phosphorus is usually considered to be effectively removed in these systems. Beal and others (2005) reviewed several studies and reported several findings including: >99 percent P removal; 83 percent P removal; and slow P movement to ground water. In a nutrient balance study, MPCA assumed that HSTS with soil adsorption systems removed phosphorus at 80 percent efficiency (Wilson and Anderson, 2004). For this study, 80 percent efficiency will be used because the studies reviewed by Beal used fresh soil columns and did not consider a reduction in efficiency with system age.

Another category of systems included in the mass balance study is soil adsorption systems that are failing to function as designed. Failure of systems is caused by a myriad of problems, so literature values are not available for phosphorus removal. For this method, the assumption is made that failing systems still involve some level of soil contact; therefore, TP removal will be in between the value of a direct discharge and a soil adsorption system. The value used for this study is 40 percent TP removal for failing soil adsorption systems, or half that is assumed for properly working systems.

A third group of HSTS is systems that are designed to discharge directly to a receiving stream. These systems use mechanical treatment trains to treat wastewater and discharge directly to streams. Like septic tanks, they are designed to remove suspended solids, but sludge removal is limited to periodic pumping. Lowe et al. (2009) studied septic tank influent and effluent and determined that there was a six percent reduction in TP. This study will use the same six percent reduction observed by Lowe and others (2009).

The final component needed to estimate HSTS loading is the relative proportion of system types, split into three categories: 1) working soil adsorption systems; 2) failing soil adsorption systems; and 3) systems designed to discharge. The Ohio Department of Health (ODH) is tasked with regulating the treatment of household sewage. In

2013, ODH published the results of a survey of county health departments in 2012 as an inventory of existing HSTS in the state by Ohio EPA district (Table A2). The Maumee River watershed is in the northwest district.

The Toledo Metropolitan Area Council of Governments (TMACOG) refined the Ohio portion of the HSTS estimate from Ohio EPA's Nutrient Mass Balance Study (TMACOG, 2018). Study improvements included refined sewershed areas for NPDES facilities and completing HSTS loading estimates at the HUC12 subwatershed scale. The improvements for the Ohio portion of the HSTS load are incorporated into this study.

Table A2: Proportions of total HSTS systems grouped into categories for Ohio's Nutrient Mass Balance Study. Adapted from the 2012 ODH statewide inventory (ODH, 2013).

Ohio EPA District	Working Soil Adsorption (%)	Failing Soil Adsorption (%)	Discharging (%)
Northwest	41.5	26.5	32
Northeast	44	27	29
Central	42.8	25.2	32
Southwest	64	14	22
Southeast	61.2	10.8	28

A2.5 Loading from the Landscape

Central to calculating the load from the landscape is the pour point load described in section A2.2 above. The calculation of the load from the landscape upstream of the pour point is the total load at the pour point minus the wastewater treatment facilities and HSTS loads upstream of the pour point. The landscape load calculated at this point includes loads contributed by all land uses. This subsection explains how the lumped landscape load is empirically broken down to different land use types.

Using land use to break down total loading from the landscape is based on the concept that there are unique and important differences in loads from different parts of the landscape. To do this in the context of an empirical mass balance, a ratio of the loads from different parts of the landscape is defined. Field scale data from different land uses is needed to define the contributions of different land use types. A review of literature was completed to summarize field scale data for different land uses. Land use was lumped into three broad categories discussed below: 1) agricultural land, 2) developed land and 3) natural lands. These uses were aggregated from the 2011 National Land Cover Database (NLCD) (USGS, 2014), as shown in Table A3.

Table A3: Land use recategorization from NLCD land use types to broader landscape mass balance groups.

NLCD Land Use Type	Mass Balance Group
Cultivated Crops	Agriculture
Hay/Pasture	Agriculture
Developed, High Intensity	Developed
Developed, Low Intensity	Developed
Developed, Medium Intensity	Developed
Developed, Open Space	Developed
Emergent Herbaceous Wetlands	Natural
Evergreen Forest	Natural
Deciduous Forest	Natural
Herbaceous	Natural
Open Water	Natural
Shrub/Scrub	Natural
Woody Wetlands	Natural
Mixed Forest	Natural

The purpose of the literature review is to index yields from the three broad landscape categories to each other, as described below in section A2.5.4 by Equations 4 through 6. The range of values from each category within the landscape will vary, however the emphasis here is on the average. Variation within these categories is complex and the data may not be available at an appropriate spatial scale. For example, soil test phosphorus and tillage practices vary across small areas but are summarized at the county or zip code level. In practice, a coarser method is more appropriate at the HUC12 watershed scale, while further detail can be added when developing NPS-IS plans for HUC12 subwatersheds.

A2.5.1 Agricultural Lands

Agriculture comprises nearly 78 percent of the landscape in the Maumee River watershed with approximately 93 percent of that area represented by cultivated crops. The abundance of the agricultural land means that its contribution weighs heavily into the average load conveyed to the pour point near the Maumee River outlet. Edge-of-field monitoring networks and modeling efforts have been employed to improve knowledge of nutrient loss from agricultural fields in Ohio. Much of this research is led by the U.S. Department of Agriculture (USDA) Soil Drainage Research Unit (SDRU) at The Ohio State University. A recent study spanning water years 2012 – 2015 summarized edge-of-field phosphorus loading from 38 field sites throughout the corn belt region of Ohio. The study reports an average annual TP yield for this period of 1.1 lbs./acre (Peace et al., 2018). USDAs Natural Resources Conservation Service Conservation Effects Assessment Program (NRCS-CEAP), estimated an annual average of 1.9 lbs./acre of TP loss at the edge of agricultural fields based on the 2012 conservation condition (NRCS, 2016). The NRCS-CEAP effort used modeling results to describe phosphorus losses across the broader landscape than can be represented in the monitoring network. The results for annual loss observed by the SDRU edge-of-field data collection ranged from ~0.1 - ~4 lbs./acre (Peace et al., 2018) were within the distribution of the NRCS-CEAP modeling effort. An earlier report by the Ohio Lake Erie Phosphorus Task Force II (Ohio Phosphorus Task Force II, 2013) estimated an average annual loss of TP yield of 2.05 lbs./acre from cultivated cropland after a review of the literature.

A2.5.2 Developed Lands

Developed lands are defined by the amount of impervious surface that they represent (Table A4). Within the Maumee River watershed approximately 11 percent of the landscape is classified as developed land. Approximating the percent imperviousness as the center of each class and the relative proportions of each class developed land is approximately 27 percent impervious in the Maumee River. Across the pervious-impervious landscape nutrient loads are described by stark differences in the volume of runoff and nutrient concentrations in the runoff.

Research pertinent to Ohio has been carried out on developed land in the upper Midwest and the Northeast. Some of the studies were executed to quantify the impact of removing phosphorus from lawn fertilizers, an action that has since been largely implemented in Ohio. In a Wisconsin study TP loss from turf grass plots were 0.05 – 0.61 lbs./acre/year over three monitoring years, 2005-2007 (Bierman et al., 2010).

The primary impact of impervious areas within the developed landscape is increased runoff. Data from U.S. EPA's Nationwide Urban Runoff Program showed the lowest event mean TP concentrations on commercial land when compared to other developed land uses, except for open spaces (U.S. EPA, 1999). However, this is compounded by increases in runoff as the amount of impervious area increases. As imperviousness increases in commercial and industrial areas, runoff volumes exceed 50 percent of observed rainfall compared to <10 percent for lawns (Bannerman et al., 1993; U.S. EPA, 1999). The same studies reported mean TP concentrations that were approximately 2.5 times greater for lawns when compared to streets and 5-10 times greater when compared to parking lots. Annual loads across the developed landscape start to balance across the landscape as concentrations are elevated in low runoff areas and lower in higher runoff areas.

Table A4: NLCD land use classes for developed land (adapted from USGS, 2014) and the percentage of each class within the Maumee River watershed's developed land.

Class	Description	% of Maumee
21	Developed, Open Space- areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses and vegetation planted in developed settings for recreation, erosion control or aesthetic purposes.	55
22	Developed, Low Intensity- areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20 percent to 49 percent of total cover. These areas most commonly include single-family housing units.	30
23	Developed, Medium Intensity -areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 percent to 79 percent of the total cover. These areas most commonly include single-family housing units.	10
24	Developed, High Intensity-highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 percent to 100 percent of the total cover.	5

A2.5.3 Natural Lands

Natural lands are grouped as areas within the watershed that are generally not managed with nutrient inputs (Table A3). Most of the research on the natural landscape has been focused on enhancing the capacity of natural lands to serve as nutrient and sediment sinks. However, across the broader landscape natural lands represent a wide variety of landforms that serve as sources and sinks. While the distribution of loads from agricultural and developed lands were always reported as positive loads, natural lands are represented by a distribution of both positive and negative loads. Without adequate monitoring data to compare with other land uses, a small positive bias of 0.1 lbs./acre/year is assumed for natural lands.

A2.5.4 Landscape Loading Summary

The literature supports the assumption that agricultural lands are the highest yielding of the three defined categories. Annual agricultural loads reported in the region ranged from 1.1 – 2.05 lbs./acre/year on average. Developed land had results that were <0.1 – 0.6 lbs./acre/year on turfgrass and similar values from the impervious landscape, albeit due to increased runoff at lower concentrations. The natural landscape is not well described with field scale monitoring data across the diverse natural landscape, but a small positive load of 0.1 lbs./acre/year is assumed. The ratio that is used to define the relative contributions at the pour point are that agricultural land yields twice as much per acre as developed land (1:0.5) and agricultural land yields 10x as much per acre as natural lands (1:0.1). Small changes in these ratios will not result in large changes in the breakdown of the total load because the equations are constrained by the large proportion of the landscape represented by agricultural production.

Equations 4 through 6 define the relative contribution of the landscape load at the pour point.

$$\frac{Landscape_{up}}{Area_{up}} = \frac{Landscape_{AG}}{Area_{AG}} + \frac{Landscape_{DEV}}{Area_{DEV}} + \frac{Landscape_{NAT}}{Area_{NAT}} \quad (4)$$

$$Landscape_{DEV} = Landscape_{AG} * 0.5 \quad (5)$$

$$Landscape_{NAT} = Landscape_{AG} * 0.1 \quad (6)$$

Note that each component in Equation 4 is normalized by area, signifying that these are yields, not total loads. $Landscape_{up}$ and $Area_{up}$ indicates the landscape load and area upstream of the pour point, respectively. Agricultural, developed and natural land areas are denoted AG, DEV and NAT, respectively.

The series of equations gives the relative load from each sector at the pour point that can then be used to estimate the load downstream of the pour point from the nonpoint source. To do this, the upstream loads are converted into yields for each land use. Then the yield is used to determine the nonpoint source downstream by assuming the same yield from the upstream area applies to the downstream area for each component of the landscape. This calculation is necessary because it is not possible to measure load directly due to the lake influence on the river downstream of the pour point.

A2.6 Distribution of Watershed Nonpoint Source Load to HUC12s and counties

Once loads are defined at the larger watershed scale there are several factors that should be considered in order to distribute landscape loads to the HUC12 subwatersheds. Three factors are considered in this distribution methodology: 1) hydrology, 2) land use and, 3) HSTS population.

A2.6.1 Hydrology - Accounting for Discharge in HUC12 Distributed Loads

Streamflow normalized to the watershed size has been shown to differ at the HUC8 scale in the Maumee River watershed. In a report, "*Methodology for Connecting Annex 4 Water Quality Targets with TMDLs in the Maumee River Basin*" (TetraTech, 2018), the authors showed a 26 percent difference in streamflow between the St. Marys and Tiffin rivers' HUC8s based on gaging stations located within each watershed. Because these differences are observed, it is important to consider the impact that differences in flow from different regions within the Maumee River watershed impact loading.

Flow and concentration combine to compute the total load, therefore, areas that have a greater discharge volume will have more load even when concentrations are the same. When total load is the primary concern, as is the case for the Lake Erie, concentration is reported as the flow weighted mean concentration (FWMC). The FWMC gives more weight to concentrations when discharge is high. Another way it can be described is as flow normalized concentration. It is equivalent to the total load (mass) divided by the total discharge (volume). The purpose of accounting for varying discharge across the larger Maumee River watershed is to account for regional influences of geology, climate and other factors can influence the total discharge.

Since there is ample monitoring of stream discharge an empirical method was developed to understand how discharge varies in the Maumee River watershed. The USGS maintains a stream gaging network and discharge data is available for download via the National Water Information System (NWIS) website (USGS, 2016). Several steps were taken to turn the point discharge record for these gaging locations into a raster grid of discharge.

The first step was selecting what gages within the region would be used for the spatial interpolation. Gages needed to contain at least 14 years of springtime (March-July) discharge between 2002-2016 to be selected. Gages were also screened out if they were regulated in some way, for example, a dam controlled the discharge upstream of the gaging location. Using these criteria, a total of 36 gages were selected within and near the Maumee River watershed (Figure A2).

Then USGS's StreamStats tool (Ries et al., 2017) was used to define the contributing watershed for each 36 gages. The watersheds were exported as a shapefile and loaded into ESRI's ArcMap program. Michigan streams were not supported with a StreamStats application so watersheds for gaging stations that were in Michigan were delineated using the ArcHydro toolbox in ArcMap 10. Once the basins were in ArcMap, they were projected into Ohio State Plane South. Some basins were nested, meaning a watershed was geographically within another. To address this the nested area was removed from the larger watershed. The result was that each gage's watershed was independent from the others. A centroid point was created for each of the basins.

Then, for each watershed, the discharge associated with the corresponding gage was downloaded from the USGS NWIS site into a spreadsheet. There were three basins that did not contain a full discharge record between 2002-2016. These gages went through a record extension process to extrapolate to the entire period. With complete records the springtime average discharge over the 14-year period (2002-2016) was calculated. The average discharge was then converted to a total volume. When a gaging station had upstream nested stations, the volumes discharged from the nested watersheds were subtracted, so the volume associated with a watershed was not counted more than once. The total volume was then normalized by watershed area by converting it to a water yield, as depth in inches, over the watershed area.

In the final step the water yield was paired with the centroids that were created for each basin in ArcMap. A spatial interpolation tool (Kriging) was used in ArcMap to create a 38 ft Raster grid of water yield across the entire Maumee River watershed. Using zonal statistics, the average yield was calculated for each HUC12 subwatershed (Figure A2). The ratio of each HUC12's average yield and the total watersheds average yield is used to determine the hydrologic weighting factor (HWF). Each HUC12 subwatershed's HWF is used to adjust the whole watershed phosphorus yields for each land use category. The HWFs range from 0.87 to 1.14.

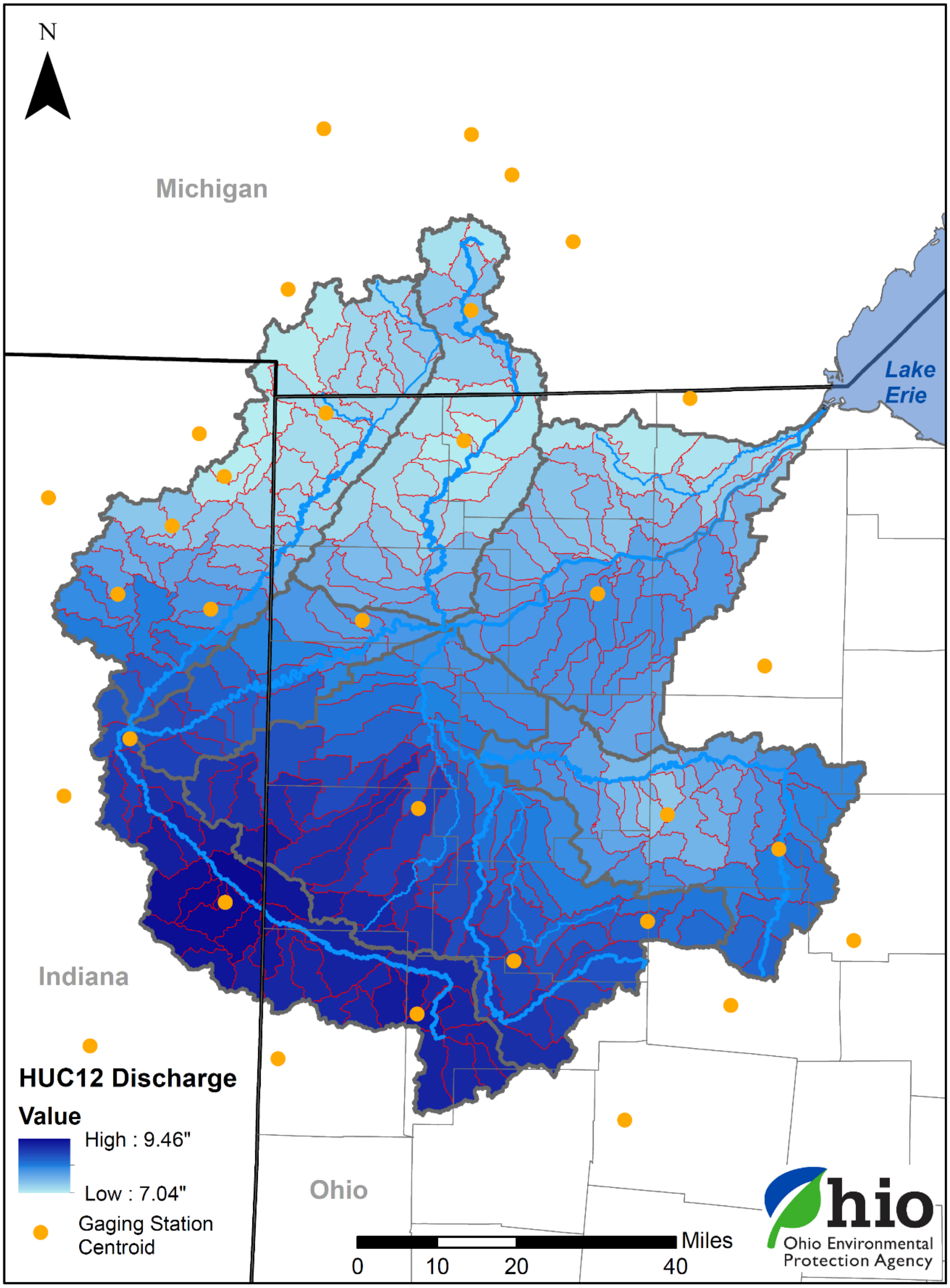


Figure A2: HUC12 average (2002-2016) springtime (March-July) water yield in the Maumee River watershed in inches. The values are interpolated from the centroid of 36 gaging stations within and surrounding the watershed. Note, four gage centroids are not shown due to being just outside of the map extent (three in the east and one in the west).

A2.6.2 Land Use - Accounting for Land Use in HUC12 Distributed Loads

A mass balance method that does not include land use factors would assume all HUC12 subwatersheds contribute at the same rate. However, agricultural land yields greater phosphorus loss than developed land followed by natural lands, as explained in section A2.5. By capturing these differences within each HUC12, realistic base loads and resulting targets can be calculated for each HUC12.

In some HUC12 watersheds where natural and/or developed land dominate the landscape, yields are relatively lower than agriculture heavy HUC12s. Without this accounting method these HUC12 watersheds might already be considered as meeting a target based on the 40 percent reduction of the 2008 base yield that applies to the entire Maumee River watershed. This would result in a situation where less load would be available to be reduced in these areas. Then HUC12 subwatersheds with the most agriculture would have to do more than the 40 percent load reduction based on the Maumee River watershed wide loading rate in order to balance out the total reduction required. This method avoids this situation by allowing for more equitable reduction expectations throughout the greater watershed.

To capture the variation in land use for each HUC12, the NLCD (USGS , 2014) dataset was analyzed using GIS software. The data were projected into the State Plane South and then summed to the HUC12 subwatersheds (Figure A3). Since data is not available to differentiate the phosphorus loss from different components of the detailed land use categories in the NLCD, land use is again grouped into the three categories described above in section A2.5.

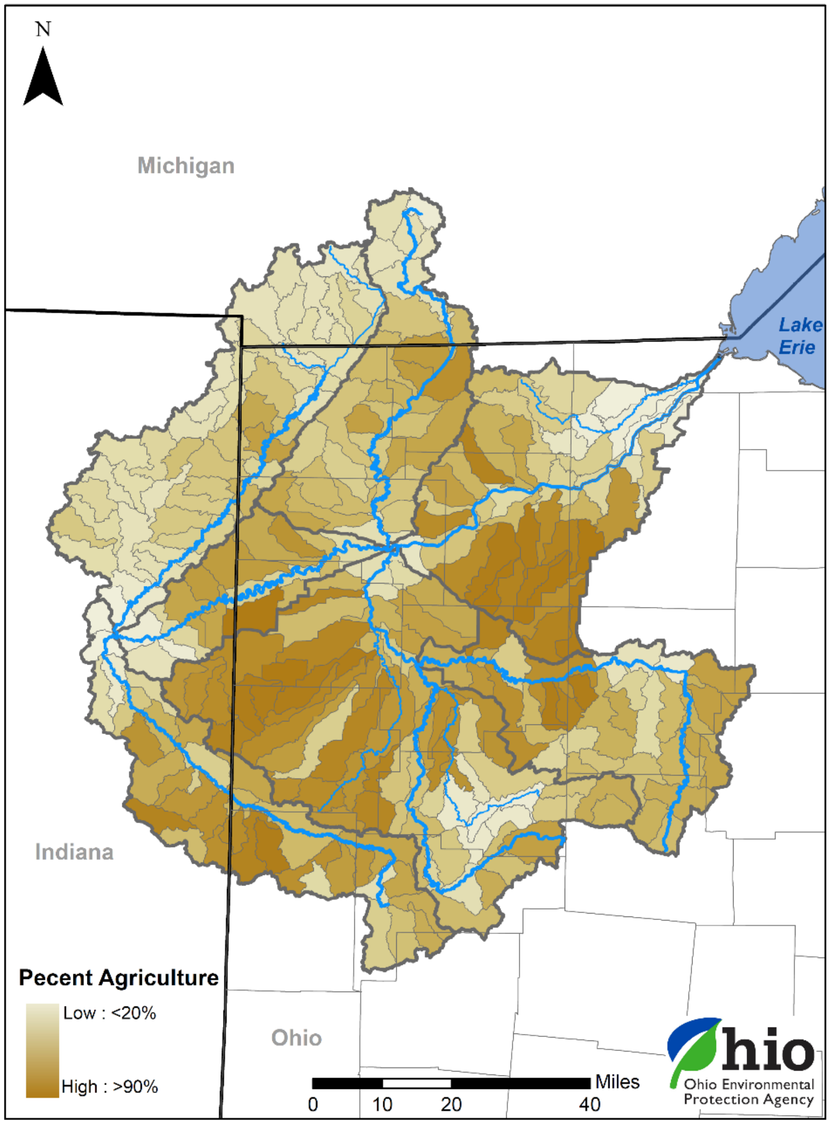


Figure A3: Percent agricultural land use by HUC12 in the Maumee River watershed.

A2.6.3 Distributing HUC 12 Loads – Combining Hydrology and Land Use

The two sub-sections above outline how hydrology and land use are considered for distributing HUC 12 loads. Equation 7 shows how the two are combined. Note that the "Maumee yield" used for each of the three land use categories is a single value determined when balancing the loads for the entire watershed. The Maumee yield values are presented in Section A3 Results, below. Equation 8 shows an example HUC12 of these calculations. The numbers values used for this example can all be found in the results section (note that only two significant digits are retained in the actual load results).

$$\text{HUC12 LOAD}_{AG,\,DEV,\,NAT} = [\,(\text{Maumee Yield}_{AG} * \text{HUC12 Area}_{AG}) + (\text{Maumee Yield}_{DEV} * \text{HUC12 Area}_{DEV}) + (\text{Maumee Yield}_{NAT} * \text{HUC12 Area}_{NAT})\,] * \text{Hydrologic weighting factor} \qquad (07)$$

Example Platter Creek – HUC12: 04100005 02 06

$$10{,}491 \text{ pounds}_{AG,\,DEV,\,NAT} = [\,(0.85 \text{ pounds/acre}_{AG} * 12{,}266 \text{ acres}_{AG}) + (0.42 \text{ pounds/acre}_{DEV} * 741 \text{ acres}_{DEV}) + (0.09 \text{ pounds/acre}_{NAT} * 870 \text{ acres}_{NAT})\,] * 0.97 \qquad (08)$$

A2.6.4 HSTS - Accounting for HSTS in HUC12 Distributed Loads

In addition to an estimate of population in Ohio's portion of the Maumee River watershed, TMACOG provided population estimates for all HUC12s in Ohio (Figure A4). This population estimate is described in section A2.5 above. The HUC12 population estimates were used directly to distribute the total HSTS TP load for Ohio to the HUC12s where it originated.

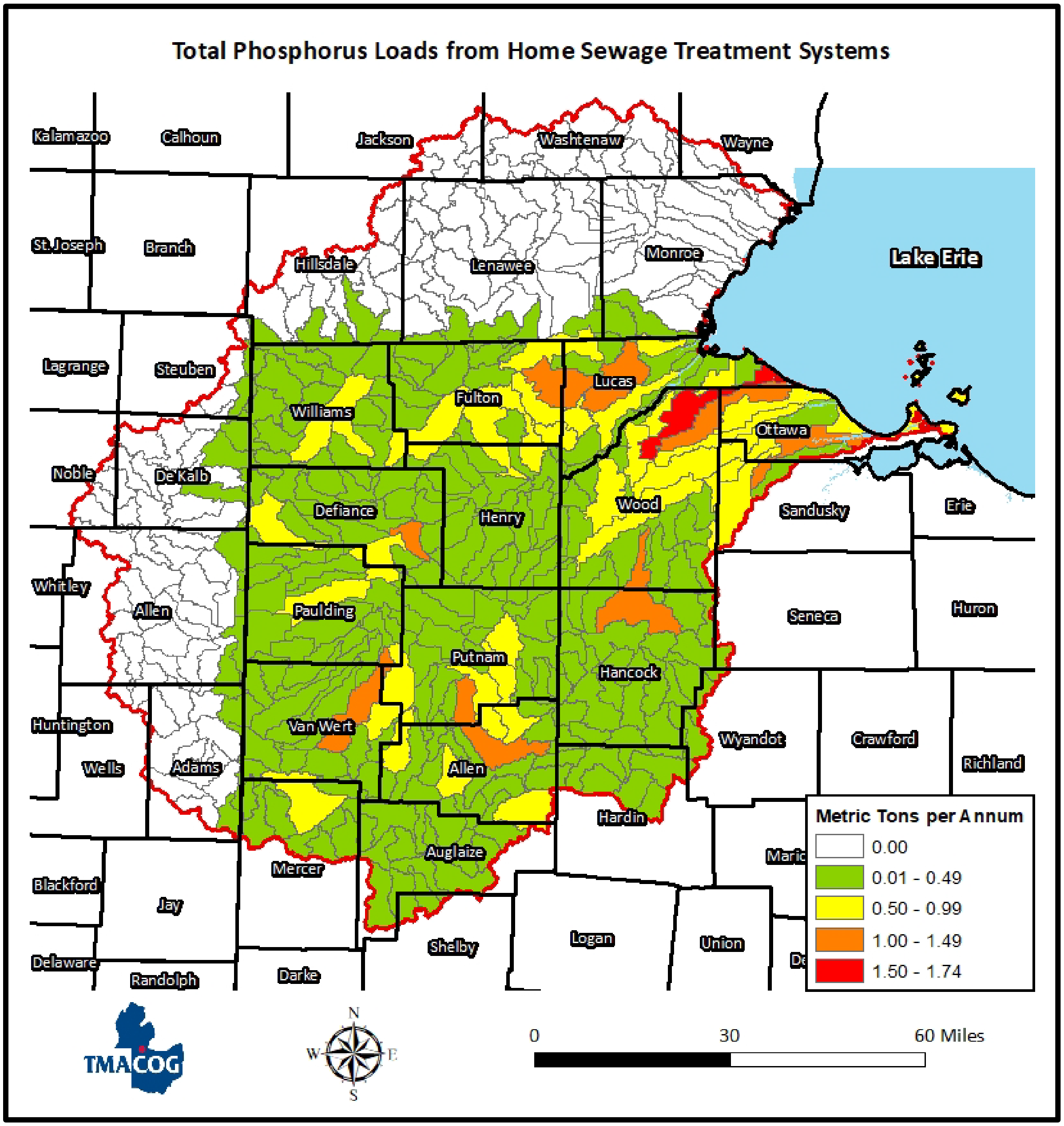


Figure A4: Phosphorus loads from HSTS for HUC12 watersheds. (TMACOG, 2018).

A3 Results

Using the modified nutrient mass balance method, the loads for the Maumee River watershed are summarized in Figure A5. Approximately one quarter of the 2008 load in the Maumee River watershed is from sources outside of Ohio. Within Ohio, Figure A5 shows the load in five categories: agricultural land, developed land, natural land, wastewater treatment and HSTS. The major loading source at nearly 85 percent of Ohio's total contribution in spring 2008 is agricultural land. Wastewater treatment (~7 percent) and developed land (~6 percent) are the next largest sources of TP in the Maumee River watershed. Finally, HSTS (~2 percent) and natural land (~1 percent) sources contribute the remaining TP load. Expressed as TP yields for spring 2008 areas with land uses of agricultural, developed and natural exported 0.85, 0.42 and 0.09 pounds per acres, respectively. Figure A5 also shows the Annex 4 TP target Maumee River watershed load to maintain Lake Erie algal species consistent with healthy aquatic ecosystems (Annex 4, 2015). The target is 860 metric tons of TP at the Waterville pour point or 903 metric tons of TP at the watershed outlet.

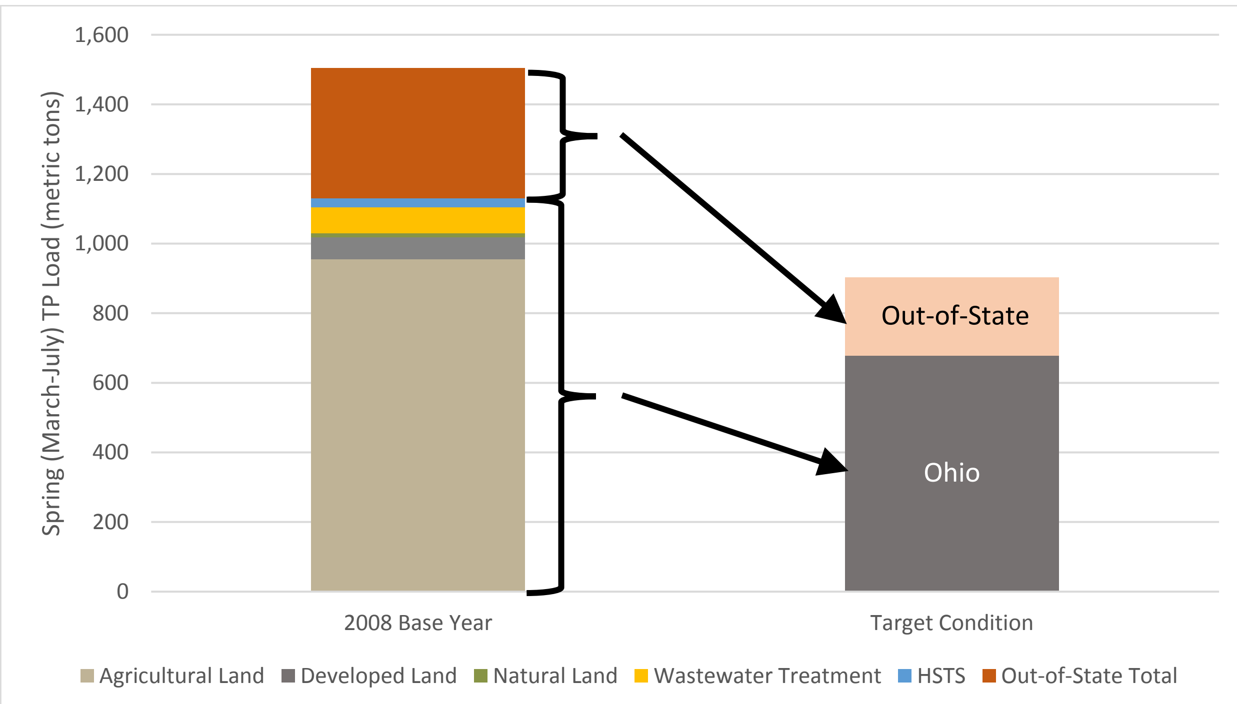


Figure A5: Maumee River watershed spring TP loading by major source category in the 2008 base year and aggregated target condition.

The Maumee River watershed includes seven HUC8 watersheds. Within Ohio, these watersheds encompass 194 HUC12 subwatersheds. Following the methods outlined in this appendix, the Maumee River watershed total loads were distributed to the HUC12 subwatersheds. When these loads are converted to yields using the contributing area of the HUC12 watersheds the effect of the method is clear. Areas with more agriculture and more streamflow have higher springtime loading in the 2008 base year than areas with less agriculture and less streamflow (Figure A6). For example, there is a group of watersheds in the southern part of the watershed that while in a higher streamflow area of the watershed (Figure A2) has lower landscape yields that the surrounding areas. The cause is a decrease in agriculture (Figure A3) due to the developed land associated with the urbanized area around the city of Lima.

Spring loads for the base year of 2008 and the corresponding targets for each HUC12 are shown in (Tables A5 through A11). Each table outlines the results for one of the seven HUC8s and only loads from Ohio are included. The landscape Annex 4 target for each HUC12 is determined as sum of the natural areas base load contribution and 0.6 times the sum of the agricultural, developed and HSTS base loads. This reflects the Annex 4 required 40 percent reduction goals. This target calculation results in loads from natural areas assumed to need no reductions. This is because these land areas are generally unmanaged and nutrient reduction from them is not expected. On Tables A5 through A11 load results greater than 100 pounds are shown with two significant digits. Results under 100 pounds are noted as less than 100.

This is to reflect the level of precision when calculating yields bound by research that generally reports results with two significant digits.

Tables A12-18 provide more information that went into the HUC12 calculations. Like the preceding set of tables, each table includes all of the Ohio HUC12s for a HUC8. Each table includes the land use area for the three categories used in this method. The HWF used for each HUC12 is next presented. The HUC12-specific land use yields are then given for each of the three land use categories. (These values can also be calculated by multiplying the whole Maumee River watershed yields by the specific HUC12s HWF. For instance, if a HUC12 has an HWF of 1.10 then that value would be multiplied by the whole-Maumee agricultural yield of 0.85 pounds/acre to come up with 0.94 pounds/acre for agriculture land in that HUC12.) The last column on Tables A12-18 shows the whole HUC12 2008 spring season phosphorus yield. This is the value determined by summing up all of the phosphorus from the land uses and the HSTS (the "landscape" load), then dividing that value by the HUC12 area. The whole HUC12 yield is also the value shown below on Figure A6.

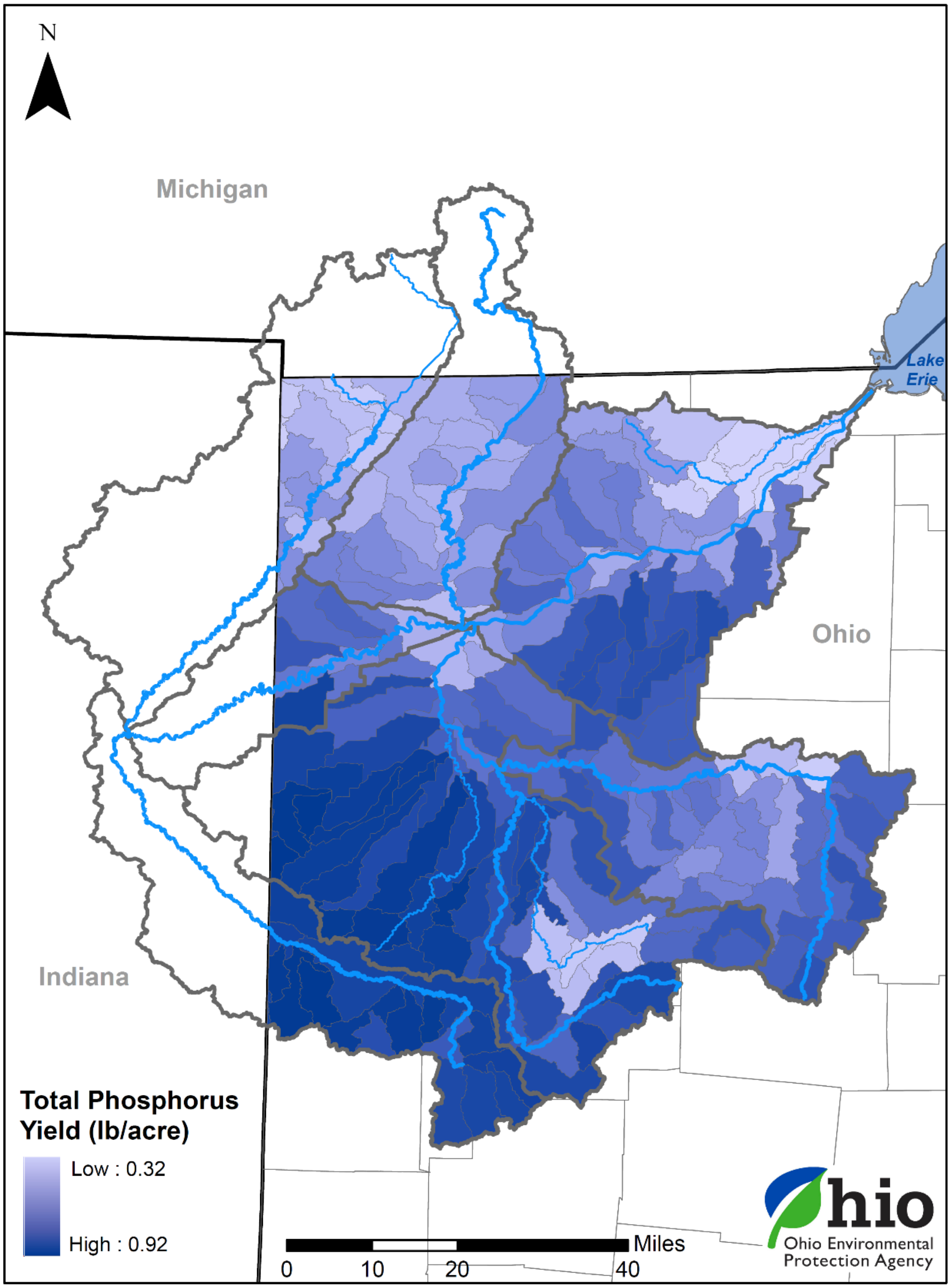


Figure A6: TP yield from the landscape by HUC12 in the Maumee River watershed for the spring 2008 base condition.

Table A5: Landscape total phosphorus loadings for HUC12s within the St. Josephs River HUC8 (Ohio contributions only) for the spring 2008 base condition and 40 percent reduction targets.

St. Josephs River – 04100003						
	Load in Pounds					
HUC12	Agricultural Land	Developed Land	Natural Land	Ohio HSTS Land	Landscape Total	Landscape Target
01 04	150	<100	<100	<100	160	100
01 06	9,600	460	150	260	11,000	6,400
02 04	4,600	310	200	190	5,300	3,300
03 01	8,300	400	160	140	9,000	5,400
03 02	3,400	280	<100	<100	3,800	2,300
03 03	14,000	580	220	280	15,000	8,900
03 04	6,800	710	190	250	8,000	4,900
03 05	9,200	390	<100	150	9,800	5,900
03 06	5,400	170	<100	120	5,800	3,500
04 02	2,700	<100	<100	<100	2,900	1,800
04 05	860	<100	<100	<100	940	580
04 06	2,500	<100	<100	<100	2,700	1,600
05 01	10,000	270	110	170	11,000	6,400
05 02	1,300	<100	<100	<100	1,400	830
05 03	6,800	550	110	110	7,500	4,600
05 05	5,200	130	<100	<100	5,500	3,400
05 06	510	<100	<100	<100	540	330

Table A6: Landscape total phosphorus loadings for HUC12s within the St. Marys River HUC8 (Ohio contributions only) for the spring 2008 base condition and 40 percent reduction targets.

St. Marys River – 04100004						
	Load in Pounds					
HUC12	Agricultural Land	Developed Land	Natural Land	Ohio HSTS Land	Landscape Total	Landscape Target
01 01	8,300	220	120	150	8,800	5,300
01 02	14,000	720	190	330	16,000	9,400
01 03	11,000	450	120	250	12,000	7,000
01 04	16,000	1,600	160	430	18,000	11,000
01 05	9,100	360	<100	200	9,700	5,900
01 06	6,900	1,100	110	230	8,300	5,000
02 01	6,700	220	<100	110	7,000	4,200
02 02	12,000	480	<100	240	13,000	7,700
02 03	6,300	960	<100	180	7,500	4,500
02 04	13,000	460	<100	160	13,000	8,000
02 05	22,000	670	240	220	23,000	14,000
03 01	14,000	370	<100	130	15,000	8,700
03 02	16,000	490	<100	160	17,000	10,000
03 03	30,000	1,500	340	590	32,000	20,000
03 04	6,300	210	<100	<100	6,700	4,000
03 05	5,700	300	<100	<100	6,100	3,700
04 01	13,000	450	140	230	14,000	8,400
04 04	590	<100	<100	<100	620	380

Table A7: Landscape total phosphorus loadings for HUC12s within the Upper Maumee River HUC8 (Ohio contributions only) for the spring 2008 base condition and 40 percent reduction targets.

Upper Maumee River – 04100005						
	Load in Pounds					
HUC12	Agricultural Land	Developed Land	Natural Land	Ohio HSTS Land	Landscape Total	Landscape Target
02 01	16,000	440	<100	130	16,000	9,800
02 02	6,000	600	<100	230	6,900	4,200
02 03	11,000	290	110	290	12,000	7,000
02 04	19,000	880	180	550	21,000	13,000
02 05	6,400	480	120	190	7,200	4,400
02 06	10,000	310	<100	190	11,000	6,400
02 07	8,000	400	<100	230	8,700	5,300
02 08	9,600	590	250	220	11,000	6,500

Table A8: Landscape total phosphorus loadings for HUC12s within the Tiffin River HUC8 (Ohio contributions only) for the spring 2008 base condition and 40 percent reduction targets.

Tiffin River – 04100006						
	Load in Pounds					
HUC12	Agricultural Land	Developed Land	Natural Land	Ohio HSTS Land	Landscape Total	Landscape Target
02 01	1,300	<100	<100	<100	1,400	830
02 02	9,300	360	<100	140	9,800	5,900
02 03	14,000	440	<100	340	15,000	9,000
02 04	13,000	440	170	250	14,000	8,200
02 05	5,900	220	<100	140	6,300	3,800
03 01	12,000	640	100	190	12,000	7,500
03 02	7,200	270	<100	140	7,600	4,600
03 03	13,000	1,000	100	360	14,000	8,700
04 01	10,000	590	200	560	12,000	7,200
04 02	13,000	710	140	310	14,000	8,400
04 03	11,000	1,400	<100	240	13,000	7,800
04 04	7,300	180	130	180	7,800	4,700
05 01	18,000	870	260	560	19,000	12,000
05 02	27,000	1,400	200	790	30,000	18,000
05 03	9,800	580	150	210	11,000	6,500
05 04	12,000	500	220	290	13,000	8,000
06 01	14,000	370	180	190	15,000	9,000
06 02	11,000	430	150	240	12,000	7,400
06 03	8,400	440	130	260	9,200	5,600
06 04	7,400	810	180	320	8,700	5,300

Table A9: Landscape total phosphorus loadings for HUC12s within the Auglaize River HUC8 (Ohio contributions only) for the spring 2008 base condition and 40 percent reduction targets.

Auglaize River – 04100007						
	Load in Pounds					
HUC12	Agricultural Land	Developed Land	Natural Land	Ohio HSTS Land	Landscape Total	Landscape Target
01 01	21,000	680	220	580	22,000	14,000
01 02	8,100	330	<100	220	8,700	5,300
01 03	14,000	600	210	380	15,000	9,300
01 04	17,000	780	220	310	18,000	11,000
01 05	9,700	1,700	140	350	12,000	7,200
02 01	15,000	1,100	180	400	16,000	9,900
02 02	4,400	380	<100	190	5,000	3,000
02 03	14,000	490	210	430	15,000	9,100
02 04	14,000	870	180	370	15,000	9,300
03 01	10,000	380	130	130	11,000	6,500
03 02	14,000	780	110	280	15,000	9,300
03 03	9,800	550	170	340	11,000	6,600
03 04	7,200	340	110	210	7,900	4,800
03 05	4,600	1,800	180	300	6,900	4,200
03 06	5,600	3,900	210	440	10,000	6,200
04 01	4,300	2,000	120	390	6,800	4,200
04 02	6,600	3,800	200	880	11,000	6,900
04 03	5,800	250	140	270	6,400	3,900
04 04	4,300	1,200	<100	360	6,000	3,600
04 05	6,800	280	<100	170	7,300	4,400
04 06	10,000	370	<100	200	11,000	6,500
05 01	27,000	2,200	360	1,000	31,000	19,000
05 02	19,000	950	<100	530	20,000	12,000
05 03	10,000	440	<100	380	11,000	6,600
06 01	10,000	340	<100	110	11,000	6,400
06 02	14,000	550	<100	130	15,000	8,900
06 03	11,000	420	<100	150	12,000	7,100
06 04	28,000	1,400	140	540	31,000	18,000
07 01	8,600	420	<100	120	9,100	5,500
07 02	27,000	1,000	120	380	29,000	17,000
07 03	21,000	740	<100	280	22,000	13,000
08 01	30,000	1,200	110	990	33,000	20,000
08 02	7,800	280	<100	<100	8,200	4,900
08 03	18,000	910	<100	380	19,000	11,000
08 04	18,000	2,300	<100	370	21,000	12,000
08 05	8,300	260	<100	<100	8,700	5,300
08 06	6,500	250	<100	150	7,000	4,200
09 01	15,000	500	<100	170	15,000	9,200
09 02	7,500	280	<100	200	8,000	4,800
09 03	13,000	1,200	<100	510	15,000	9,000
09 04	10,000	480	<100	260	11,000	6,600
09 05	9,900	390	110	230	11,000	6,400
09 06	6,500	270	<100	110	7,000	4,200
09 07	7,200	390	120	170	7,900	4,800
10 01	8,400	330	<100	<100	8,800	5,300
10 02	14,000	420	<100	110	14,000	8,500
10 03	11,000	310	<100	<100	11,000	6,600

Auglaize River – 04100007						
	Load in Pounds					
HUC12	Agricultural Land	Developed Land	Natural Land	Ohio HSTS Land	Landscape Total	Landscape Target
10 04	25,000	810	110	250	26,000	15,000
10 05	10,000	380	120	180	11,000	6,500
11 01	21,000	720	250	370	23,000	14,000
11 02	18,000	820	130	280	19,000	12,000
11 03	4,900	330	130	210	5,600	3,400
12 01	5,600	130	<100	<100	5,800	3,500
12 04	260	<100	<100	<100	280	170
12 05	20,000	850	<100	290	21,000	13,000
12 06	22,000	1,200	250	480	24,000	14,000
12 07	8,800	310	<100	110	9,200	5,600
12 08	13,000	480	140	130	14,000	8,200
12 09	12,000	1,300	360	600	14,000	8,800

Table A10: Landscape total phosphorus loadings for HUC12s within the Blanchard River HUC8 for the spring 2008 base condition and 40 percent reduction targets.

Blanchard River – 04100008						
	Load in Pounds					
HUC12	Agricultural Land	Developed Land	Natural Land	Ohio HSTS Land	Landscape Total	Landscape Target
01 01	11,000	380	140	160	12,000	7,000
01 02	9,100	590	<100	260	10,000	6,100
01 03	16,000	690	170	260	17,000	10,000
01 04	13,000	650	<100	200	14,000	8,500
01 05	17,000	800	190	220	18,000	11,000
02 01	13,000	560	110	210	14,000	8,600
02 02	18,000	730	160	290	19,000	11,000
02 03	10,000	350	140	130	11,000	6,500
02 04	12,000	730	110	300	13,000	8,000
02 05	3,800	1,800	120	190	5,900	3,600
03 01	12,000	620	150	220	13,000	7,700
03 02	13,000	1,600	220	280	15,000	9,000
03 03	7,100	740	<100	190	8,100	4,900
03 04	12,000	2,800	160	450	15,000	9,200
04 01	6,400	310	<100	150	6,900	4,200
04 02	6,100	290	<100	<100	6,600	4,000
04 03	6,400	710	<100	260	7,500	4,500
04 04	6,000	680	<100	180	6,900	4,200
04 05	11,000	590	110	280	12,000	7,100
05 01	8,300	330	<100	130	8,900	5,300
05 02	19,000	880	210	420	21,000	12,000
05 03	6,200	170	<100	110	6,500	3,900
05 04	6,800	180	<100	<100	7,100	4,300
05 05	6,900	170	<100	150	7,200	4,400
05 06	19,000	700	<100	260	20,000	12,000
06 01	21,000	850	110	570	23,000	14,000
06 02	12,000	1,200	100	860	14,000	8,300
06 03	11,000	370	<100	270	12,000	7,000
06 04	5,900	230	<100	240	6,400	3,900
06 05	18,000	700	210	390	19,000	12,000

Table A11: Landscape total phosphorus loadings for HUC12s within the Lower Maumee River HUC8 for the spring 2008 base condition and 40 percent reduction targets.

Lower Maumee River – 04100009						
	Load in Pounds					
HUC12	Agricultural Land	Developed Land	Natural Land	Ohio HSTS Land	Landscape Total	Landscape Target
01 01	7,900	210	<100	<100	8,300	5,000
01 02	10,000	370	<100	110	11,000	6,400
01 03	19,000	770	<100	300	20,000	12,000
01 04	18,000	570	<100	230	19,000	11,000
01 05	11,000	350	<100	150	12,000	7,200
01 06	6,100	260	<100	130	6,500	3,900
02 01	4,900	1,300	130	1,200	7,500	4,500
02 02	11,000	390	<100	190	12,000	7,100
02 03	16,000	710	270	310	17,000	10,000
02 04	13,000	690	<100	340	14,000	8,200
02 05	10,000	780	<100	250	11,000	6,700
02 06	8,800	750	<100	200	9,900	6,000
02 07	6,700	660	140	170	7,700	4,700
03 01	9,000	380	120	450	9,900	6,000
03 02	16,000	1,200	210	790	18,000	11,000
04 01	12,000	340	<100	240	12,000	7,300
04 02	21,000	1,400	130	760	23,000	14,000
04 03	12,000	540	100	370	13,000	7,700
05 01	10,000	430	<100	180	11,000	6,500
05 02	12,000	410	<100	120	13,000	7,800
05 03	8,200	250	<100	<100	8,600	5,200
05 04	16,000	740	<100	350	17,000	10,000
05 05	12,000	650	<100	190	13,000	7,600
05 06	11,000	340	<100	110	11,000	6,800
05 07	11,000	310	<100	120	11,000	6,900
05 08	11,000	320	<100	110	12,000	7,200
05 09	7,400	330	<100	220	8,000	4,800
05 10	9,200	580	190	310	10,000	6,300
06 01	21,000	940	100	550	23,000	14,000
06 02	8,300	590	190	420	9,500	5,800
06 03	5,300	970	<100	400	6,700	4,100
07 01	18,000	1,300	400	1,100	20,000	12,000
07 02	11,000	630	170	900	13,000	7,600
07 03	2,100	570	520	610	3,800	2,500
08 01	5,600	480	380	910	7,300	4,600
08 02	9,600	700	150	390	11,000	6,600
08 03	2,400	3,300	410	1,300	7,400	4,600
08 04	5,900	5,100	190	880	12,000	7,300
09 01	9,900	1,100	<100	690	12,000	7,100
09 02	1,800	2,300	<100	510	4,700	2,800
09 03	1,800	2,400	270	250	4,700	2,900
09 04	<100	3,200	170	<100	3,400	2,100

Table A12: Land use area, total phosphorus hydrologic weighting factor (HWF) and resulting total phosphorus yields for HUC12s within the St. Josephs River HUC8 (Ohio contributions only) for the spring 2008 base condition. The whole HUC12 yield is the sum of loads from the three land use categories and HSTS loads, divided by the total area.

St. Josephs River – 04100003								
	Area in Acres			Hydrologic	HUC12 Specific TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land	Natural Land	Weighting Factor	Agricultural Land	Developed Land	Natural Land	Whole HUC12
01 04	196	5	57	0.91	0.77	0.39	0.08	0.63
01 06	12,670	1,217	1,903	0.90	0.76	0.38	0.08	0.67
02 04	6,079	823	2,541	0.90	0.76	0.38	0.08	0.57
03 01	10,999	1,050	2,003	0.89	0.75	0.38	0.08	0.64
03 02	4,455	734	1,010	0.89	0.76	0.38	0.08	0.61
03 03	18,075	1,535	2,789	0.89	0.75	0.38	0.08	0.66
03 04	9,011	1,869	2,453	0.89	0.76	0.38	0.08	0.60
03 05	12,215	1,031	1,071	0.89	0.75	0.38	0.08	0.69
03 06	7,174	453	1,153	0.89	0.76	0.38	0.08	0.66
04 02	3,627	243	1,132	0.87	0.74	0.37	0.08	0.59
04 05	1,154	88	451	0.88	0.74	0.37	0.08	0.56
04 06	3,311	217	434	0.90	0.76	0.38	0.08	0.68
05 01	13,037	717	1,439	0.90	0.76	0.38	0.08	0.69
05 02	1,675	97	154	0.92	0.78	0.39	0.08	0.71
05 03	8,715	1,406	1,358	0.92	0.78	0.39	0.08	0.66
05 05	6,555	322	1,015	0.94	0.80	0.40	0.08	0.70
05 06	631	15	141	0.96	0.81	0.41	0.08	0.69

Table A13: Land use area, total phosphorus hydrologic weighting factor (HWF) and resulting total phosphorus yields for HUC12s within the St. Marys River HUC8 (Ohio contributions only) for the spring 2008 base condition. The whole HUC12 yield is the sum of loads from the three land use categories and HSTS loads, divided by the total area.

St. Marys River – 04100004								
	Area in Acres			Hydrologic	HUC12 Specific TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land	Natural Land	Weighting Factor	Agricultural Land	Developed Land	Natural Land	Whole HUC12
01 01	8,814	472	1,238	1.12	0.95	0.47	0.10	0.84
01 02	15,099	1,513	1,934	1.12	0.95	0.47	0.10	0.84
01 03	11,445	954	1,201	1.12	0.95	0.47	0.10	0.86
01 04	16,605	3,346	1,661	1.12	0.95	0.48	0.10	0.83
01 05	9,587	761	926	1.12	0.95	0.47	0.10	0.86
01 06	7,157	2,313	1,087	1.13	0.96	0.48	0.10	0.79
02 01	6,926	462	529	1.13	0.96	0.48	0.10	0.89
02 02	12,443	998	909	1.13	0.96	0.48	0.10	0.89
02 03	6,679	2,031	604	1.12	0.95	0.47	0.10	0.81
02 04	13,364	968	746	1.11	0.94	0.47	0.10	0.88
02 05	23,104	1,425	2,489	1.11	0.94	0.47	0.10	0.85
03 01	14,740	781	446	1.12	0.95	0.47	0.10	0.91
03 02	17,064	1,028	790	1.12	0.95	0.47	0.10	0.89
03 03	31,412	3,134	3,493	1.12	0.95	0.48	0.10	0.85
03 04	6,605	446	424	1.13	0.96	0.48	0.10	0.89
03 05	5,882	625	666	1.14	0.97	0.48	0.10	0.86
04 01	13,547	942	1,431	1.14	0.96	0.48	0.10	0.87
04 04	615	51	53	1.13	0.95	0.48	0.10	0.86

Table A14: Land use area, total phosphorus hydrologic weighting factor (HWF) and resulting total phosphorus yields for HUC12s within the Upper Maumee River HUC8 (Ohio contributions only) for the spring 2008 base condition. The whole HUC12 yield is the sum of loads from the three land use categories and HSTS loads, divided by the total area.

Upper Maumee River – 04100005								
	Area in Acres			Hydrologic Weighting Factor	HUC12 Specific TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land	Natural Land		Agricultural Land	Developed Land	Natural Land	Whole HUC12
02 01	17,899	987	212	1.04	0.88	0.44	0.09	0.86
02 02	6,874	1,372	980	1.03	0.87	0.44	0.09	0.75
02 03	12,835	667	1,272	1.01	0.85	0.43	0.09	0.79
02 04	23,165	2,112	2,145	0.98	0.83	0.42	0.09	0.76
02 05	7,587	1,126	1,328	1.00	0.85	0.42	0.09	0.72
02 06	12,266	741	870	0.97	0.82	0.41	0.09	0.77
02 07	9,624	950	1,079	0.98	0.83	0.42	0.09	0.75
02 08	11,508	1,408	2,963	0.98	0.83	0.42	0.09	0.67

Table A15: Land use area, total phosphorus hydrologic weighting factor (HWF) and resulting total phosphorus yields for HUC12s within the Tiffin River HUC8 (Ohio contributions only) for the spring 2008 base condition. The whole HUC12 yield is the sum of loads from the three land use categories and HSTS loads, divided by the total area.

Tiffin River – 04100006								
	Area in Acres			Hydrologic Weighting Factor	HUC12 Specific TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land	Natural Land		Agricultural Land	Developed Land	Natural Land	Whole HUC12
02 01	1,742	104	129	0.89	0.75	0.38	0.08	0.70
02 02	12,364	951	1,080	0.89	0.75	0.38	0.08	0.68
02 03	18,957	1,188	1,179	0.88	0.75	0.37	0.08	0.70
02 04	17,035	1,162	2,228	0.89	0.75	0.38	0.08	0.67
02 05	8,007	589	649	0.87	0.74	0.37	0.08	0.68
03 01	15,638	1,721	1,369	0.87	0.74	0.37	0.08	0.67
03 02	9,513	710	869	0.89	0.75	0.38	0.08	0.69
03 03	17,259	2,657	1,291	0.88	0.75	0.37	0.08	0.68
04 01	13,707	1,560	2,556	0.90	0.76	0.38	0.08	0.66
04 02	16,246	1,786	1,713	0.93	0.79	0.40	0.08	0.71
04 03	14,521	3,530	995	0.91	0.77	0.39	0.08	0.68
04 04	9,122	450	1,553	0.94	0.80	0.40	0.08	0.70
05 01	23,227	2,304	3,349	0.89	0.76	0.38	0.08	0.67
05 02	35,899	3,764	2,514	0.90	0.76	0.38	0.08	0.71
05 03	12,728	1,510	1,839	0.91	0.77	0.38	0.08	0.67
05 04	15,440	1,251	2,646	0.93	0.79	0.40	0.08	0.68
06 01	17,628	909	2,151	0.95	0.81	0.40	0.08	0.72
06 02	14,129	1,053	1,839	0.95	0.81	0.40	0.08	0.72
06 03	10,334	1,096	1,598	0.95	0.81	0.40	0.08	0.71
06 04	9,087	1,989	2,154	0.97	0.82	0.41	0.08	0.66

Table A16: Land use area, total phosphorus hydrologic weighting factor (HWF) and resulting total phosphorus yields for HUC12s within the Auglaize River HUC8 (Ohio contributions only) for the spring 2008 base condition. The whole HUC12 yield is the sum of loads from the three land use categories and HSTS loads, divided by the total area.

Auglaize River – 04100007								
	Area in Acres			Hydrologic	HUC12 Specific TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land	Natural Land	Weighting Factor	Agricultural Land	Developed Land	Natural Land	Whole HUC12
01 01	23,261	1,509	2,341	1.07	0.90	0.45	0.09	0.83
01 02	8,756	721	948	1.09	0.92	0.46	0.10	0.84
01 03	15,520	1,312	2,274	1.07	0.91	0.46	0.09	0.80
01 04	18,229	1,652	2,273	1.11	0.94	0.47	0.10	0.83
01 05	10,445	3,652	1,413	1.10	0.93	0.47	0.10	0.77
02 01	16,018	2,409	1,876	1.08	0.92	0.46	0.09	0.81
02 02	4,678	813	898	1.10	0.93	0.47	0.10	0.78
02 03	15,146	1,064	2,215	1.09	0.92	0.46	0.10	0.82
02 04	15,330	1,925	1,880	1.07	0.91	0.45	0.09	0.80
03 01	11,596	855	1,409	1.04	0.88	0.44	0.09	0.78
03 02	16,390	1,807	1,280	1.02	0.87	0.43	0.09	0.79
03 03	11,072	1,239	1,895	1.05	0.89	0.44	0.09	0.77
03 04	8,302	794	1,218	1.02	0.87	0.43	0.09	0.76
03 05	5,150	4,002	1,992	1.05	0.89	0.45	0.09	0.62
03 06	6,385	8,861	2,264	1.04	0.88	0.44	0.09	0.58
04 01	4,797	4,405	1,306	1.07	0.90	0.45	0.09	0.65
04 02	7,351	8,528	2,141	1.05	0.89	0.45	0.09	0.63
04 03	6,425	566	1,503	1.06	0.90	0.45	0.09	0.76
04 04	4,935	2,794	746	1.03	0.88	0.44	0.09	0.70
04 05	7,688	629	295	1.04	0.88	0.44	0.09	0.84
04 06	11,704	859	701	1.03	0.87	0.44	0.09	0.82
05 01	31,876	5,125	4,047	1.02	0.86	0.43	0.09	0.76
05 02	22,442	2,262	796	0.99	0.84	0.42	0.09	0.80
05 03	11,662	1,016	495	1.02	0.86	0.43	0.09	0.83
06 01	10,645	715	830	1.12	0.95	0.47	0.10	0.87
06 02	14,921	1,169	669	1.12	0.94	0.47	0.10	0.89
06 03	11,966	900	699	1.10	0.93	0.47	0.10	0.87
06 04	31,858	3,076	1,571	1.06	0.89	0.45	0.09	0.84
07 01	9,268	911	159	1.09	0.93	0.46	0.10	0.88
07 02	28,891	2,203	1,250	1.10	0.93	0.47	0.10	0.88
07 03	22,985	1,619	476	1.07	0.91	0.46	0.09	0.88
08 01	33,113	2,628	1,168	1.08	0.92	0.46	0.09	0.89
08 02	8,156	591	471	1.13	0.95	0.48	0.10	0.89
08 03	18,684	1,939	982	1.11	0.94	0.47	0.10	0.88
08 04	19,115	4,865	796	1.10	0.93	0.47	0.10	0.83
08 05	9,310	575	614	1.06	0.90	0.45	0.09	0.83
08 06	7,399	581	934	1.03	0.88	0.44	0.09	0.78
09 01	15,548	1,063	663	1.10	0.93	0.47	0.10	0.88
09 02	8,151	602	178	1.08	0.92	0.46	0.09	0.89
09 03	14,496	2,709	780	1.07	0.91	0.45	0.09	0.83
09 04	11,563	1,101	795	1.03	0.88	0.44	0.09	0.81
09 05	11,421	908	1,256	1.02	0.87	0.43	0.09	0.78
09 06	7,594	627	524	1.01	0.86	0.43	0.09	0.80
09 07	8,342	892	1,324	1.03	0.87	0.43	0.09	0.75
10 01	8,978	713	94	1.10	0.93	0.47	0.10	0.90
10 02	14,510	906	449	1.10	0.94	0.47	0.10	0.89

Auglaize River – 04100007								
	Area in Acres			Hydrologic	HUC12 Specific TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land	Natural Land	Weighting Factor	Agricultural Land	Developed Land	Natural Land	Whole HUC12
10 03	11,647	686	118	1.08	0.91	0.46	0.09	0.88
10 04	27,722	1,829	1,251	1.04	0.88	0.44	0.09	0.83
10 05	11,713	877	1,301	1.01	0.86	0.43	0.09	0.77
11 01	25,276	1,708	2,866	0.99	0.84	0.42	0.09	0.76
11 02	21,353	1,940	1,478	1.00	0.85	0.42	0.09	0.78
11 03	5,933	781	1,514	0.98	0.83	0.42	0.09	0.68
12 01	5,847	268	211	1.13	0.96	0.48	0.10	0.92
12 04	273	19	23	1.11	0.94	0.47	0.10	0.87
12 05	22,145	1,870	941	1.07	0.91	0.45	0.09	0.85
12 06	25,314	2,817	2,767	1.03	0.87	0.44	0.09	0.78
12 07	10,236	728	444	1.01	0.86	0.43	0.09	0.81
12 08	15,047	1,119	1,594	1.00	0.85	0.43	0.09	0.76
12 09	14,547	2,982	4,185	0.99	0.84	0.42	0.09	0.66

Table A17: Land use area, total phosphorus hydrologic weighting factor (HWF) and resulting total phosphorus yields for HUC12s within the Blanchard River HUC8 for the spring 2008 base condition. The whole HUC12 yield is the sum of loads from the three land use categories and HSTS loads, divided by the total area.

Blanchard River – 04100008								
	Area in Acres			Hydrologic	HUC12 Specific TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land	Natural Land	Weighting Factor	Agricultural Land	Developed Land	Natural Land	Whole HUC12
01 01	12,388	864	1,529	1.04	0.88	0.44	0.09	0.78
01 02	10,300	1,329	933	1.05	0.89	0.44	0.09	0.80
01 03	18,320	1,571	1,906	1.03	0.87	0.44	0.09	0.78
01 04	15,200	1,511	1,098	1.02	0.87	0.43	0.09	0.79
01 05	19,599	1,861	2,180	1.01	0.86	0.43	0.09	0.76
02 01	15,657	1,319	1,222	1.01	0.85	0.43	0.09	0.78
02 02	21,016	1,723	1,776	1.00	0.85	0.43	0.09	0.78
02 03	12,001	834	1,556	1.00	0.85	0.42	0.09	0.75
02 04	14,565	1,742	1,329	0.99	0.84	0.42	0.09	0.76
02 05	4,532	4,410	1,391	0.99	0.84	0.42	0.09	0.58
03 01	13,723	1,456	1,673	1.00	0.85	0.43	0.09	0.75
03 02	15,452	3,791	2,525	0.98	0.83	0.41	0.09	0.68
03 03	8,727	1,823	907	0.95	0.81	0.40	0.08	0.70
03 04	14,481	6,830	1,849	0.96	0.81	0.41	0.08	0.65
04 01	7,610	730	843	0.99	0.84	0.42	0.09	0.76
04 02	7,402	690	1,079	0.98	0.83	0.42	0.09	0.72
04 03	7,691	1,693	1,017	0.98	0.83	0.42	0.09	0.72
04 04	7,466	1,689	774	0.95	0.80	0.40	0.08	0.70
04 05	13,308	1,465	1,313	0.96	0.81	0.41	0.08	0.73
05 01	10,366	816	1,087	0.95	0.80	0.40	0.08	0.72
05 02	23,980	2,207	2,558	0.94	0.80	0.40	0.08	0.72
05 03	8,029	427	208	0.91	0.77	0.39	0.08	0.75
05 04	8,710	461	443	0.92	0.78	0.39	0.08	0.74
05 05	8,703	434	311	0.94	0.79	0.40	0.08	0.77
05 06	23,410	1,753	1,200	0.94	0.79	0.40	0.08	0.74
06 01	25,666	2,040	1,257	0.98	0.83	0.42	0.09	0.79
06 02	14,262	2,822	1,222	0.96	0.82	0.41	0.08	0.75
06 03	13,114	879	474	0.98	0.83	0.42	0.09	0.80
06 04	7,117	554	440	0.98	0.83	0.42	0.09	0.79
06 05	21,107	1,641	2,426	1.00	0.85	0.42	0.09	0.76

Table A18: Land use area, total phosphorus hydrologic weighting factor (HWF) and resulting total phosphorus yields for HUC12s within the Lower Maumee River HUC8 for the spring 2008 base condition. The whole HUC12 yield is the sum of loads from the three land use categories and HSTS loads, divided by the total area.

Lower Maumee River – 04100009								
	Area in Acres			Hydrologic	HUC12 Specific TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land	Natural Land	Weighting Factor	Agricultural Land	Developed Land	Natural Land	Whole HUC12
01 01	9,515	491	202	0.99	0.83	0.42	0.09	0.81
01 02	12,259	881	314	0.98	0.83	0.42	0.09	0.80
01 03	22,168	1,830	872	0.99	0.84	0.42	0.09	0.79
01 04	21,269	1,359	566	0.99	0.84	0.42	0.09	0.81
01 05	13,643	834	318	0.99	0.84	0.42	0.09	0.81
01 06	7,271	625	927	0.98	0.83	0.42	0.09	0.74
02 01	5,882	3,080	1,531	0.98	0.83	0.41	0.09	0.71
02 02	13,718	956	703	0.97	0.82	0.41	0.08	0.77
02 03	19,077	1,711	3,090	0.98	0.83	0.42	0.09	0.72
02 04	15,724	1,730	839	0.94	0.80	0.40	0.08	0.75
02 05	12,757	1,974	580	0.93	0.79	0.40	0.08	0.73
02 06	10,879	1,832	940	0.96	0.81	0.41	0.08	0.72
02 07	8,193	1,614	1,638	0.97	0.82	0.41	0.08	0.67
03 01	12,033	1,018	1,523	0.88	0.75	0.37	0.08	0.68
03 02	20,801	3,126	2,590	0.92	0.78	0.39	0.08	0.69
04 01	14,694	856	571	0.93	0.79	0.39	0.08	0.76
04 02	26,699	3,660	1,600	0.92	0.78	0.39	0.08	0.72
04 03	14,902	1,359	1,250	0.93	0.79	0.39	0.08	0.73
05 01	12,257	1,026	483	0.98	0.83	0.42	0.09	0.79
05 02	14,991	977	89	0.98	0.83	0.42	0.09	0.81
05 03	9,869	601	220	0.99	0.84	0.42	0.09	0.80
05 04	20,056	1,820	278	0.96	0.81	0.41	0.08	0.78
05 05	14,254	1,582	231	0.98	0.83	0.41	0.09	0.79
05 06	13,345	837	306	0.96	0.82	0.41	0.08	0.78
05 07	13,184	733	192	0.99	0.84	0.42	0.09	0.81
05 08	13,653	762	529	0.99	0.84	0.42	0.09	0.80
05 09	8,925	809	1,000	0.98	0.83	0.41	0.09	0.75
05 10	11,299	1,408	2,261	0.96	0.82	0.41	0.08	0.69
06 01	25,418	2,279	1,202	0.98	0.83	0.41	0.09	0.78
06 02	10,162	1,447	2,294	0.96	0.81	0.41	0.08	0.68
06 03	6,490	2,397	1,048	0.96	0.81	0.41	0.08	0.68
07 01	23,641	3,548	5,277	0.88	0.74	0.37	0.08	0.63
07 02	14,227	1,669	2,227	0.90	0.76	0.38	0.08	0.69
07 03	2,733	1,479	6,593	0.91	0.77	0.39	0.08	0.35
08 01	7,085	1,232	4,659	0.93	0.79	0.39	0.08	0.57
08 02	12,089	1,751	1,823	0.94	0.80	0.40	0.08	0.69
08 03	3,218	8,695	5,371	0.88	0.75	0.37	0.08	0.43
08 04	7,719	13,416	2,352	0.90	0.76	0.38	0.08	0.51
09 01	12,364	2,807	605	0.94	0.80	0.40	0.08	0.74
09 02	2,329	5,972	405	0.92	0.78	0.39	0.08	0.54
09 03	2,303	6,085	3,395	0.92	0.78	0.39	0.08	0.40
09 04	53	8,348	2,148	0.89	0.76	0.38	0.08	0.32

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Appendix B: Agricultural Best Management Practices Toolkit

The following list of recommended Best Management Practices (BMPs) was developed by the Ohio Department of Agriculture (ODA), Ohio Environmental Protection Agency (Ohio EPA), and the Ohio Lake Erie Commissionm (OLEC). Practices prioritized for H2Ohio implementation are sorted by category in the following three areas:

Nutrient Management — Fertilizer and manure application rates, timing, placement

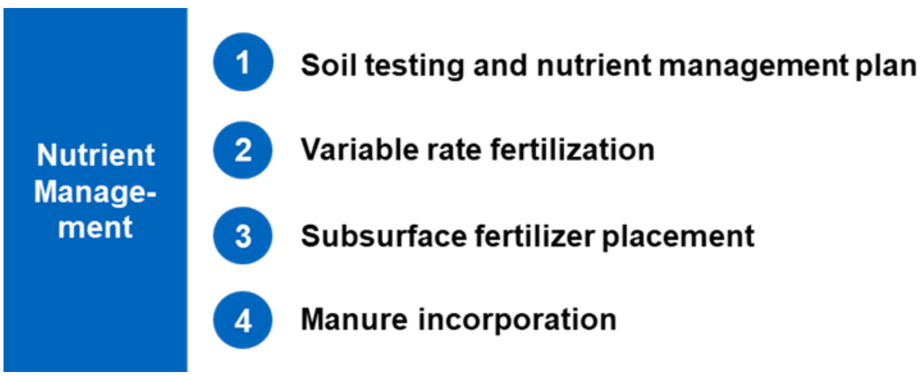
Erosion Management – Rotation, cover crops

Water Management— Retention, detention and treatment of surface runoff and subsurface drainage waters using physical barriers — both natural and constructed

Additional agricultural conservation practices beyond those listed as part of H2Ohio implementation will be suitable in certain situations and should be considered through watershed and farm conservation planning for installation and/or implementation using other funding sources.

Nutrient Management

Priority practices for State H2Ohio funding:



1) Develop Voluntary Nutrient Management Planning (VNMP)

- ODA is providing funding to develop VNMPs. The VNMP outlines how agricultural nutrients will be applied across the agricultural operation to ensure that nutrient recommendations are developed to reduce environmental risk.

2 & 3) Variable Rate Fertilization and Subsurface Placement Equipment

- Technologies to improve nutrient management, transport and application methodology continue to evolve. In many cases adopting new technologies via equipment purchase comes at significant cost. The State will continue to pursue opportunities and, where appropriate and permissible, pursue grant funding for equipment acquisition for multi-partner usage and/or offer cost-share to aid in equipment acquisition directly to producers (Great Lakes Restoration Initiative, H2Ohio).

4) Manure Incorporation

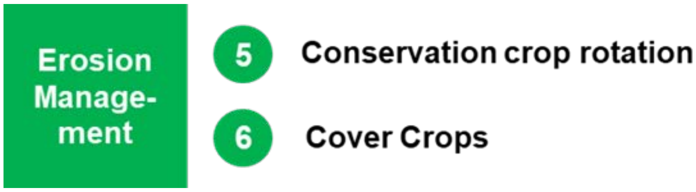
- Manure that is mixed with or placed below the surface of the soil reduces the risk that the manure and/or the soluble nutrients in the manure will be readily transported with rainwater or snowmelt. Manure incorporation can be done during manure application or within 24 hours of a surface application using a full width-disturbance tillage tool set to a minimum depth of three inches.

Additional Practices for Nutrient Management Beyond H2Ohio Implementation

- Whole Farm Conservation Plan
- Comprehensive Nutrient Management Plan

Erosion Management

Priority practices for state H2Ohio funding:



5 & 6) Conservation Crop Rotation that Include Cover Crops (USDA-NRCS-EQIP, H2Ohio)

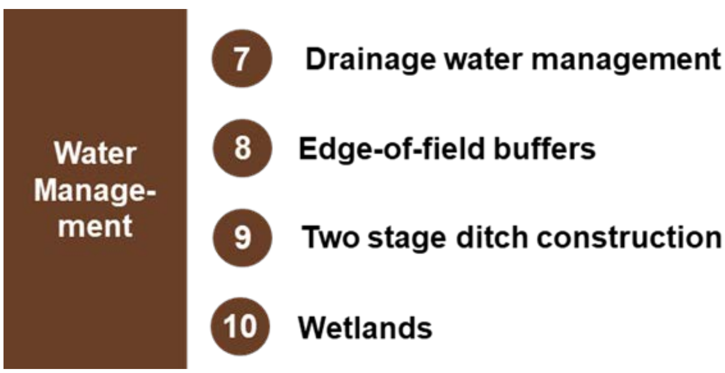
- Contributes to *Soil Health* improvement effort.
- Increases soil organic matter, which improves soil moisture storage capacity; cover crops provide living root to scavenge nutrients; improves microbial communities in soil; and more effective nutrient assimilation into soil biology.

Additional Practices for Erosion Management Beyond H2Ohio Implementation

- Grassed Waterways (see also Cascading Waterways in Water Management)
- Grade Stabilization Structures
- Minimally Invasive Tillage
- Retirement of Marginally Productive Lands (CRP & CREP)

Water Management

Priority practices for state H2Ohio funding:



7) Drainage Water Management

- Provide control over discharges from drainage tile systems. Operation allows for these structures to be managed according to planting and harvest periods where they are opened, and during the growing season when they are closed, allowing for more water storage in the fields and reduced discharge.

8) Edge-of Field Buffers

- Ohio Working Lands Hay Buffer Program
  - Program offered by ODA and administered through county Soil and Water Conservation Districts in the Western Lake Erie Basin (WLEB);
  - Incentivizes producers ($120/acre per year) to establish year-round vegetative cover near environmentally sensitive areas;
  - Requires maintaining vegetative buffer (50'-300' width) for five years; and
  - Allows producers to harvest hay, which will remove phosphorus and other nutrients from the riparian area, thus keeping them out of nearby surface waters.
  - Plant Riparian Forest Buffer Establishment of Trees and Shrubs
  - Wooded riparian buffer plantings dramatically increase water storage and nutrient assimilation next to streams and creeks.

- ***Saturated Buffer***
  - Saturated buffers store water within the soil of field buffers by diverting tile water into shallow laterals that raise the water table within the buffer and slow outflow.
  - When the saturated buffer is operating, a water control structure directs a portion of the subsurface tile drainage water into the buffer rather than discharging directly to surface water.

9) Two-stage Ditches

- Drainage ditches that have been modified by adding benches that serve as floodplains within the overall channel. This results in a more sustainable ditch that restores some of the beneficial natural processes within the ditch environment while providing the drainage capacity necessary for production.

10) Wetlands

- Wetlands are areas that are wet at a frequency and duration sufficient to support vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas inland, along streams and along the coast.
- Wetlands are important because they provide services such as nutrient and sediment filtering, flood water retention, and wildlife benefits.
- The Ohio Department of Natural Resources (ODNR) is taking the lead using H2Ohio funds to identify opportunities for wetland development and restoration projects.

Additional Practices for Water Management Beyond H2Ohio Implementation

- Soil Health Initiatives for Increased Soil Organic Matter
- Structure for Water Control
- Water Retention and Detention Basins
- Cascading Waterways

Farmstead Structural BMPs — Including Manure Storage and Management

The structural practices listed below are those that are regularly funded under cost-share agreements through the EQIP program at Ohio-NRCS that also have potential water quality benefits. These are listed below according by *most dollars spent* (high to low) through Ohio's EQIP program to install these items (planning years 2016-2019).

The USDA-NRCS EQIP program should remain the primary funding source for these practices. Some of these practices (as noted below) could potentially be eligible for cost-share through ODA's WLEB Soil and Water Phosphorus Program and/or the H2Ohio program in future funding cycles.

- Waste Storage Facility (FOTG-313)
- Roofs and Covers (FOTG-367)
- Fence (FOTG-382)
- Watering Facility, Livestock Pipeline, Pumping Plant (FOTG 614, 516, 533)
- Heavy Use Area Protection (FOTG-561)
- Access Road (FOTG 560)
- Animal Mortality Facility (FOTG 316)
- Structure for Water Control (FOTG 587) (*This practice is also recommended to be funded by other sources)
- Roof Runoff Structure (FOTG 558)
- Waste Transfer (FOTG 634)
- Grassed Waterway (FOTG 587) (*This practice is also recommended to be funded by other sources)
- Waste Separation Facility (FOTG 632)
- WASCOB (FOTG 638) (*This practice is also recommended to be funded by other sources)

References

4R Nutrient Stewardship Certification. ***https://4rcertified.org/about/.***

Western Lake Erie Basin Phosphorus Reduction Programs. "The Voluntary Nutrient Management Plan Development Program." ***https://agri.ohio.gov/wps/portal/gov/oda/divisions/soil-and-water-conservation/resources/WLEB_Programs.***

Transforming Drainage. ***https://transformingdrainage.org/practices/saturated-buffers/.***

Jaynes, Reinhart, Hay, Isenhart, Jacquemin, Kjaersgaard, Nelson and Utt. "Questions and Answers about Saturated Buffers for the Midwest." Purdue Extension Bulletin ABE-160. ***https://www.extension.purdue.edu/extmedia/ABE/ABE-160.pdf.***

NRCS Soil Quality Institute. "Managing Soil Organic Matter: The Key to Air and Water Quality." Soil Quality Technical Note No. 5. August 2003. ***https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_050965.pdf.***

Conservation Drainage for the Midwest. ***https://engineering.purdue.edu/watersheds/conservationdrainage/ditch.html.***

Appendix C: Marginal Abatement Cost Curve for Phosphorus Reduction

I. Overview

Being able to track the expenditure of public and private dollars going toward nutrient reduction is critical to determining the effectiveness and efficiency of those expenditures. Improved coordination of where dollars go and improved accountability for results observed will be a high priority for Ohio.

To determine the right portfolio of practices, the state developed a data-driven marginal abatement cost curve. A marginal abatement cost curve is a tool for presenting pollution abatement options – in this case, agricultural best management practices (BMPs) – ranked by cost effectiveness relative to a baseline that represents a zero-cost option.

The cost curve combines scientific and economic research to assign a net cost per pound of potential total phosphorus (TP) reduction to each abatement intervention. Then, each practice is ordered from least to most expensive per pound to identify cost-efficient pathways to the phosphorus reduction target. Other factors related to implementation feasibility such as operational complexity, regulatory requirements, ease of adoption, and time horizon as well as potential for impact on dissolved reactive phosphorus (decreasing or increasing) were used to further prioritize the interventions. Figure C-1 is a generic example of a marginal abatement cost curve for purposes of illustration.

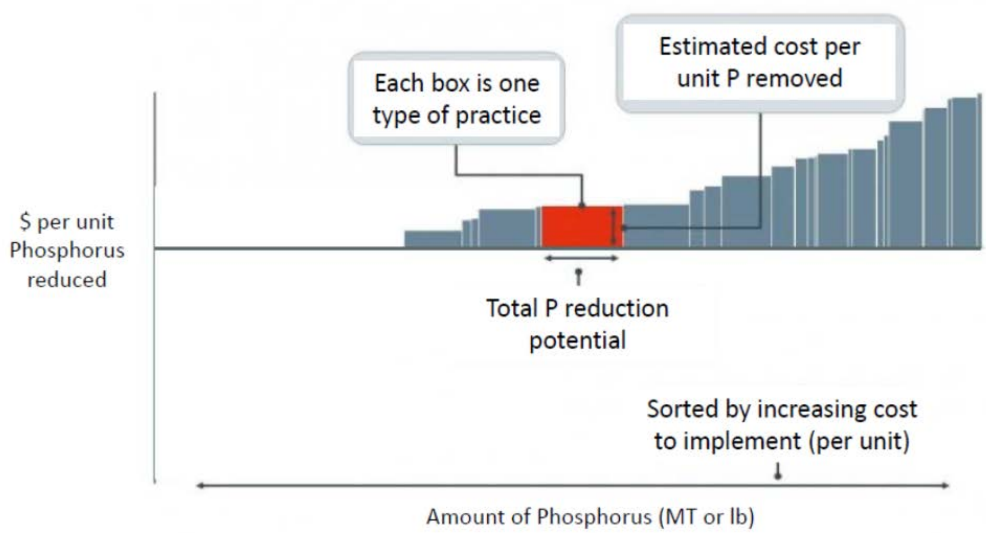


Figure C-1: Generic Marginal Abatement Cost Curve. The horizontal axis represents the amount of reductions being sought. Roughly speaking, the shorter and wider the boxes are, the more cost effective the abatement option is considered to be.

This sort of marginal abatement cost curve is based on business-oriented procedures for determining the cost effectiveness of production. The method was adapted in the 1980s and 1990s for pollution abatement. It is currently in use most notably to examine cost effectiveness and other fiscal implications of greenhouse gas reduction actions (for an example, see McKinsey 2009 or King County 2015; for literature reviews and critique, see Ekins et al. 2011 and Eorya et al. 2018).

In order to construct the cost curve, expert technical staff at Ohio Department of Agriculture (ODA) and Ohio EPA first compiled a list of approximately 100 phosphorus reduction practices that the State had been considering. A technical working team narrowed these 100+ practices down to a shorter list of 28 practices based on professional judgement of which were the most likely to be cost effective and suitable to northwest Ohio.

The shorter list of 28 BMPs was then assessed using the latest scientific and agronomic literature to develop estimates for three critical parameters: the cost of implementation, the phosphorus removal efficiency, and the applicability or amount of land or water where practice could be applied in the Maumee River basin. This information was used to calculate the load reduction possible for each practice as well as the cost per pound of (total) phosphorus of achieving that reduction. Other factors related to implementation feasibility such as operational complexity, regulatory requirements, ease of adoption and time horizon as well as potential for impact on dissolved reactive phosphorus (decreasing or increasing) were used to further modify the cost or expected reduction potential, or served as a basis for removing the practice from consideration. Then, each practice was ordered on a chart from least to most expensive per pound.

A target amount can be indicated on the horizontal axis of the chart for comparison. Practices that are to the left of the target amount are preferred, and theoretically represent the suite of practices and quantities of each that are needed to achieve the target reduction. Given the large degree of uncertainty around the estimates that go into this analysis, this is not intended as a projection of the result but rather a hypothetical potential. Figure C-2 shows the charted results of the cost curve analysis. The calculations of each of these is presented in graphical form in section II of this appendix (below).

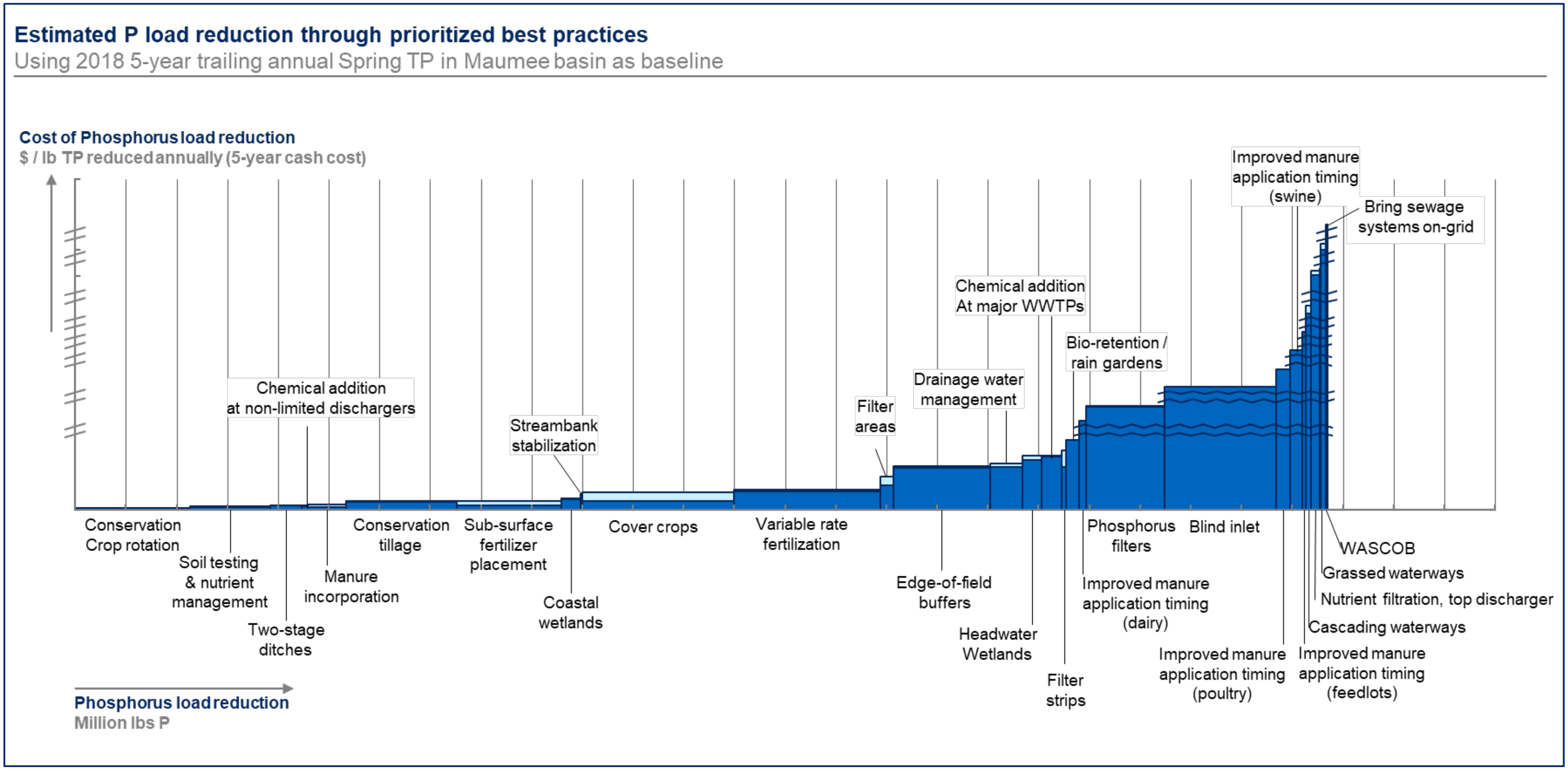
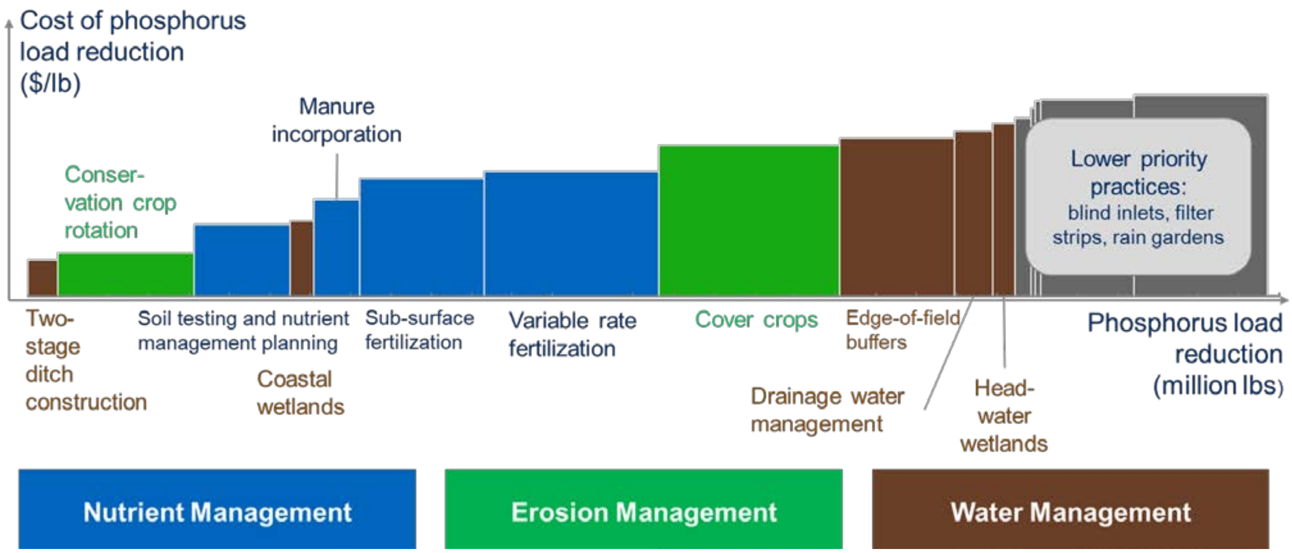


Figure C-2: Cost curve showing relative cost of phosphorus load reduction and extent of possible load reduction for identified best management practices, sorted from low to high cost. The width of each bar indicates the amount of phosphorus reduction that can be achieved with a practice and the height indicates the cost per lb of total phosphorus reduced. Dark blue are one-time costs to install, and light blue are recurring annual costs (for initial five years).

The results of this exercise reveal that the majority of the TP reduction target could be achieved by focusing on ten cost-efficient practices (the ones presented in Appendix B), which will form the focus of initial H2Ohio nutrient reduction spending, see Figure C-3.



FigureC-3: Marginal Abatement Cost Curve for H2Ohio Interventions. The vertical axis is dollars per pound of TP reduction. The horizontal axis is pounds of TP potentially reduced if the BMP is applied at reasonable rates of adoption.

There are some caveats to using this methodology, as described in Ekins et al. 2011. The ones most applicable to the current exercise include: difficulty incorporating ancillary benefits (such as the wildlife habitat benefits of wetlands); difficulty factoring in interactions between multiple BMPs located in proximity or on the same site (which may result in greater, or more likely less, reductions than expected); and difficulty depicting uncertainty.

There might not be the same cost effectiveness (the same reduction potential) if more than one practice is applied to control runoff on a single field/area. For example, an individual field could have soil tests and subsurface placement with variable rate equipment, and then cover crops in the off season. The effect of this is not completely additive; there is a limit to how much phosphorus reduction would occur across the field. If there is also a structural practice downstream, it will not have the expected percent reduction either, since the input will already be reduced. In the Maumee River basin, we know we will need widespread adoption of practices. Because of this, there is certainly the possibility, perhaps even a likelihood, that some areas will see a lot of overlap. This could be one way in which ramped up adoption may not result in expected reductions. Since research generally focuses on single interventions in order to control the number of variables, this is another area where additional research could provide insight.

An attempt has been made to provide ranges of costs and effectiveness for each practice. Although the charts depict a specific level (that reflects the mean value), it is possible to look at the information collected for each practice and determine how wide the range is compared to the mean value. In order to keep the charts simpler to read, we have not attempted to graph the range values, but that could be done in the future. It may also be possible to better model the uncertainty for some practices that have more information available (Eorya et al. 2018 suggest a Monte Carlo analysis).

Importantly, the cost curve is intended to be a living tool. As BMPs are implemented, the cost curve will be updated and refined to reflect the most recent on-the-ground data for costs and expected phosphorus reductions. It will also be possible to adjust expectations for applicability.

References

Ekins P., Kesicki, F., Smith, A.Z.P. 2011. "Marginal Abatement Cost Curves: A Call for Caution." UCL Energy Institute.

Eorya, V., Pellerin, S., Garcia, G.C., Lehtonen, H., Licite, I., Mattila, H., Lund-Sørensen, T., Muldowney, J., Popluga, D., Strandmark, L., Schulte, R. "Review: Marginal Abatement Cost Curves for Agricultural Climate Policy: State-of-the-art, Lessons Learnt and Future Potential." Journal of Cleaner Production. Volume 182, 1 May 2018, Pages 705-716.

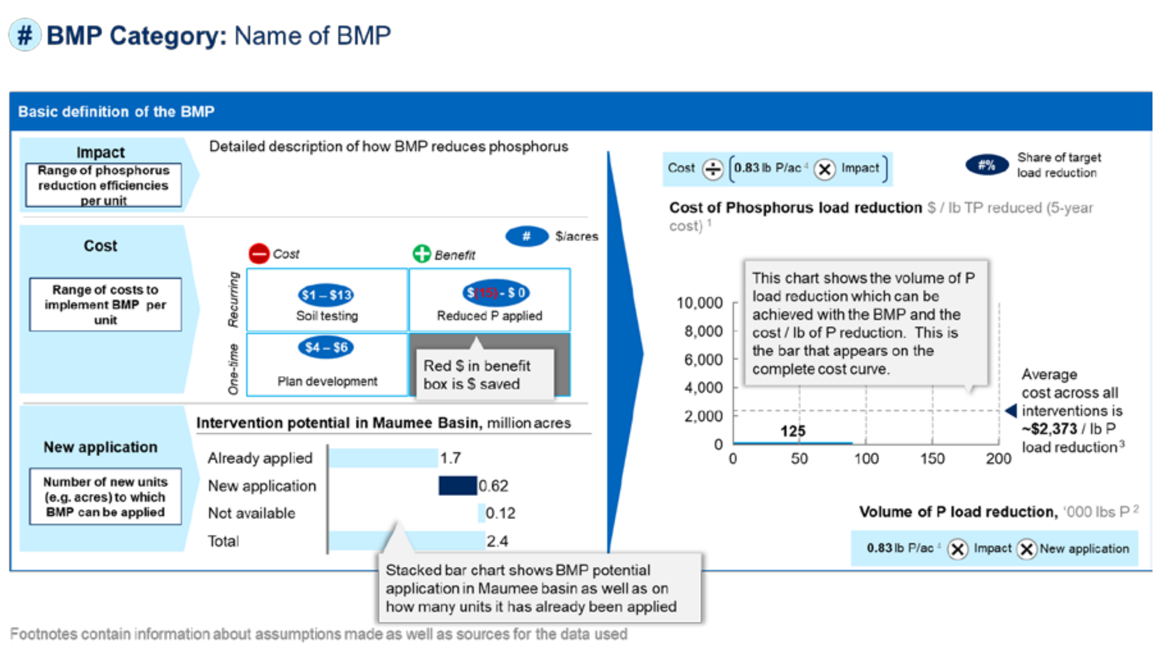
McKinsey & Company. 2009. "Pathways to a Low-Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve."

King County Strategic Climate Action Plan. November 2015. Accessed Dec. 20, 2019. ***https://your.kingcounty.gov/dnrp/climate/documents/2015_King_County_SCAP-Full_Plan.pdf***.

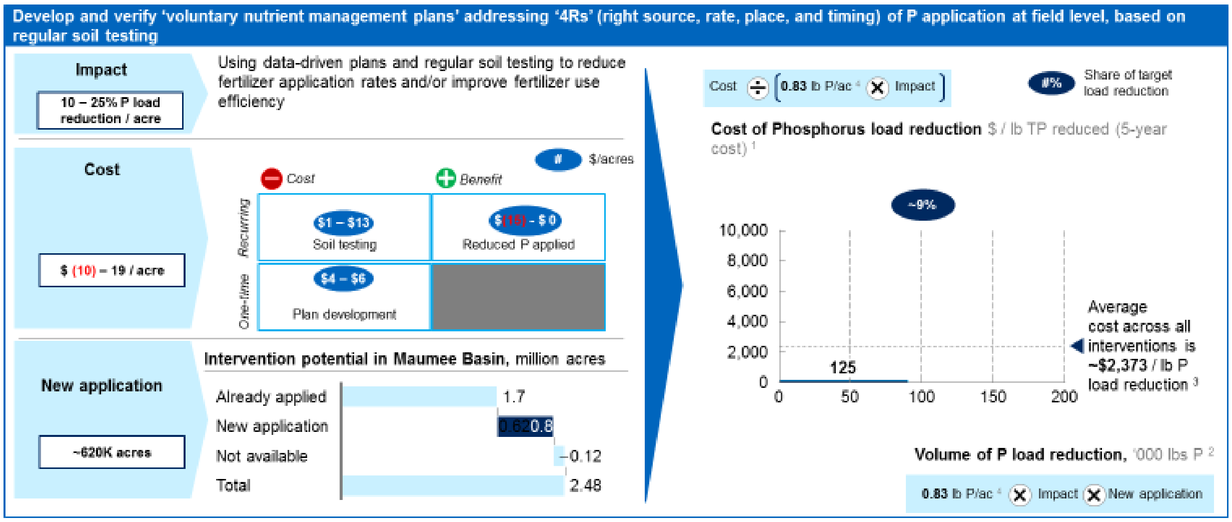
II. Cost Curve Data for 20 Select BMPs

An in-depth analysis of the top twenty identified BMPs was performed as a part of the cost curve exercise to combine scientific and economic research in prioritizing practices. Three main elements form the basis for the cost curve: cost, impact and applicability. A brief summary of these elements can be found below. The remainder of this Appendix contains the BMP analysis summaries, including the numbers that went into the cost curve as well as the sourcing of that data.

Cost curve element	Description	Unit
Cost	Cost of implementing and maintaining given intervention	$ / lb P load reduced
×		
Impact	Share of P load the intervention reduces	% P load reduced per unit (i.e., acre)
×		
Applicability	Incremental units to which interventions can be applied	# incremental units (i.e., acre)



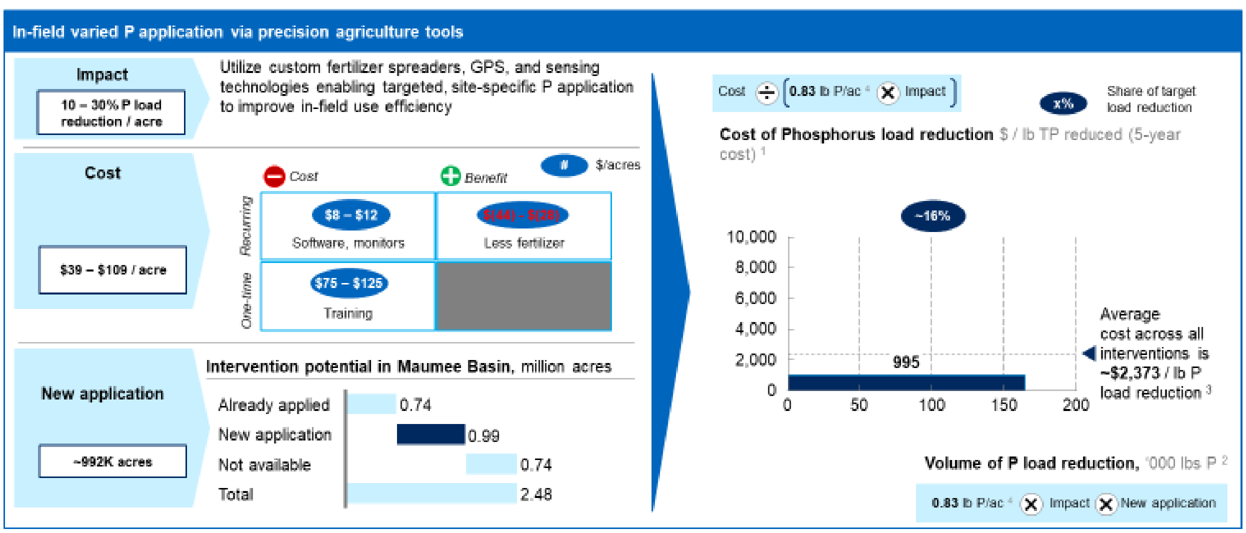
1 Nutrient management: Soil testing & nutrient management planning



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land

SOURCE: For [Cost] and [Impact] Preliminary estimates from "The Agricultural BMP Handbook for Minnesota" and "Chesapeake Assessment Scenario Tool", OSU "Nutrient Management Plan", refined via ODA internal estimates; [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

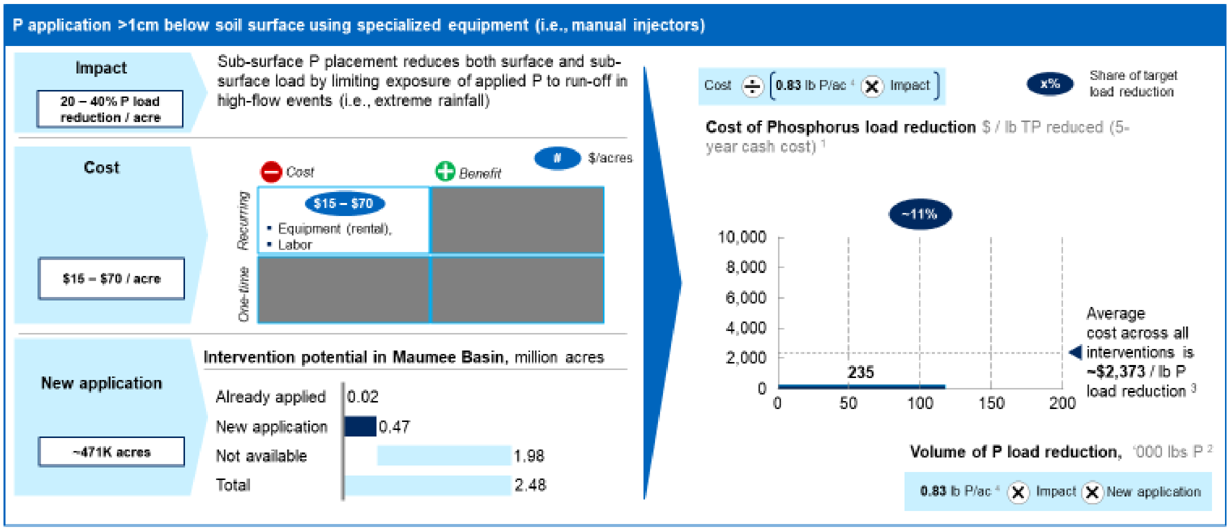
2 Nutrient management: Variable rate fertilization



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land; 5 Likely inclusive, rather than incremental, to 'soil testing & nutrient management planning'

SOURCE: For [Cost] and [Impact] Preliminary estimates from the Chesapeake Bay Program (2019), US EPA STEPL/Region 5 "BMPList", and "Chesapeake Assessment Scenario Tool", refined via ODA internal estimates; [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

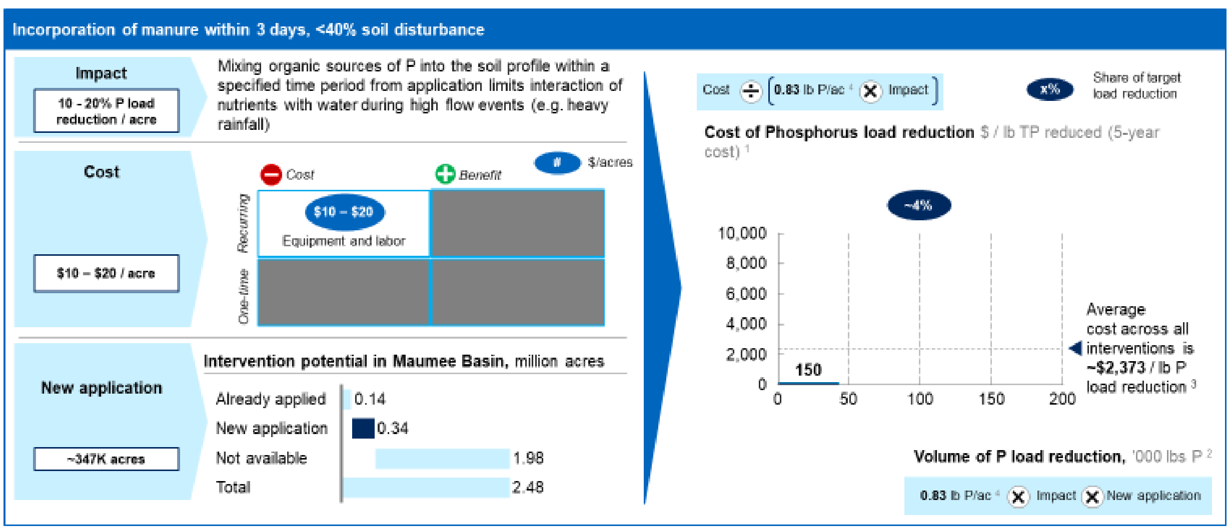
3 Nutrient management: Sub-surface fertilizer placement



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land

SOURCE: For [Cost] and [Impact] Preliminary estimates from ODA Estimate; Ohio EPA (2019), "Draft - Evaluating Management Options to Reduce Lake Erie Algal Blooms with Models of the Maumee Watershed"; University of Michigan Water Center, "Informing Lake Erie Agriculture Nutrient Management"; "Executive Summary – Iowa Science Assessment of Nonpoint Source Practices to Reduce Nitrogen and Phosphorus Transport in the Mississippi River basin" (2013). [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

4 Nutrient Management: Manure incorporation



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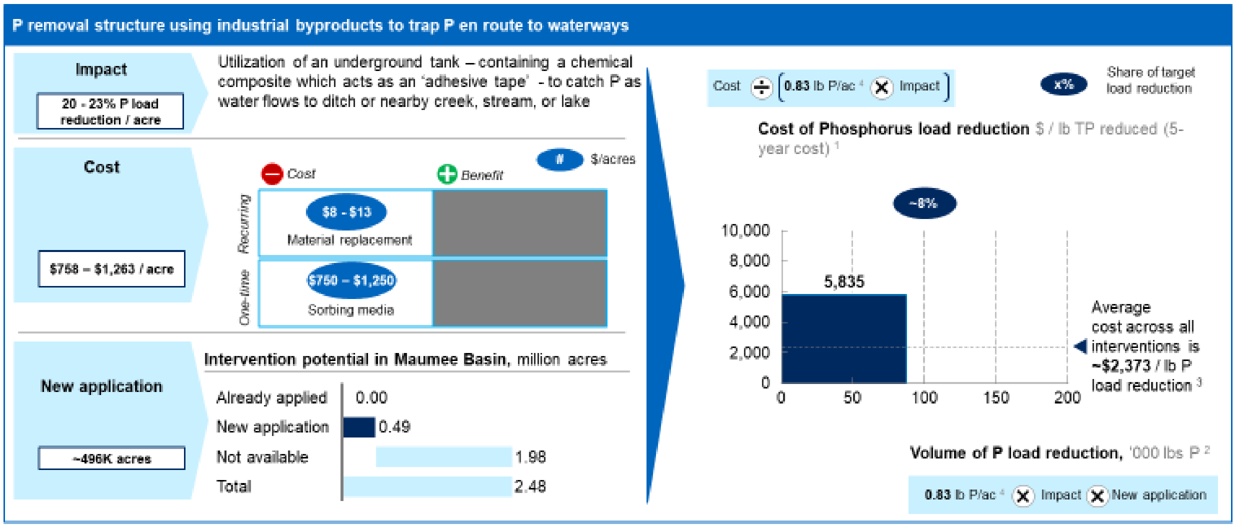
SOURCE: For [Cost] and [Impact] Preliminary estimates from Chesapeake Bay Program (2019), "Chesapeake Assessment Scenario Tool"; [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

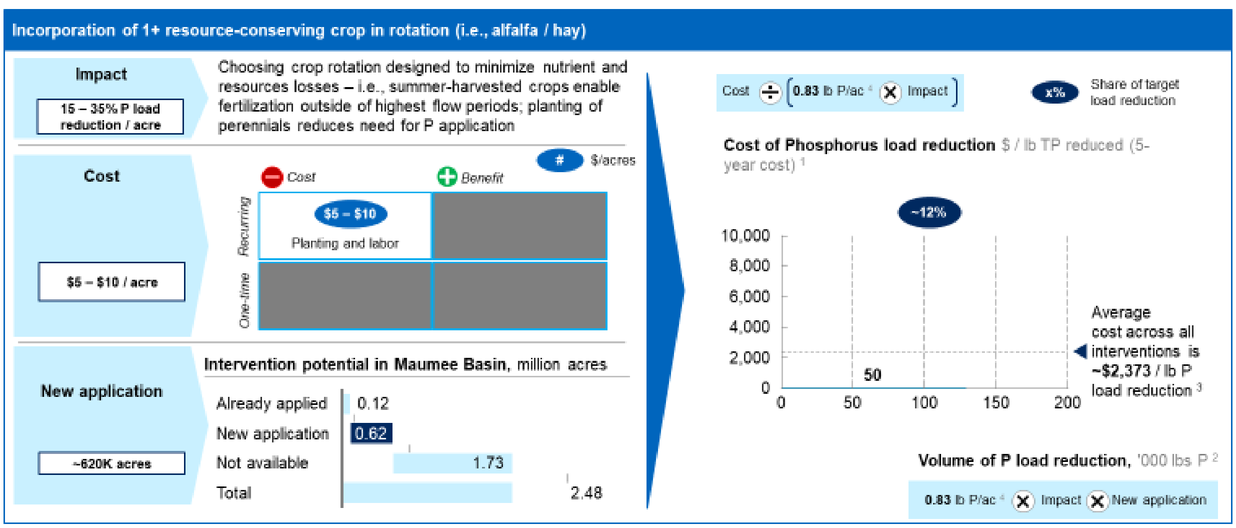
5 Nutrient Management: Phosphorus filters



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recuring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land; 5 Application of Phosphorus filters on single acre results in treatment of ~20 acres, on average

SOURCE: For [Cost] and [Impact] Preliminary estimates from BalticSea 2020, "Ditch dams and filters to trap phosphorus in agriculture" (article); [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

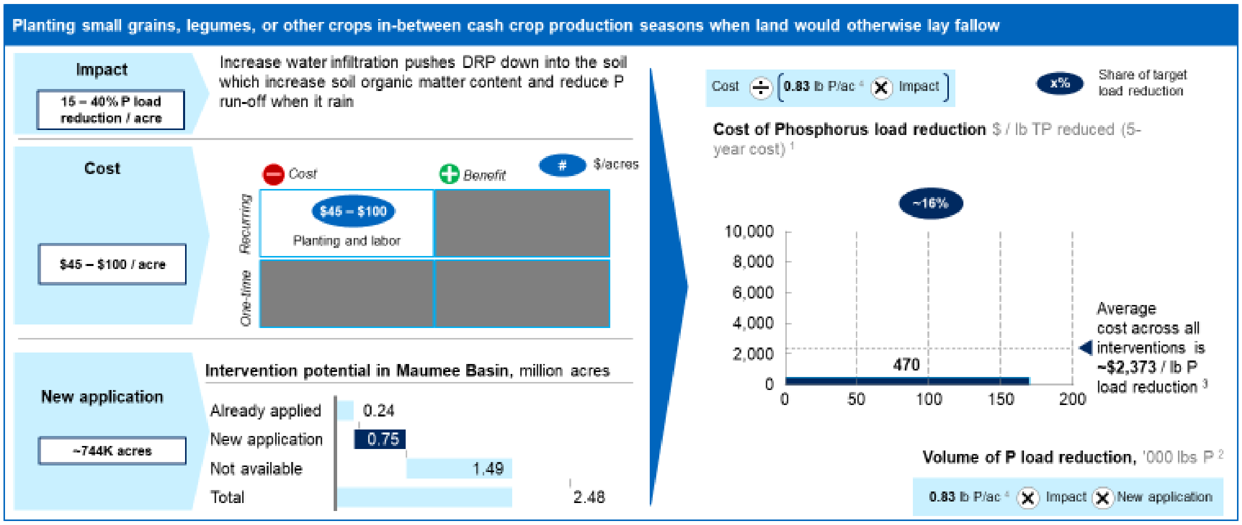
6 Erosion Management: Conservation crop rotation



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recuring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land

SOURCE: For [Cost] and [Impact] Preliminary estimates from Iowa State University, "Executive Summary - Iowa Science Assessment of Nonpoint Source Practices to Reduce Nitrogen and Phosphorus Transport in the Mississippi River Basin" (2013); US EPA, STEPL/Region 5 "BMPList"; University of Michigan Water Center; ; [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

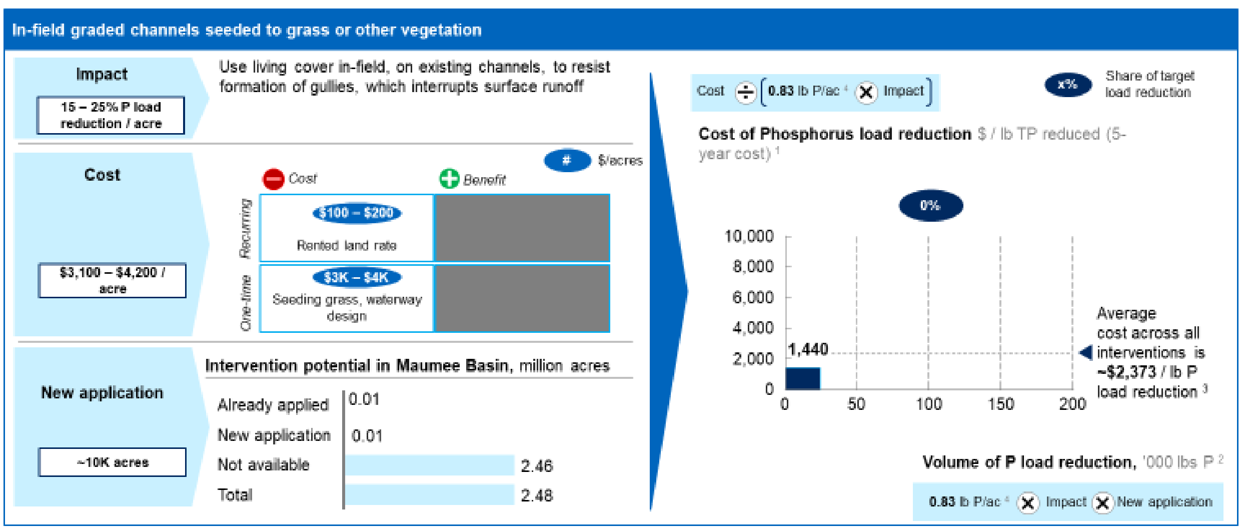
7 Erosion Management: Cover crops



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land

SOURCE: For [Cost] and [Impact] Preliminary estimates from Iowa State University, "Executive Summary - Iowa Science Assessment of Nonpoint Source Practices to Reduce Nitrogen and Phosphorus Transport in the Mississippi River Basin" (2013); US EPA, STEPL/Region 5 "BMPList"; University of Michigan Water Center, "Informing Lake Erie Agriculture Nutrient; Goldman-Carter, J. & Bryant, L. (2016); [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

8 Erosion Management: Grassed waterways



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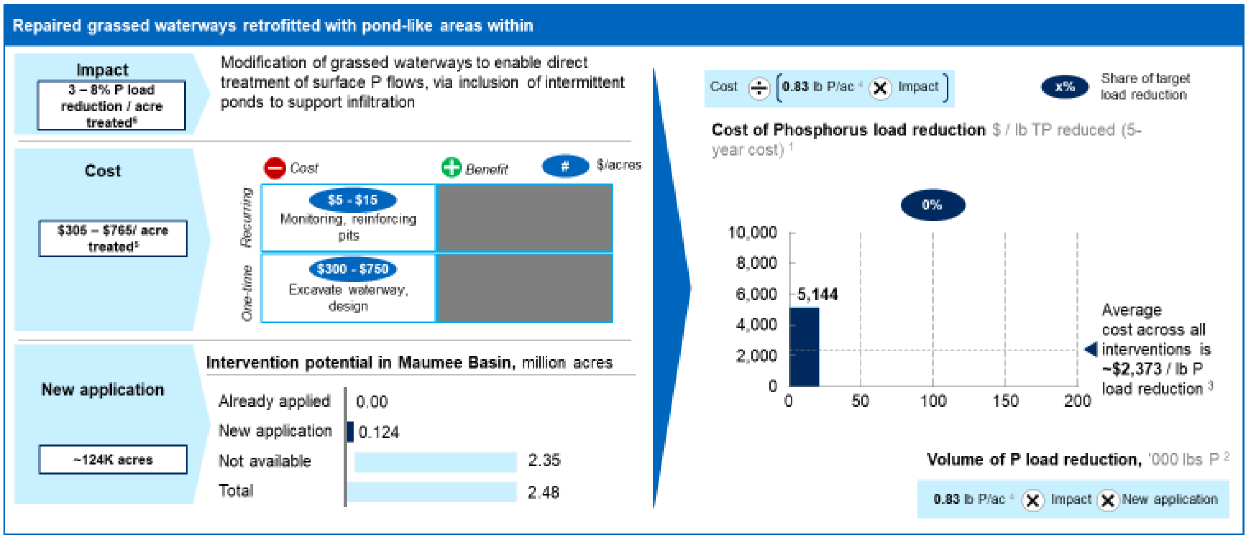
SOURCE: For [Cost] and [Impact] Preliminary estimates from The Agricultural BMP Handbook for Minnesota; Rush Creek Headwaters SWA (2018) ; [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

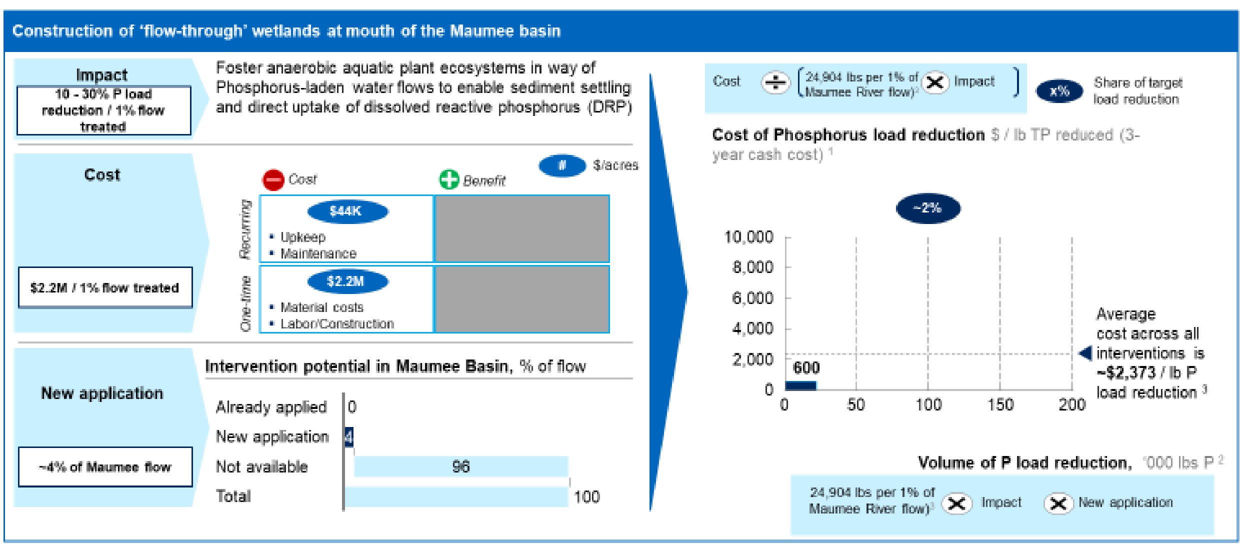
9 Erosion Management: Cascading waterways



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recuring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land; 5 Application of cascading waterways on single acre results in treatment of ~20 acres, on average; 6 incremental to impact of grassed waterways

SOURCE: For [Cost] and [Impact] Preliminary estimates from ODA estimates; [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

10 Wetlands: Coastal flow-through wetlands (created)

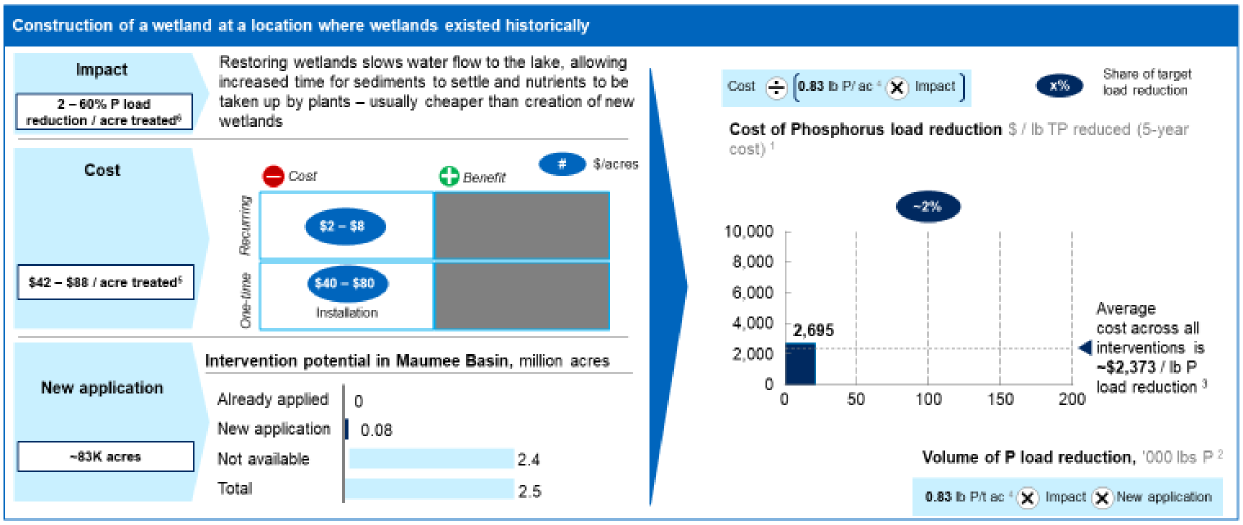


1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recuring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 load per acre (5yr trailing average) in Maumee basin on agricultural land

SOURCE: For [Cost] and [Impact] Preliminary estimates from ODNR, incl. project-specific estimates appraised; Ohio EPA (2019), "Draft - Evaluating Management Options to Reduce Lake Erie Algal Blooms with Models of the Maumee Watershed"; [Incremental implementation] estimates consider budgeted projects from ODNR

29

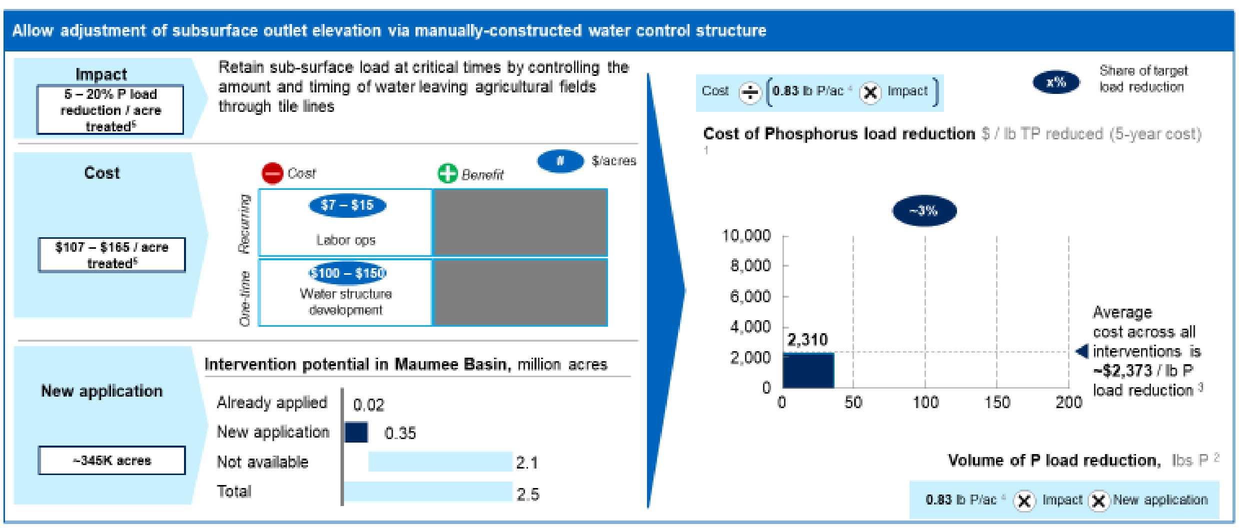
11 Wetlands: Wetlands restoration (inland)



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land; 5 Single acre of wetlands estimated to treat ~50 acres, on average; 6 Considered inclusive, rather than incremental, of base load reduction from non-functioning or pre-existing wetlands'

SOURCE: For [Cost]: Ohio EPA (2019), "Draft - Evaluating Management Options to Reduce Lake Erie Algal Blooms with Models of the Maumee Watershed"; Chesapeake Bay Program (2019), "Chesapeake Assessment Scenario Tool" and [Impact]: US Army Corps of Engineers Review, "Wetlands for Phosphorus Reduction in Great Lakes Watersheds" (2017); "Arkansas BMP Tool" (reproduced from Table 2, Merriman, 2009); Chesapeake Bay Program (2019), "Chesapeake Assessment Scenario Tool"; The Agricultural BMP Handbook for Minnesota; [Incremental implementation] estimates are illustrative and to be refined.

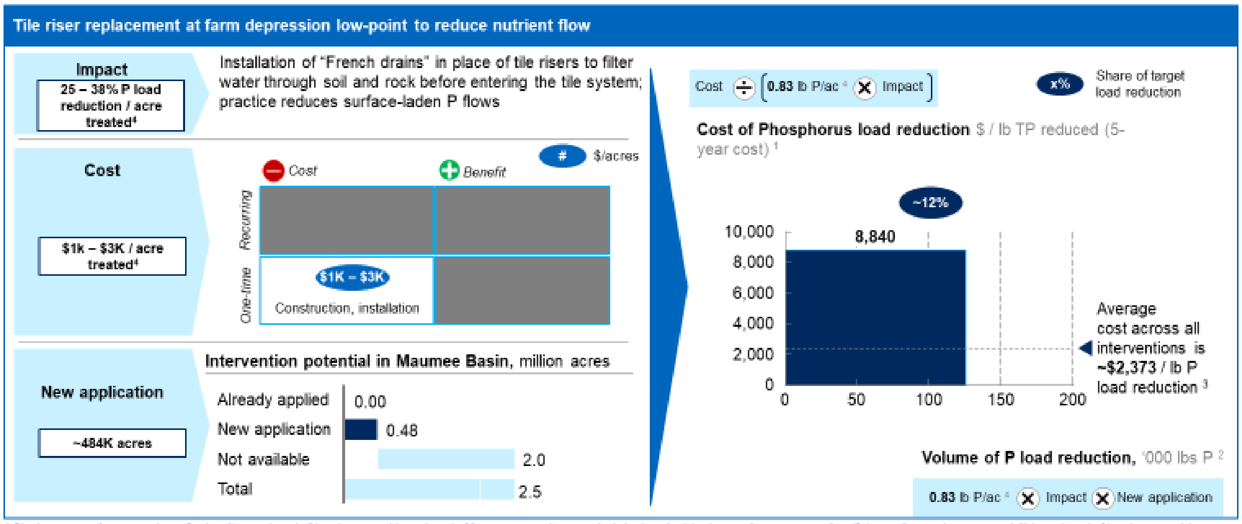
12 Hydraulic Retention / Detention: Drainage water management



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land; 5 For every acre on which drainage water management structures are applied, ~20 acres are treated, on average

SOURCE: For [Cost]: USDA NRCS 'Cost Scenarios'; For [Impact] Rush Creek Headwaters SWA (2018); "Executive Summary - Iowa Science Assessment of Nonpoint Source Practices to Reduce Nitrogen and Phosphorus Transport in the Mississippi River Basin" (2013); Williams, M.R., King, K.W., & Fausey, N.R. (2016); Needelman, B.A., Kleinman, P.J.A., Strock, J.S., & Allen, A.L. (2007); Skaggs, R.W., Breve, M.A., & Gilliam, J.W. (2009); Refined via ODA and OEPA experts; [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

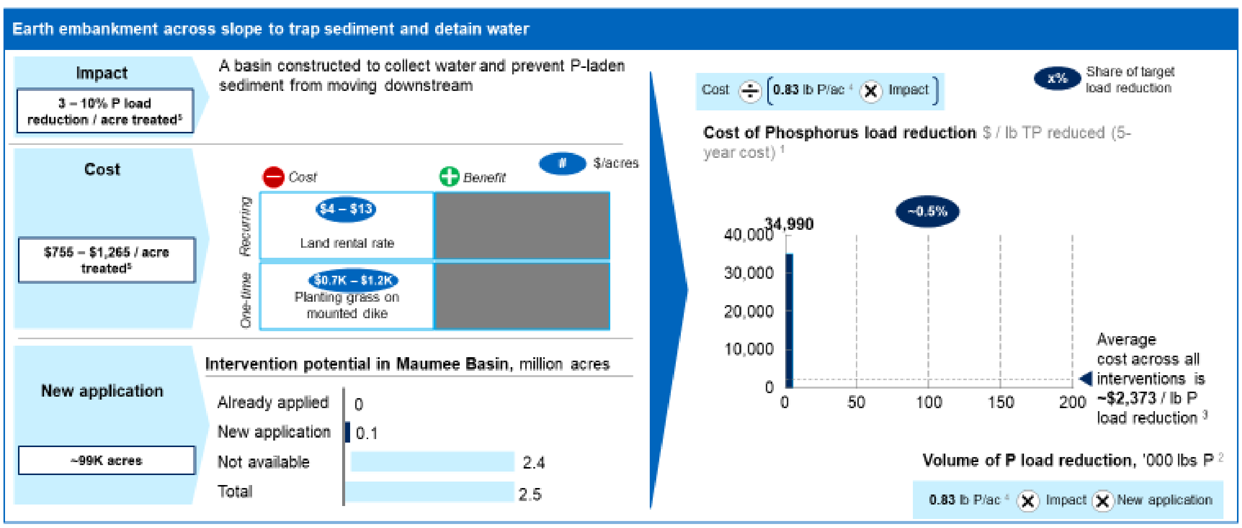
13 Hydraulic Retention / Detention: Blind inlet



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land; 4 For every acre applied, blind inlets are estimated to treat ~10 acres

SOURCE: For [Cost] and [Impact] Preliminary estimates from Gupta et al (2018), "Evaluating WASCoBs, Vegetative Filter Strips, and Road-side Ditches in a Rural Watershed"; Ohio Phosphorus Task Force (2012), "Significance of Tile Drainage as a Conduit for Phosphorus Transport"; Gupta et al (2018), "Evaluating WASCoBs, Vegetative Filter Strips, and Road-side Ditches in a Rural Watershed"; Significance of Tile Drainage as a Conduit for Phosphorus Transport" >; [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

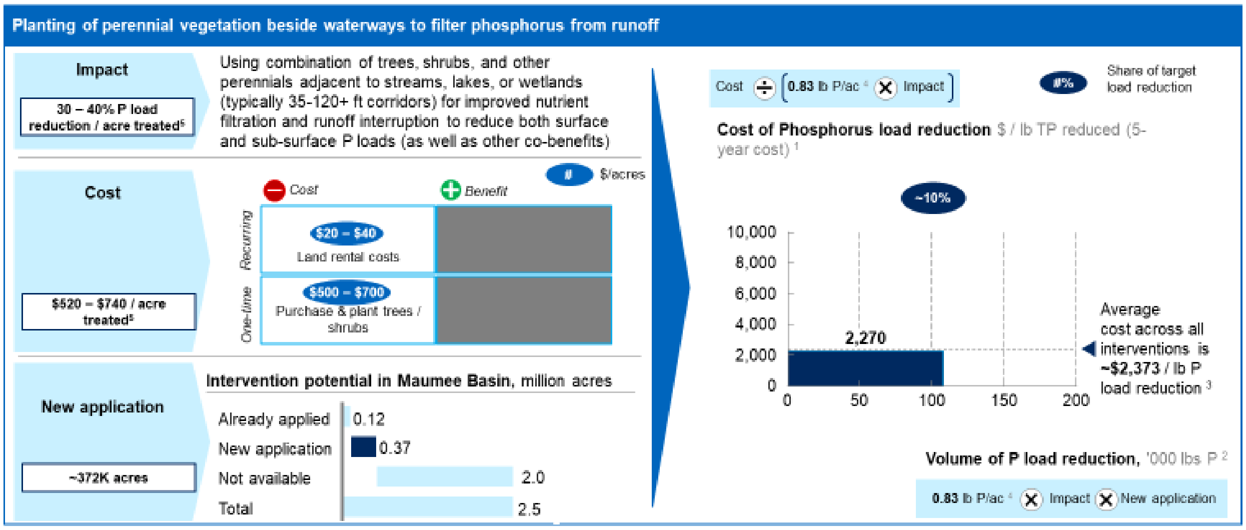
14 Hydraulic Retention / Detention: Water and sediment control basin (WASCOB)



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land; 5 Application of WASCOB on single acre results in treatment of ~20 acres, on average

SOURCE: For [Cost] and [Impact] Stinner et al (2018), "Instrumentation, Measurement, and Findings from the USDA-ARS Edge-of-Field Research Network"; Williams et al (2013), "Drainage water management effects on tile discharge and water quality" refined via ODA and OEPA experts; [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

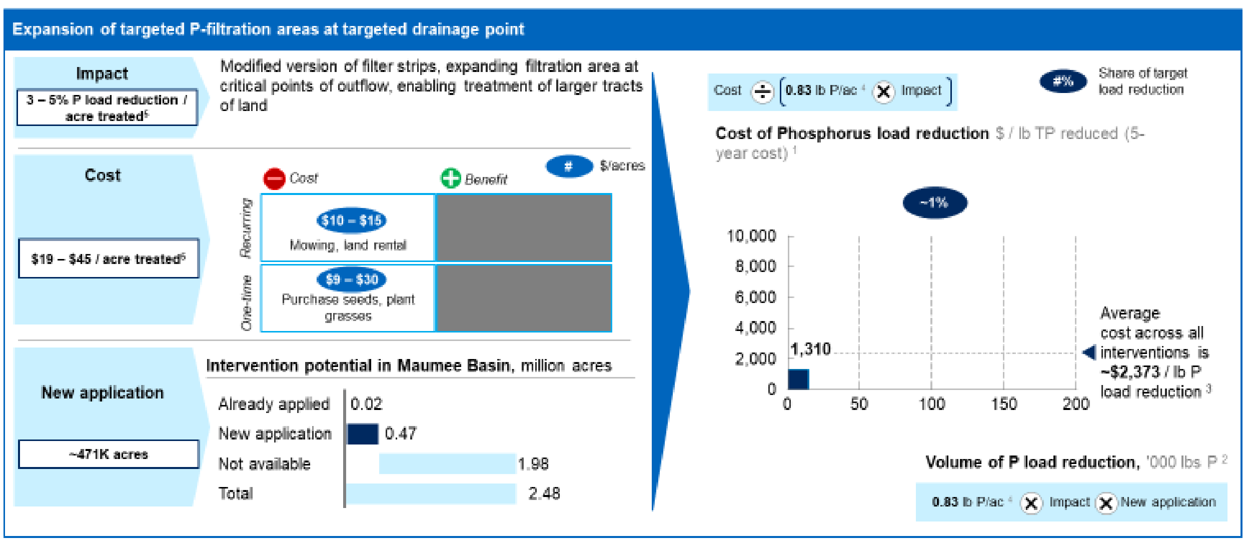
15 Edge-of-field buffers: Riparian forest buffers



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land; 5 Application of riparian forest buffer on single acre results in treatment of 2-3 acres, on average

SOURCE: For [Cost] and [Impact] Preliminary estimates come from The Agricultural BMP Handbook for Minnesota; US EPA, STEPL/Region 5 "BMPList"; [Incremental implementation] with refinement driven from ODA estimates and academic literature (OSU)

16 Edge-of-field buffers: Filter areas



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land; 5 Application of filter areas on single acre results in treatment of ~20 acres, on average (~50 acres per square mile treatment)

SOURCE: For [Cost] and [Impact] Preliminary estimates are from ODA; [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

17 Edge-of-field buffers: Filter strips

Herbaceous vegetation areas near waterways removing P from overland flow

Impact

30 – 43% P load reduction / acre

Herbaceous coverage – typically grasses, sedges, ferns, legumes, etc. which may tolerate intermittent flooding – reduces sediment and flow into ditches and streams

Cost

$370 – $900 / acre

$/acres

	Cost	Benefit
Recurring	$200 – $300 Mowing, land not rented	
One-time	$170 – $600 Purchase seeds, plant grasses	

New application

~18K acres

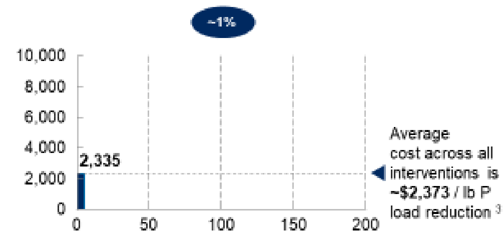
Intervention potential in Maumee Basin, million acres

Already applied	0.03
New application	0.02
Not available	2.43
Total	2.48

Cost ÷ (0.83 lb P/ac[4] × Impact)

#% Share of target load reduction

Cost of Phosphorus load reduction $ / lb TP reduced (5-year cost)[1]



Volume of P load reduction, '000 lbs P[2]

0.83 lb P/ac[4] × Impact × New application

1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land

SOURCE: ODA expert insights; Helmers et al, "Buffers and vegetative filter strips"

18 Stream management: Two-stage ditch construction

Installation of two-stage ditches to restore floodplain access

Impact

5 – 30% P load reduction / Lineal ft

Constructed ditches slow down and spread out water during periods of high flow. This and vegetation placed throughout the channel helps retain a greater proportion of sediments and nutrients.

Cost

$3 - $18/ Lineal ft

	Cost	Benefit
Recurring		
One-time	$3 – 18	

New application

~327K Lineal ft

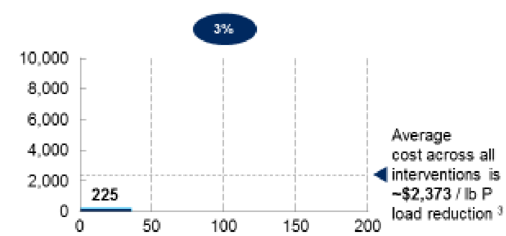
Intervention potential in Maumee Basin, lineal feet

Already applied	0.00
New application	0.13
Not available	3.03
Total	3.27

Cost ÷ (0.83 lb P/Lineal ft[4] × Impact)

#% Share of target load reduction

Cost of Phosphorus load reduction $ / lb TP reduced (5-year cost)[1]



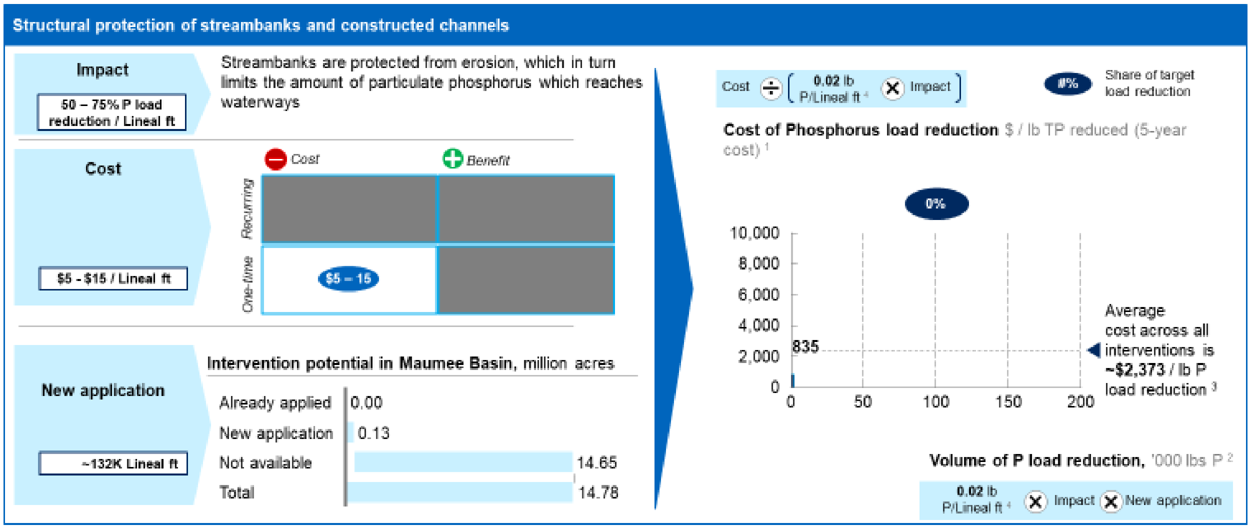
Volume of P load reduction, '000 lbs P[2]

0.83 lb P/Lineal ft[4] × Impact × New application

1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land

SOURCE: For [Cost] and [Impact] estimates from Indiana, "Recommended Measures & Estimated Load Reductions" and Clary et al, "Stream Restoration BMP Database"; US EPA, STEPL/Region 5 (bottom-up modeling); [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

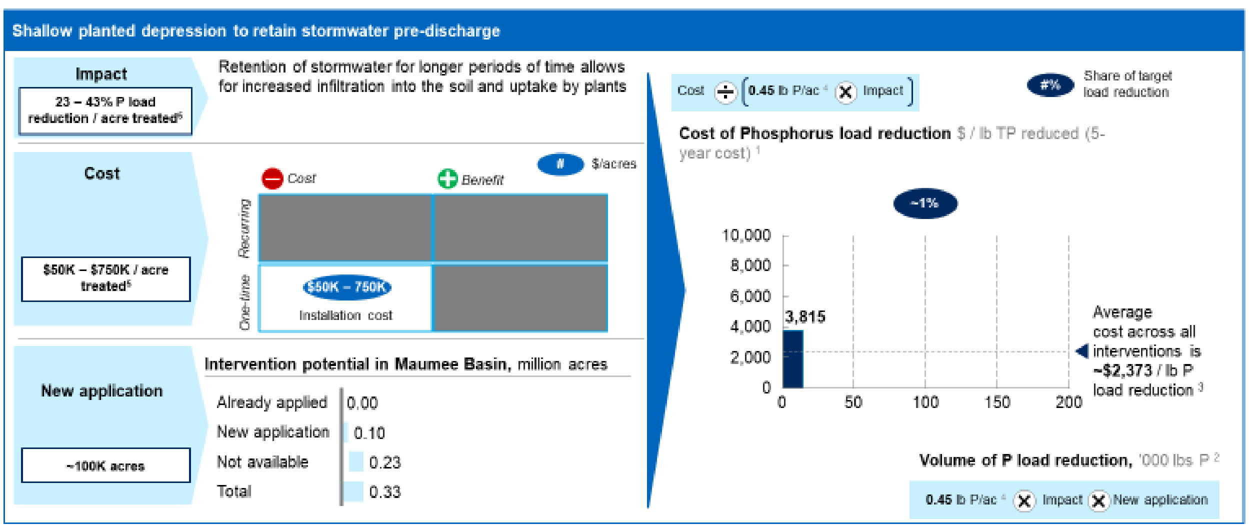
19 Stream management: Streambank stabilization



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land

SOURCE: For [Cost] and [Impact] estimates from Indiana, "Recommended Measures & Estimated Load Reductions"; Clary et al, "Stream Restoration BMP Database"; Open Channel / Two-Stage Ditch (NRCS 582) via USDA; [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

20 Green infrastructure: Bio-retention / rain gardens



1 Simple average of two scenarios, reflecting (i) upper bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs, and (ii) lower bound of 'cost' range and lower bound of 'impact range, where cost includes 'one-time' implementation costs, as well as (5x) annually-recurring costs; 2 Simple average of two scenarios, reflecting (i) lower bound and (ii) upper bound of 'impact' range; 3 Simple average of "Cost of Phosphorus load reduction" for ~20 most cost-efficient practices towards target load reduction; 4 Baseline Spring TP load per acre (5yr trailing average) in Maumee basin on agricultural land; 5 For each acre on which bio-retention / rain gardens are applied, ~20 acres are estimated to be treated, on average

SOURCE: For [Cost] and [Impact] Chesapeake Bay Program (2019), "Chesapeake Assessment Scenario Tool"; US EPA, STEPL/Region 5 "BMPList"; Refined through ODA and OEPA expert insights; [Incremental implementation] estimates driven from ODA estimates and academic literature (OSU)

Appendix D: State Agricultural Programs

All program documents in this Appendix are final as of 1-23-2020.

H2Ohio

1. Voluntary Nutrient Management Plan Development & Implementation

Purpose

1. To encourage agricultural producers to develop and submit a four-year voluntary nutrient management plan to the local SWCD Board of Supervisors for approval
2. To increase producer collection and use of soil test results to develop nutrient recommendations
3. To properly utilize commercial fertilizer, manure and/or organic by-products as a plant nutrient source or soil amendment
4. To reduce agricultural nonpoint source pollution of surface water and groundwater resources

Applicability

Applies to cropland acres in the 14-county project area. Acres receiving payment under any other county, state or federal program (CSP, EQIP, etc.), are not eligible.

Specifications

1. Voluntary Nutrient Management Plans (VNMP) developed through this program must meet the minimum requirements set forth in ORC 905.31(DD)
2. VNMP may be developed by a 4R Certified Ag Retailer, Certified Crop Advisor (CCA), Soil and Water Conservation District (SWCD), or producer
3. Plans must be reviewed and approved by the local SWCD Board of Supervisors or director's designee
4. Producers utilizing a 4R Certified Ag Retailer, who is a director's designee, will need to submit their nutrient management plan to the local SWCD
5. Average yield goals shall be used for phosphorus and potassium fertilizer recommendations

Technical Responsibilities

Producer Responsibilities

1. For VNMP not developed by SWCD, submit completed VNMP to SWCD for review and or approval
2. For VNMP developed by SWCD, provide soil test reports, crop rotation, yields, proposed nutrient sources, and timing of nutrient application to SWCD
3. Make nutrient application records available to the SWCD for review and compliance with VNMP

H2Ohio

2. Variable Rate Phosphorus Application

Purpose

1. To maximize nutrient use efficiency
2. To budget, supply, and conserve nutrients for plant production
3. To minimize risk of agricultural nonpoint source pollution of surface water and groundwater resources
4. To maintain or improve the physical, chemical, and biological condition of soil

Applicability

Applies to cropland acres in the 14-county project area. Acres receiving payment under any other county, state or federal program (CSP, EQIP, etc.) are not eligible.

Specifications

1. The producer has an approved Voluntary Nutrient Management Plan (VNMP)
2. Grids may be no greater than six acres, zones may be no greater than 12 acres
3. All phosphorus nutrients will be variable rate applied, consistent with prescription provided
4. Phosphorus prescriptions and applications shall not exceed two-year crop recommendations
5. Producer is eligible for payment in fields where phosphorus variable rate application is completed
6. If prescription calls for no phosphorus application, that field is not eligible for variable rate application
7. Broadcast applications of wheat starter are ineligible
8. A geo-referenced as-applied map will be submitted to the local SWCD
9. Producers may apply for up to four years of funding for this practice

Technical Responsibilities

Producer Responsibilities

1. Provide VNMP to SWCD
2. Provide SWCD with documentation of how the variable rate application will be accomplished (nutrient application equipment, custom applicator, proposed ag retailer)
3. Provide geo-referenced as-applied nutrient application map to SWCD for review annually

3. Subsurface Phosphorus Replacement

Purpose

1. To encourage agricultural producers to utilize nutrient application equipment that places nutrients below the soil surface
2. To reduce risk of agricultural nonpoint source pollution of surface water and groundwater resources

Applicability

Applies to cropland acres in the 14-county project area. Acres enrolled in Manure Incorporation are not eligible for Subsurface Fertilizer Placement. Acres receiving payment under any other county, state or federal program (CSP, EQIP, etc.) are not eligible.

Specifications

1. The producer has an approved Voluntary Nutrient Management Plan (VNMP) with the local SWCD
2. Producer must provide detailed plan of fertilizer and placement equipment to be used to achieve program requirements
3. For the length of the agreement, all phosphorus will be placed a minimum of two inches below the surface for each acre contracted
   a. Phosphorus rates shall not exceed more than two years Tri-State Fertilizer Recommendation
   b. Phosphorus may be placed in multiple applications, if the total amount does not exceed VNMP
   c. Wheat starter at removal rate is exempt from the placement requirement, however, no placement payment will be made for that crop year
4. Subsurface placement equipment includes, but is not limited to; planter, sidedress, strip-till or nutrient placement toolbars
5. Broadcasting and incorporation of phosphorus is not eligible
6. Producers will only be paid for acres on which fertilizer is prescribed and applied in accordance with Tri-State Fertilizer Recommendations
7. Potassium may be broadcast
8. Producers may apply for up to four years of funding for this practice

Technical Responsibilities

Producer Responsibilities

1. Provide VNMP to SWCD
2. Provide SWCD with documentation of how the nutrient placement will be accomplished (nutrient application equipment, custom applicator, proposed ag retailer)
3. Provide as-applied nutrient application documentation to SWCD for review annually

H2Ohio

4. Manure Incorporation

Purpose

1. To encourage the application and incorporation of manure into a growing crop or to apply manure in the late summer to early fall timeframe
2. To better utilize nitrogen and phosphorus contained in manure
3. To reduce the risk of manure and nutrient runoff

Applicability

Applies to cropland acres in the 14-county project area. Acres enrolled in Subsurface Fertilizer Placement are not eligible for Manure Incorporation. Acres receiving payment under any other county, state or federal program (CSP, EQIP, WL Small Grains, etc.) are not eligible.

Specifications

1. Producer must provide a nutrient management plan consistent with Ohio NRCS 590 Standard
2. Manure application is consistent with the requirements established in Ohio NRCS 590 Standard
3. Manure cannot be surface applied to frozen, snow-covered or saturated soils
4. Manure cannot be surface applied when the local weather forecast for the application area contains greater than a 50% chance of precipitation exceeding one-half inch in a 24 hour period
5. Fields receiving manure must have soil tests showing Bray P1 levels of 50 ppm or less. Grid sampled fields must have an average Bray P1 soil test phosphorus of 50 ppm or less (Mehlich-III soil test level of 70 ppm or less)
6. Manure applied for this practice must originate in the county of application or from within the Maumee watershed
7. Manure application must be accomplished consistent with one of the following methods and timing
    a. Manure is applied via side dress injection to a growing corn crop after emergence
    b. Manure is surface applied to a growing corn crop after emergence and incorporated using a row cultivator within 24 hours of application
    c. Manure is surface applied after the harvest of a small grain and incorporated within 24 hours of application; furthermore, all incorporation shall be completed prior to October 15
    d. Manure is injected directly into the soil through a strip-till toolbar or similar tool with minimal surface disruption after harvest and prior to October 15
8. All manure will be placed a minimum of two inches below the surface
9. Surface applied manure must be incorporated using a full-width disturbance tillage tool to mix the manure with the soil
10. A cover crop is required for manure applications completed after July 1 and where a growing crop is not present
11. If an overwintering cover crop is used, the producer may also be eligible for the Overwintering Cover Crop practice
12. Plant available nitrogen applied through the manure shall not exceed the nitrogen recommendations for the existing crop or the following years planned crop, whichever is applicable. If the following crop is a legume, nitrogen can be applied at the nitrogen removal rate for the legume crop up to a maximum of 150 pounds of plant available nitrogen
13. All manure applications and incorporation must be completed by October 15
14. Producers may apply for up to four years of funding for this practice

Technical Responsibilities

<u>Producer Responsibilities</u>

1. Producer must have a current approved VNMP on file with the SWCD
2. Provide a manure application plan detailing the fields where application will be completed which includes crop rotation, application timing, application rates, application methods, and a representative manure analysis
3. Obtain approval (confirmation) of the manure application plan from the SWCD
4. Notify the SWCD 24 to 48 hours prior to manure application
5. Follow applicable guidelines and setbacks for manure application set forth in Ohio NRCS 590 Standard Nutrient Management
6. Manure application must be consistent with any other applicable permits or local requirements
7. Obtain a copy of the weather forecast for the day and location of each manure application
8. Incorporate surface applied manure within 24 hours of manure application
9. Provide a copy of the manure application records, manure analysis, and weather forecast to the SWCD for review annually

Adapted from NRCS Appendix A - Seeding Tables. 11-19-19 – See Appendix A for additional guidance on establishment, maintenance, termination

		Seeding Rates in Pounds PLS (Percentage of Mix)					Seeding depth	
Species	Overwintering[1]	100%	75%	50%	33%	25%	(in)	North
Winter Rye	Yes	50	38	25	17	13	1	8-1 to 10-15*
Winter Barley	Yes	59	44	29	19	15	1	8-15 to 10-10
Winter Wheat	Yes	64	48	32	21	16	1	9-22 to 10-15*
Winter Triticale	Yes	60	45	30	20	15	1	8-1 to 10-15*
Spelt	Yes	64	48	32	21	16	1	9-22 to 10-15*
Annual Ryegrass	Yes	18	13	9	6	4	0.5	8-1 to 9-20
Oats	No	40	30	20	14	10	1	8-1 to 9-20
Oilseed Radish	No	NR	NR	NR	2	1.5	0.5	8-1 to 9-15
Rapeseed/Canola/Kale[3]	Yes	4	3	2	1.5	1	0.5	8-1 to 9-15
Mustards	No	4	3	2	1.5	1	0.5	8-1 to 9-15
Turnip	No	2.5	2	1	0.75	0.5	0.25	7-20 to 9-15
Alfalfa[4]	Yes	16	12	8	6	4	0.25	8-1 to 8-15
Red Clover	Yes	9	7	5	3	2	0.25	7-20 to 8-30
Yellow Sweet Clover	Yes	8	6	4	3	2	0.25	7-20 to 8-30
Crimson Clover	Yes	12	9	6	4	3	0.25	6-15 to 9-15
Winter Pea	No	40	30	20	14	10	1.25	8-1 to 9-15
Hairy Vetch	Yes	16	12	8	5	4	1	8-1 to 9-20
Sorghum-Sudangrass	No	24	18	12	8	6	1	5-15 to 7-5
Sudangrass	No	20	15	10	7	5	1	5-15 to 7-20
Pearl Millet	No	12	9	6	4	3	0.75	5-15 to 7-20
Japanese Millet	No	14	11	7	5	4	0.75	5-15 to 7-20
Buckwheat	No	NR	NR	12	8	6	1	6-15 to 8-15
Sunflower	No	NR	NR	NR	4	3	2	5-15 to 7-20
Cowpea	No	60	45	30	20	15	0.75	6-15 to 8-1
Sunn Hemp	No	12	9	6	4	3	1	6-15 to 8-1
Berseem Clover	No	11	8	5	3	2	0.25	5-15 to 8-15
Soybean	No	54	40	27	18	13	1.5	6-15 to 8-15

* Dates adapted to meet program seeding requirements

1. Overwintering only when planted during the fall dates and establishment. Winter kill may occur
2. Do not plant until after the Hessian fly free date; dates varies from Sept 22 in northern Ohio to Oct 5 in southern Ohio. Wheat and spelt cover crops can be planted up to 20 days past the fly free date. See the Ohio Agronomy Guide for specific county dates.
3. Fall planted varieties planted in the fall are "non-winter killed"; spring planted varieties planted in the fall or spring are winter killed.
4. In order to meet the intent and definition of cover crops (seasonal vegetative cover) alfalfa must be terminated and managed as an annual. Alfalfa planted to provide forage for Conservation Crop Rotation – Forages must be maintained for a minimum of 2 years and meet guidelines for that program.

5a. Conservation Crop Rotation – Small Grains

Purpose

1. Encourage agriculture producers to establish a soil conserving small grain crop in a crop rotation
2. Reduce sheet, rill, and wind erosion
3. Reduce water quality degradation due to excess nutrients
4. Increase cropping system diversity

Applicability

Applies to cropland acres in the 14-county project area. Acres receiving a payment under any other county, state or federal program (CSP, EQIP, WL Small Grain, etc.) are not eligible. Practice is limited to no more than one third of the applicants total cropland acres.

Specifications

1. Small grains are winter annuals (wheat, barley, rye, etc.)
2. Crop must be harvested as a grain, crop cannot be harvested as a forage
3. A cover crop or double crop is required to be planted following the harvest of the small grain crop
    a. Cover crops or double crop must be planted by October 15
    b. Seeding rates and dates for cover crops shall follow NRCS Appendix A (11-19-19) seeding table
    c. If an overwintering cover crop is used, the producer may also be eligible for the Overwintering Cover Crop practice
4. All nutrients must be applied in accordance with approved VNMP
    a. No manure shall be applied following the seeding of the cover crop nor prior to March 15
    b. Fertilizer may be placed a minimum of two inches below the soil surface with a placement tool or by strip tillage providing cover crop residue is maintained outside the placement area
    c. No broadcast fertilizer applications are allowed during the time period the cover crop or double crop is required to be maintained
5. Crop residue must be maintained until March 15, no fall or winter full width tillage is allowed
6. Producers may sign up for four years of funding for this practice

Adapted from NRCS Appendix A - Seeding Tables. 11-19-19 – See Appendix A for additional guidance on establishment, maintenance, termination

		Seeding Rates in Pounds PLS (Percentage of Mix)						
Species	Overwintering [1]	100%	75%	50%	33%	25%	Seeding depth (in)	North
Winter Rye	Yes	50	38	25	17	13	1	8-1 to 10-15*
Winter Barley	Yes	59	44	29	19	15	1	8-15 to 10-10
Winter Wheat	Yes	64	48	32	21	16	1	9-22 to 10-15*
Winter Triticale	Yes	60	45	30	20	15	1	8-1 to 10-15*
Spelt	Yes	64	48	32	21	16	1	9-22 to 10-15*
Annual Ryegrass	Yes	18	13	9	6	4	0.5	8-1 to 9-20
Oats	No	40	30	20	14	10	1	8-1 to 9-20
Oilseed Radish	No	NR	NR	NR	2	1.5	0.5	8-1 to 9-15
Rapeseed/Canola/Kale[3]	Yes	4	3	2	1.5	1	0.5	8-1 to 9-15
Mustards	No	4	3	2	1.5	1	0.5	8-1 to 9-15
Turnip	No	2.5	2	1	0.75	0.5	0.25	7-20 to 9-15
Alfalfa[4]	Yes	16	12	8	6	4	0.25	8-1 to 8-15
Red Clover	Yes	9	7	5	3	2	0.25	7-20 to 8-30
Yellow Sweet Clover	Yes	8	6	4	3	2	0.25	7-20 to 8-30
Crimson Clover	Yes	12	9	6	4	3	0.25	6-15 to 9-15
Winter Pea	No	40	30	20	14	10	1.25	8-1 to 9-15
Hairy Vetch	Yes	16	12	8	5	4	1	8-1 to 9-20
Sorghum-Sudangrass	No	24	18	12	8	6	1	5-15 to 7-5
Sudangrass	No	20	15	10	7	5	1	5-15 to 7-20
Pearl Millet	No	12	9	6	4	3	0.75	5-15 to 7-20
Japanese Millet	No	14	11	7	5	4	0.75	5-15 to 7-20
Buckwheat	No	NR	NR	12	8	6	1	6-15 to 8-15
Sunflower	No	NR	NR	NR	4	3	2	5-15 to 7-20
Cowpea	No	60	45	30	20	15	0.75	6-15 to 8-1
Sunn Hemp	No	12	9	6	4	3	1	6-15 to 8-1
Berseem Clover	No	11	8	5	3	2	0.25	5-15 to 8-15
Soybean	No	54	40	27	18	13	1.5	6-15 to 8-15

* Dates adapted to meet program seeding requirements

1. Overwintering only when planted during the fall dates and establishment. Winter kill may occur
2. Do not plant until after the Hessian fly free date; dates varies from Sept 22 in northern Ohio to Oct 5 in southern Ohio. Wheat and spelt cover crops can be planted up to 20 days past the fly free date. See the Ohio Agronomy Guide for specific county dates.
3. Fall planted varieties planted in the fall are "non-winter killed"; spring planted varieties planted in the fall or spring are winter killed.
4. In order to meet the intent and definition of cover crops (seasonal vegetative cover) alfalfa must be terminated and managed as an annual. Alfalfa planted to provide forage for Conservation Crop Rotation – Forages must be maintained for a minimum of 2 years and meet guidelines for that program.

5b. Conservation Crop Rotation – Forages

Purpose

1. Encourage agriculture producers to establish a soil conserving forage crop in their crop rotation
2. Reduce sheet, rill, and wind erosion
3. Reduce water quality degradation due to excess nutrients
4. Increase cropping system diversity

Applicability

Applies to cropland acres in the 14-county project area. Existing cropland acres where forage crops are established is not eligible for payment. Acres receiving a payment under any other county, state or federal program for (CSP, EQIP,WL Buffer, etc.) are not eligible.

Specifications

1. Perennial forages must be established in the rotation
2. Seeding rates for forages shall follow NRCS Appendix A seeding table or OSU Agronomy Guide, 15th ed.
3. Manure and/or fertilizer applications, following the approved VNMP, are permitted between March 15 and October 15
4. Practice must be maintained a minimum of two years from the date of practice installation.
5. Residual forage height must be a minimum of four inches height by October 15 each year
6. Residual forage must be maintained during the non-growing season
7. Grazing according to a Grazing Management Plan between March 15 and October 15 is permitted
8. Producer may enroll for a minimum of two years and no more than four years of funding for this practice

Technical Responsibilities

Producer Responsibilities

1. Provide VNMP to SWCD
2. Provide acres and field maps of forage established
3. Provide seed tags (including: % purity, % germ., % weed seed , Ohio noxious weed content) for forages

Adapted from NRCS Appendix A - Seeding Tables. 11-19-19 – See Appendix A for additional guidance on establishment, maintenance, termination

		Seeding Rates in Pounds PLS (Percentage of Mix)						
Species	Overwintering [1]	100%	75%	50%	33%	25%	Seeding depth (in)	North
Winter Rye	Yes	50	38	25	17	13	1	8-1 to 10-15*
Winter Barley	Yes	59	44	29	19	15	1	8-15 to 10-10
Winter Wheat	Yes	64	48	32	21	16	1	9-22 to 10-15*
Winter Triticale	Yes	60	45	30	20	15	1	8-1 to 10-15*
Spelt	Yes	64	48	32	21	16	1	9-22 to 10-15*
Annual Ryegrass	Yes	18	13	9	6	4	0.5	8-1 to 9-20
Oats	No	40	30	20	14	10	1	8-1 to 9-20
Oilseed Radish	No	NR	NR	NR	2	1.5	0.5	8-1 to 9-15
Rapeseed/Canola/Kale[3]	Yes	4	3	2	1.5	1	0.5	8-1 to 9-15
Mustards	No	4	3	2	1.5	1	0.5	8-1 to 9-15
Turnip	No	2.5	2	1	0.75	0.5	0.25	7-20 to 9-15
Alfalfa[4]	Yes	16	12	8	6	4	0.25	8-1 to 8-15
Red Clover	Yes	9	7	5	3	2	0.25	7-20 to 8-30
Yellow Sweet Clover	Yes	8	6	4	3	2	0.25	7-20 to 8-30
Crimson Clover	Yes	12	9	6	4	3	0.25	6-15 to 9-15
Winter Pea	No	40	30	20	14	10	1.25	8-1 to 9-15
Hairy Vetch	Yes	16	12	8	5	4	1	8-1 to 9-20
Sorghum-Sudangrass	No	24	18	12	8	6	1	5-15 to 7-5
Sudangrass	No	20	15	10	7	5	1	5-15 to 7-20
Pearl Millet	No	12	9	6	4	3	0.75	5-15 to 7-20
Japanese Millet	No	14	11	7	5	4	0.75	5-15 to 7-20
Buckwheat	No	NR	NR	12	8	6	1	6-15 to 8-15
Sunflower	No	NR	NR	NR	4	3	2	5-15 to 7-20
Cowpea	No	60	45	30	20	15	0.75	6-15 to 8-1
Sunn Hemp	No	12	9	6	4	3	1	6-15 to 8-1
Berseem Clover	No	11	8	5	3	2	0.25	5-15 to 8-15
Soybean	No	54	40	27	18	13	1.5	6-15 to 8-15

* Dates adapted to meet program seeding requirements

1. Overwintering only when planted during the fall dates and establishment. Winter kill may occur
2. Do not plant until after the Hessian fly free date; dates varies from Sept 22 in northern Ohio to Oct 5 in southern Ohio. Wheat and spelt cover crops can be planted up to 20 days past the fly free date. See the Ohio Agronomy Guide for specific county dates.
3. Fall planted varieties planted in the fall are "non-winter killed"; spring planted varieties planted in the fall or spring are winter killed.
4. In order to meet the intent and definition of cover crops (seasonal vegetative cover) alfalfa must be terminated and managed as an annual. Alfalfa planted to provide forage for Conservation Crop Rotation – Forages must be maintained for a minimum of 2 years and meet guidelines for that program.

6. Overwintering Cover Crops

Purpose

1. Encourage agriculture producers to establish an overwintering cover crop
2. Reduce sheet, rill, and wind erosion
3. Reduce water quality degradation due to excess nutrients
4. Increase cropping system diversity

Applicability

Applies to cropland acres in the 14-county project area. Acres receiving payment under any other county, state or federal program (CSP, EQIP, WL Small Grains, etc.) are not eligible.

Specifications

1. Establish overwintering cover crop no later than October 15
2. The completed practice must meet the criteria for seeding, establishment and maintenance per NRCS Appendix A, including seed quality and testing requirements
3. Seed mix must include a minimum of 50% of full rate of an overwintering species
4. Cover crop must be maintained until March 15
5. Crop can be harvested as a forage or grazed after March 15
6. Manure and/or fertilizer, based on the VNMP, may be applied prior to seeding or after March 15
    a. Manure shall not be applied on frozen, snow-covered or saturated soils or applied when the local weather forecast for the application area contains greater than a 50% chance of precipitation exceeding one-half inch in a 24 hour period
    b. Fertilizer shall not be applied on frozen, snow-covered or saturated soils or applied when the local weather forecast for the application area contains greater than a 50% chance of precipitation exceeding one inch in a 12 hour period
7. Producers may sign up for four years of this practice

Technical Responsibilities

<u>Producer Responsibilities</u>

1. Provide VNMP to SWCD
2. Provide acres and field maps where cover crop is established
3. Provide seed tags or seed tests (including: % purity, % germ., % weed seed, Ohio noxious weed content) and bills for the cover crop

Adapted from NRCS Appendix A - Seeding Tables. 11-19-19 – See Appendix A for additional guidance on establishment, maintenance, termination

		Seeding Rates in Pounds PLS (Percentage of Mix)					Seeding depth	
Species	Overwintering[1]	100%	75%	50%	33%	25%	(in)	North
Winter Rye	Yes	50	38	25	17	13	1	8-1 to 10-15*
Winter Barley	Yes	59	44	29	19	15	1	8-15 to 10-10
Winter Wheat	Yes	64	48	32	21	16	1	9-22 to 10-15*
Winter Triticale	Yes	60	45	30	20	15	1	8-1 to 10-15*
Spelt	Yes	64	48	32	21	16	1	9-22 to 10-15*
Annual Ryegrass	Yes	18	13	9	6	4	0.5	8-1 to 9-20
Oats	No	40	30	20	14	10	1	8-1 to 9-20
Oilseed Radish	No	NR	NR	NR	2	1.5	0.5	8-1 to 9-15
Rapeseed/Canola/Kale[3]	Yes	4	3	2	1.5	1	0.5	8-1 to 9-15
Mustards	No	4	3	2	1.5	1	0.5	8-1 to 9-15
Turnip	No	2.5	2	1	0.75	0.5	0.25	7-20 to 9-15
Alfalfa[4]	Yes	16	12	8	6	4	0.25	8-1 to 8-15
Red Clover	Yes	9	7	5	3	2	0.25	7-20 to 8-30
Yellow Sweet Clover	Yes	8	6	4	3	2	0.25	7-20 to 8-30
Crimson Clover	Yes	12	9	6	4	3	0.25	6-15 to 9-15
Winter Pea	No	40	30	20	14	10	1.25	8-1 to 9-15
Hairy Vetch	Yes	16	12	8	5	4	1	8-1 to 9-20
Sorghum-Sudangrass	No	24	18	12	8	6	1	5-15 to 7-5
Sudangrass	No	20	15	10	7	5	1	5-15 to 7-20
Pearl Millet	No	12	9	6	4	3	0.75	5-15 to 7-20
Japanese Millet	No	14	11	7	5	4	0.75	5-15 to 7-20
Buckwheat	No	NR	NR	12	8	6	1	6-15 to 8-15
Sunflower	No	NR	NR	NR	4	3	2	5-15 to 7-20
Cowpea	No	60	45	30	20	15	0.75	6-15 to 8-1
Sunn Hemp	No	12	9	6	4	3	1	6-15 to 8-1
Berseem Clover	No	11	8	5	3	2	0.25	5-15 to 8-15
Soybean	No	54	40	27	18	13	1.5	6-15 to 8-15

* Dates adapted to meet program seeding requirements

1. Overwintering only when planted during the fall dates and establishment. Winter kill may occur
2. Do not plant until after the Hessian fly free date; dates varies from Sept 22 in northern Ohio to Oct 5 in southern Ohio. Wheat and spelt cover crops can be planted up to 20 days past the fly free date. See the Ohio Agronomy Guide for specific county dates.
3. Fall planted varieties planted in the fall are "non-winter killed"; spring planted varieties planted in the fall or spring are winter killed.
4. In order to meet the intent and definition of cover crops (seasonal vegetative cover) alfalfa must be terminated and managed as an annual. Alfalfa planted to provide forage for Conservation Crop Rotation – Forages must be maintained for a minimum of 2 years and meet guidelines for that program.

H2Ohio

7. Drainage Water Management

Purpose

1. Encourage producers to install and manage water control structures
2. Reduce nutrient loading to downstream receiving waters

Applicability

Applies to cropland acres in the 14-county project area. Acres receiving payment under any other county, state or federal program for Drainage Water Management (EQIP, LE-NRP, etc.) are not eligible.

Specifications

1. Outlet pipe needs to be a minimum of six inches in diameter
2. Outlet structures need to be installed per engineering plan
3. Minimum 10 acres controllable area based on a 30 inches control height with out submain installation
4. Minimum 20 acres controllable area based on a 30 inches control height with submain installation
5. Structures should not be installed on a main tile that drains another landowners land, unless written permission is obtained from the upstream landowners
6. Producer will provide SWCD or DSWC access to the control structure

Technical Responsibilities

Producer Responsibilities

1. Provide tile maps and any necessary written permissions from upstream landowners
2. Install structure per provided design
3. Manage structure in accordance with provided management plan and provide documentation annually for four years

SWCD Responsibilities

1. Receive application from the producer, docmument plan on BMP Worksheet, and complete contract
2. Locate sites to install practices
3. Enter all required information into Beehive
4. Obtain landowner agreement
5. Obtain current drainage tile plan
6. Design and lay out structures
7. Oversee construction
8. Verify structures are closed per the provided management plan annually for four years
9. Process payment to producer

Participant Payments

Producer will receive $1,500 per site without submain installation. Producer will receive $4,000 per site with submain installation. Producer will receive an additional $200/structure/year, in years two, three and four, after operation and management records have been reviewed and certified by the SWCD.

Appendix E: Point Source Facilities in Ohio's Annex 4 Priority Watersheds

Beginning with the Great Lakes Water Quality Agreement (GLWQA) in 1972, it was acknowledged that municipal point source discharges contributed to the nutrient loadings to the lake. The early versions of the GLWQA recommended that all major wastewater treatment plants (WWTPs) discharging within the lake basin meet a 1.0 mg/L total phosphorus (TP) effluent concentration. By 1980, the affected WWTPs were implementing reduction efforts to a level that non-point sources became the major contributor of phosphorus loading to the lake. The majority of the WWTPs began treating for phosphorus using chemical additional of metal salts to precipitate out phosphorus and incorporate it into the biosolids at the end of the treatment process.

Coupled with the effluent controls at the major WWTPs were reductions in the phosphorus content in laundry detergents. Beginning in the late 1980s, Ohio began limiting the allowed amount of phosphorus in household and commercial laundry detergents. In 2010, Ohio became one of 16 states that also included a requirement that dishwasher detergent could not contain more than 0.5 percent phosphorus. Not only did these measures reduce the influent phosphorus concentration to the WWTPs but also reduced contributions from uncontrolled point sources such as combined sewer overflows (CSOs) and bypasses. It is also worthwhile to mention that in collaboration with the Ohio Lake Erie Phosphorus Task Force, the Scotts company has removed phosphorus as a component of residential lawn fertilizers. This effort has further reduced inputs from CSOs and municipal separate storm sewer (MS4) permitted storm water communities.

Across all of Lake Erie, the National Pollutant Discharge Elimination System (NPDES) permitted TP loads have been calculated by the Ohio Nutrient Mass Balance study. Figure E1 below shows the proportion of TP from the various NPDES permitted loads for all Lake Erie watershed plants in Ohio. This calculation does not include storm water and home sewage treatment system (HSTS) loads some of which is permitted, as explained later in this appendix. Of the permitted point source discharges to Lake Erie in Ohio, municipal facilities with greater than 1.0 million gallon per day of design flow (major) contribute 76 percent of the TP load from NPDES permitted facilities.

Note that Figure E1 only breaks down the types of permitted point source loads to Lake Erie. Since not all of Lake Erie's tributaries are included in Ohio's Nutrient Mass Balance study, the percent of permitted point sources that make up the total load for all of Ohio's Lake Erie watershed is unknown. For context, in the western tributaries the permitted point source load is very small; between 4-8 percent of the total load. In the more populated Cuyahoga River watershed, permitted point sources make up 44 percent of the total.

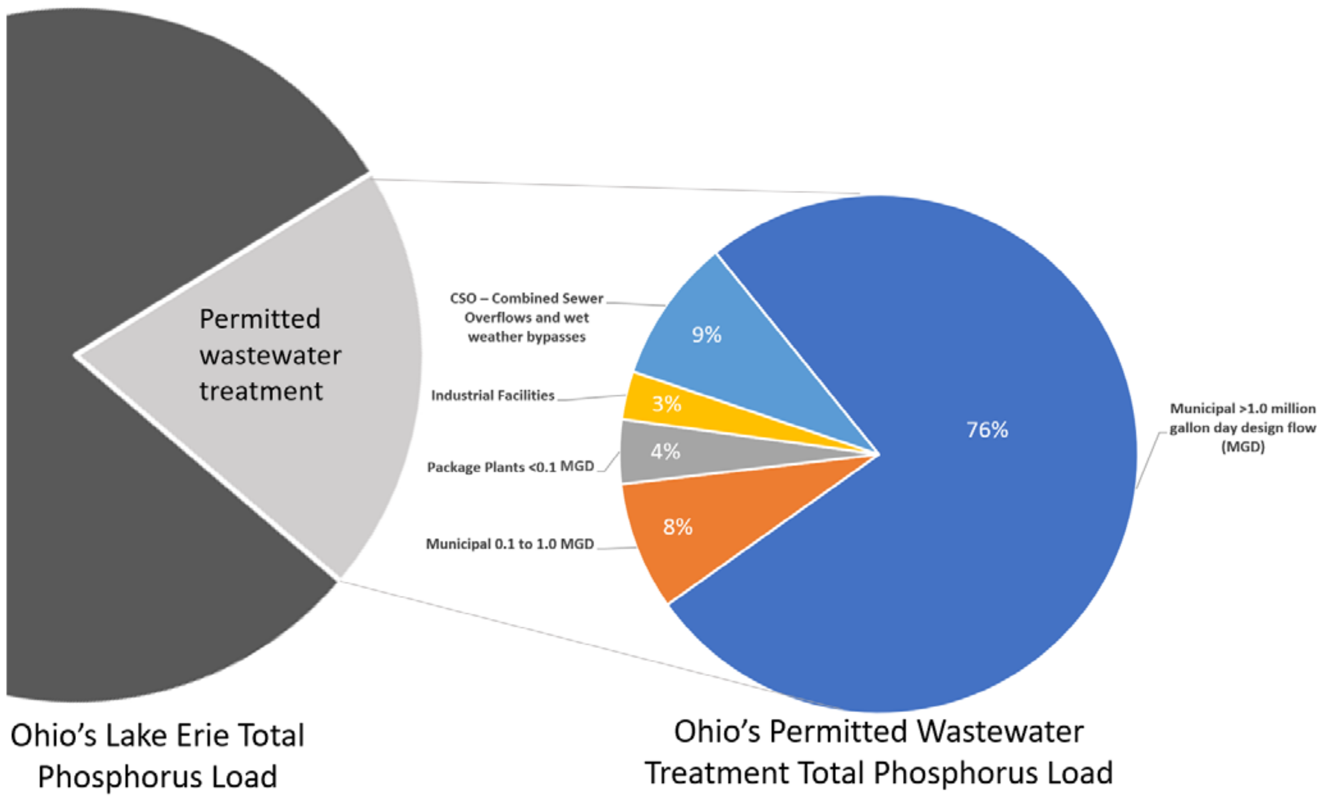


Figure E1: Relative total phosphorus loads from wastewater treatment NPDES permitted facilities grouped by type in the Lake Erie watershed (within Ohio). Note that the percent of wastewater load of the total Ohio delivered Lake Erie phosphorus has not been calculated because not all Lake Erie tributaries are included in Ohio's mass balance calculations. For reference, the western basin tributaries have between 4-8 percent of their total load from treated wastewater; in the Cuyahoga River it represents 44 percent.

NPDES – Permitted Discharges, Final Outfalls

There is a combined total of 913 permitted facility outfalls in the Annex 4 priority watersheds in Ohio, which discharged a combined total of 473 metric tons annual average for water years 2013-2017. Table E1 breaks out these the NPDES permitted facilities and water years' 2013-2017 annual average total TP load for each Annex 4 priority tributary. The next nutrient mass balance study that Ohio EPA will publish in 2020 will update these values.

Table E1: Number of NPDES individual facility permits by Annex 4 Priority Watershed, with water year 2013-2017 total phosphorus average annual load from all permitted outfalls. This includes all facilities, public or private, that report discharge of total phosphorus.

Watershed		Number of Permitted Facilities	Total Phosphorus Load (MTA)
Annex 4 Priority Watersheds (State of Ohio)	Maumee	255	136
	Toussaint	17	1.85
	Sandusky	84	14.5
	Portage	42	14.0
	Huron	34	3.75
	Vermillion	24	2.45
	Cuyahoga	152	125
	Grand	87	6.72
Annex 4 Priority Total		695	304
All Other Lake Erie Drainage		487	169
Total		**1,182**	**473**

Major Municipal WWTP Loading in the Maumee River Watershed

The TP loads from wastewater treatment facilities have remained minimal compared to the non-point source contributions in the western Lake Erie basin tributaries. The non-storm water permitted point source loads only contribute eight percent of the Maumee River watershed TP load. For all of the Lake Erie tributaries and, in particular for the Maumee River, the loads from major municipal point sources contribute the majority of the permitted non-storm water sources of load. The following provides a close examination of the loads from major municipal WWTPs in the Maumee River watershed.

For historical perspective, major point source springtime TP are displayed back to 1995 in Figure E2. This period was chosen to develop an understanding of TP loads from major facilities during the period of re-eutrophication of Lake Erie from the mid-1990s to the mid-2000s. The largest discharges are city of Toledo Bayview WWTP, Lucas County Maumee River WRF, city of Lima WWTP, and city of Findlay WWTP. These facilities are presented individually in the figure with remaining major municipal wastewater treatment facilities grouped together.

Major municipal facility loading remained relatively flat during the period of re-eutrophication of the western basin of Lake Erie. That period was followed by a period starting in 2005 where springtime TP loads have been trending downward. TP load from major municipal facilities averaged 53 metric tons per spring from 2004-2008 and 42 metric tons per spring from 2014-2018. This was a net decrease of 22 percent for major municipal facilities in the Maumee River watershed in the period leading up to the 2008 base year and the most recent conditions. The downward trend is attributed to voluntary load reductions, mainly driven by the Toledo Bayview WWTP. In the five springs from 2004 – 2008, the Toledo Bayview WWTP discharged an average of 29 MT/spring, in the last five years (2014 – 2018) the discharge has averaged 18 MT/spring.

Monitoring of dissolved orthophosphate (orthoP) at major municipal facilities in Ohio started in recent years as required by state legislation passed in 2015. This monitoring requirement is being phased in as permits are renewed. For instance, the Toledo WWTP started monitoring and reporting orthoP to Ohio EPA in September 2016. Because of this, a dissolved form of phosphorus dataset from WWTPs does not contain a long enough record for a reasonable trend assessment. Most of the phosphorus treatment changes in the Maumee River watershed in recent years have been using additional chemical precipitation. Because of this, it is likely that the dissolved to total ratio of effluent phosphorus is being reduced with additional treatment. Therefore, were these data available over the same period as the trend shown in Figure E2, an even more dramatic reduction would be observed.

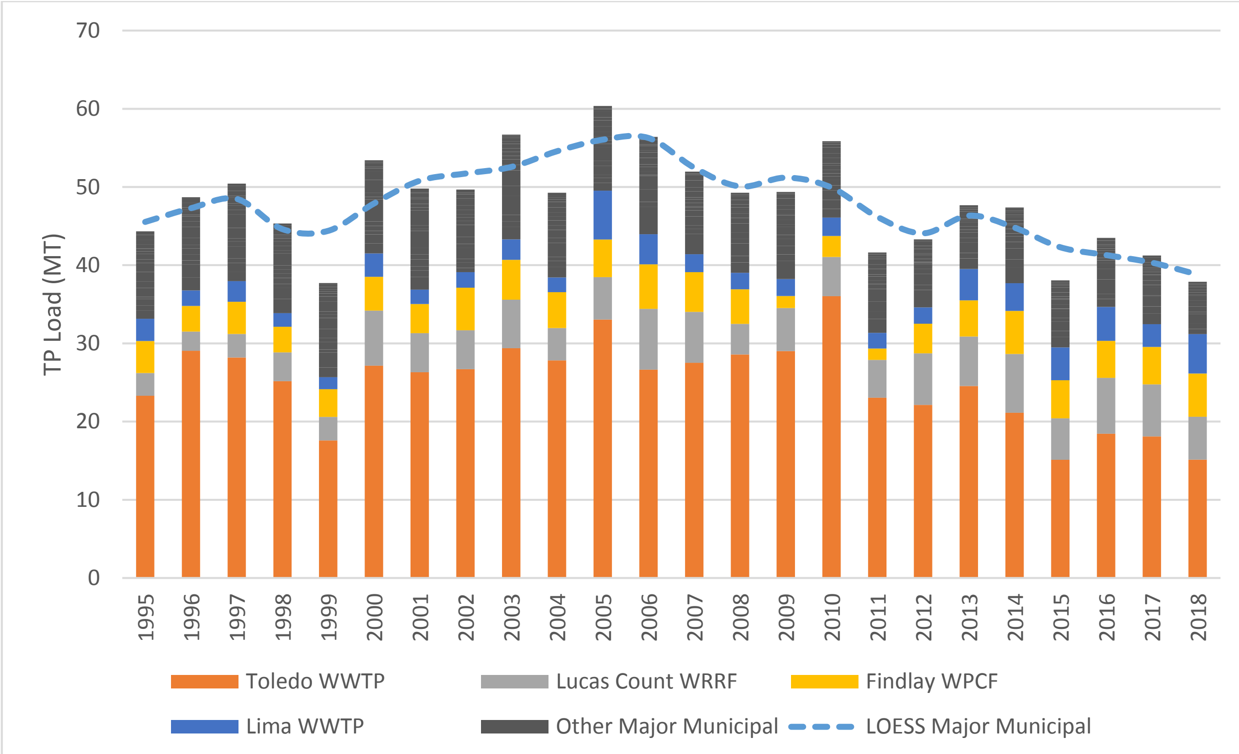


Figure E2: Springtime TP loads from major municipal wastewater treatment facilities in the Maumee River watershed from 1995 - 2018.

Major Municipal WWTP Phosphorus Removal Operation and Progress

While municipal major WWTPs are required to achieve an effluent concentration of 1.0 mg/L in order to comply with their NPDES permits, many treatment plants consistently perform well below this level. One reason for this is to remain in compliance throughout varying flow rates, operating conditions and process upsets. Statistically speaking, if one were to apply the same methodologies of reasonable potential to exceed the 1.0 mg/L limit as we do with other water quality criteria, a facility would need to achieve a long-term average concentration of 0.78 mg/L in order to remain in compliance 99 percent of the time.

As older WWTPs are being upgraded, they often include provisions for nutrient removal. This can be somewhat attributed to the state of the technology and engineering for new facilities. Many equipment manufacturers operate across the county and in areas that may have more stringent nutrient reduction requirements than Ohio. As this equipment is installed in locations here in Ohio, we reap the benefits of these new technologies proliferating throughout the wastewater industry as the standard of practice. An example of this is the Liverpool Township WWTP located in Medina County and discharging to the Rocky River watershed. As part of recent $35 million upgrade to the facility, equipment was installed that harvests nutrients from the biosolids processing and eliminates them from the effluent discharge.

Other facilities across the state are piloting different treatment technologies in efforts to vet their potential application at larger scales. The city of Perrysburg WWTP located in Wood County, and discharging to the Maumee River, has been involved in multiple such efforts. They evaluated technology that utilizes algae to absorb phosphorus from the effluent. The new algae that grows is harvested from the system removing the nutrients with it. Perrysburg recently piloted a side stream nutrient recovery system located on the biosolids processing return flow. This system strips phosphorus from the waste stream and forms calcium phosphate as a useful product. A pilot project that will be implemented full scale at the treatment plant is the addition of magnesium hydroxide. Magnesium hydroxide will be added during low flow periods at the WWTP when low alkalinity and pH become inhibiting to the nitrification process at the WWTP. An added benefit is that this pH adjustment will allow the existing ferrous chloride feed to be optimized, as it can be affected in a negative way at low pH values.

Since 2017, Ohio EPA had reviewed at least 28 optimization plans. These plans have periodically identified potential optimization opportunities and permittees have submitted schedules to implement changes when appropriate. A few examples of projects to be completed are summarized below.

- Perrysburg's wastewater treatment facility, discharging to the Maumee River watershed, will utilize old primary clarifier tanks to equalize anaerobic digester supernatant flows to less peak nutrient loadings and possible bleed through to the effluent.
- The Gary L. Kron Lake County wastewater facility, which discharges directly to Lake Erie, will adjust their operational phosphorus target concentration from 0.7 mg/L to 0.6 mg/L. This extra reduction is anticipated to cost an additional $1,500/yr which was deemed economically reasonable.
- Fremont's wastewater treatment facility, discharging to the Sandusky River watershed, recently completed construction of a new wastewater treatment facility. Biological nutrient removal capabilities were included in the upgrades and the facility continues minor process adjustments to achieve optimal effluent quality. Current phosphorus concentrations are ~41 percent lower than the former facility was able to achieve.
- The city of Crestline, in the Sandusky River watershed, will be implementing facility improvements to comply with the existing effluent limit in their NPDES permit. Preliminary reports have identified increased chemical feed rates as an interim solution with the possibility of constructing a new biological removal facility as a long-term solution.
- Several other facilities already operate below the 0.5 mg/L range and were not able to identify current optimization opportunities within the scope of the investigation.

NPDES – Permitted Discharges, CSOs

Some communities have storm water outfalls that are regulated, which include CSOs and individual or general storm water permits. Overflows from combined sewers due to urban storm water are the primary source of untreated sewage discharges to Lake Erie. In the Lake Erie basin, 44 communities currently have CSOs. Ohio EPA's 2018 Nutrient Mass Balance Study reports that CSOs accounted for between 0.1 – 3.7 percent of the TP load exported from several Lake Erie watersheds from water years 2013 – 2017. For these years, the average CSO percentage of TP load was 0.5 percent in the Maumee River, 1.0 percent in the Portage River, 1.1 percent in the Sandusky River, 0.1 percent in the Vermillion River and 3.7 percent in the Cuyahoga River watersheds.

Ohio EPA works to control CSOs through provisions in NPDES permits and using orders and consent agreements when appropriate. The NPDES permits require CSO communities to implement nine minimum control measures. Requirements to develop and implement Long-Term Control Plans (LTCPs) are also included where appropriate. Billions of dollars have already been invested by communities to abate their CSO discharges. Details about CSOs can be found on Ohio EPA's website at: ***https://epa.ohio.gov/dsw/cso/csoindex.***

NPDES – Permitted Discharges, Storm Water Discharges

Storm water discharges are generated by runoff from land and impervious areas such as paved streets, parking lots and building rooftops during rainfall and snow events. Storm water can contain pollutants in quantities that could adversely affect water quality. Most storm water discharges are considered point sources and require coverage by the NPDES program. There are numerous storm water permits throughout the Lake Erie watershed. This includes 224 MS4 communities (covered under 123 permits due to cooperation of communities as co-permittees), hundreds of facilities with individual NPDES permits that include storm water and over 1,000 general industrial storm water permits. Additionally, thousands of general construction storm water permits in Ohio's portion of the Lake Erie watershed are open at any given time. The general permits and MS4 regulated areas can be viewed on an interactive map hosted by Ohio EPA[26].

Best management practices like green infrastructure and street sweeping can reduce nutrient loading from MS4 discharges. Ohio EPA is currently investigating opportunities to encourage MS4 communities to voluntarily sample for nutrients.

[26]Interactive map of permitted storm water communities is available at ***http://oepa.maps.arcgis.com/apps/webappviewer/index.html?id=b680bd65d1874023ae6ec2f911acb841.***

Appendix F: Restoration Projects

This appendix details the specific actions of the Ohio Department of Natural Resources (ODNR) and provides updated project lists.

ODNR has identified several different project types that will provide direct nutrient and sediment-reduction benefits to the Maumee River Watershed, Western Lake Erie Basin, Sandusky Bay and other watersheds throughout the state.

In-Water or Flow-Through Coastal Wetlands: One of the highest priorities is to place multiple flow-through, in-water coastal wetland restoration projects in the basin, particularly within the Maumee and Sandusky River mouths. The placement of these wetlands will include those that beneficially use dredged material and natural river flows to deliver sediment and nutrient-laden waters from the river into the wetlands. These projects will be designed, engineered and constructed at locations that maximize nutrient reduction benefits and improve fish and wildlife habitat.

Reconnecting Diked Wetlands: Many of the existing wetlands along the western basin shoreline are diked wetlands that are disconnected from Lake Erie and the adjacent tributaries and agricultural drainage channels that flow directly into the Lake. There is a desire to upgrade those wetlands with new innovative water control/fish access structures to reconnect the wetlands to the basin hydrology. These water control structures will allow the wetlands to continue to be managed for vegetation and waterfowl and will also provide the ability to divert surface water flow from upland areas into the wetlands to process sediments and nutrients before reaching the Lake.

Nature-Based Shoreline Wetlands: The addition of nature-based wetlands along the shoreline will be considered in areas where hardened shoreline protection is either absent or needs to be replaced. These wetlands may be constructed to include natural materials and/or beneficially use dredge materials to fill the cells to create new coastal wetlands. These nature-based shoreline projects control erosion, improve nearshore water quality by filtering water flowing from small tributaries and drainage channels flowing into Lake Erie.

Stream Buffers: The use of vegetative and/or forested buffers will be used where appropriate. Streamside trees, shrubs and native grasses prevent pollution from entering waterways, stabilize stream banks, provide food and habitat to wildlife, and keep streams cool during hot weather.

Nutrient Processing Wetlands and Surface Water Treatment Trains: Investments will be made in projects that treat nutrient-laden water derived from agricultural and urban lands using an engineered treatment train that consists of multiple wetland complexes. Scientists at Grand Lake St. Marys have developed a series of these wetlands and have reported phosphorus reductions up to 80 percent. Because of this success, ODNR will engineer wetland complexes where incoming water is captured upstream and pumped through the water control structure, then released into riparian or coastal wetlands designed to provide for sediment and nutrient reduction benefits. The water is then released through a water control structure or into a diked wetland where additional processing occurs before the water reaches the lake.

Stream Buffers, Riparian Restoration and In-field Wetlands: The use of vegetative and/or forested buffers and enhanced and/or restored riparian or in-field wetlands will be used where appropriate. These projects will be located within high phosphorus load areas in the Maumee and Sandusky River basins and combined with other best management practices (BMPs) to attain desired phosphorus reduction and water quality benefits. These projects will include planting streamside trees, shrubs or native grasses to prevent pollution from entering waterways, stabilize stream banks, and restore riparian fish and wildlife habitat that also improves water quality.

ODNR will pursue the following actions to implement projects that improve water quality within the Ohio Lake Erie basin, coastal and inland, as well as elsewhere in Ohio.

Lake Erie Coastal Zone

ODNR, in cooperation with local, state and federal agencies and using H2Ohio funding, will continue to fund and complete engineering and design work for potential in-water coastal wetland restoration projects in the western basin and Sandusky Bay that beneficially use dredged material and can help assimilate in-lake nutrients. Specifically, ODNR will implement multiple in-water, flow-through coastal wetland restoration projects in the mouth of the Maumee and Sandusky Rivers.

ODNR will complete two coastal wetland pilot projects recommended for Great Lakes Restoration Initiative funding by the U.S. Fish & Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), and U.S. Environmental Protection Agency (U.S. EPA) Great Lakes Coastal Conservation Working Group. These pilot projects will reconnect existing degraded tributary and diked wetlands with Sandusky Bay resulting in restored nutrient processing functions and enhancing habitat connectivity with Sandusky Bay. These pilot projects serve as a template for the restoration of hydrologic connectivity of tributary and diked wetlands along the western basin shoreline of Lake Erie.

ODNR will use H2Ohio funds to renovate/enhance coastal diked wetlands to incorporate adjacent agricultural drainage where applicable and, if possible, install fish passage structures which will (when Lake levels permit) allow free flow of lake water to the wetlands, thus improving water quality.

ODNR, through the Division of Wildlife, will work with partners to implement multiple wetland enhancement and restoration projects identified in the Sandusky Bay Initiative. These projects will include the restoration of nature-based shoreline wetlands, creation of in-water wetlands and shallow shoals/islands to absorb wave energy and reduce sediment resuspension, and implementation of multiple projects to reconnect of tributary and diked wetlands to restore nutrient processing functions and enhance habitat connectivity with Sandusky Bay.

ODNR will continue to coordinate with and assist the USFWS/NOAA/U.S. EPA Great Lakes Coastal Conservation Working Group to develop and implement tools to identify potentially restorable wetlands for the western basin that incorporates landscape conservation design principles and goals, with a focus on restoring and conserving functional coastal wetlands that maximize sediment trapping and nutrient processing/reduction benefits. This will result in the development of multiple projects in targeted areas to reduce loading impacts in the western basin of Lake Erie.

ODNR, in cooperation with Ohio Sea Grant, will jointly fund projects to investigate and quantify nutrient processing and reduction benefits of coastal wetlands at the Old Woman Creek National Estuarine Research Reserve and other western basin wetlands in support of the new H2Ohio Initiative. The information and data derived from these projects will assist in the design and long-term management of on-the-ground nutrient and sediment reduction projects.

Maumee and Sandusky River Watersheds

ODNR, through the Division of Wildlife and working with partners, will evaluate opportunities through the Private Lands program and joint state-federal programs (e.g. Conservation Reserve Enhancement Program) to identify and develop projects in the Maumee and Sandusky River basins that provide water quality benefits through enhancement and creation of riparian buffers and wetlands. These buffers will include planting streamside trees, shrubs or native grasses to prevent pollution from entering waterways; stabilization of stream banks, and the restoration of riparian fish and wildlife habitat structures that also improve water quality.

Inland Watersheds Throughout Ohio

Using a targeted-watershed approach, an inter-agency team of ODNR experts continues to identify areas where inland wetlands can be used to effectively reduce nutrient loading into waterways that feed into Lake Erie and the Ohio River. Project practices will range from treatment trains and forested buffers to wetland creation and in-river/in-stream techniques. ODNR will select the appropriate wetland practice for each project to maximize the likelihood of phosphorus, nitrogen and/or sediment reduction. Construction techniques and costs will be factored into these decisions and the ultimate placement of water-quality improvement practices.

The following table outlines examples of specific wetland projects that are in various stages of development, ranging from planning to engineering and design work to in-contract status. This is not an exhaustive list of the wetland restoration work that ODNR is currently undertaking, nor is it a guarantee that each listed project will be implemented, due to the nature of local approvals and permitting decisions.

Project Title	Partner	Funding Source
Maumee River Watershed, Coastal		
Cullen Park Wetland Restoration	Lucas County Port Authority, city of Toledo	H2Ohio
Grassy Island Flow-Through Wetland Restoration	Lucas County Port Authority, city of Toledo	H2Ohio
Maumee River Watershed, Inland		
Maumee - St. Joseph’s River Confluence Wetland Restoration	Black Swamp Conservancy	H2Ohio
St. Joseph’s River Wetland Restoration	Black Swamp Conservancy	H2Ohio
Oak Openings Preserve Expansion	Metroparks Toledo	H2Ohio
Maumee – Forder Bridge Riparian Restoration	Black Swamp Conservancy	H2Ohio
Maumee & Tiffin Rivers Riparian Protection	Project in development	H2Ohio
Hancock County Wetland Restoration Project	Project in development	H2Ohio
Western Lake Erie Basin, Coastal		
Maumee Bay State Park Wetland Reconnection	The Nature Conservancy, Ohio EPA, U.S. EPA	H2Ohio
Riverside Dredge Center for Innovation – AG Field Placement	Port of Toledo, Ohio Lake Erie Commission	HLEF
Five Lake Erie South Shore Wetland Reconnections, Lucas County	Projects in development	H2Ohio
Eight Sandusky Bay Coastal Wetland Reconnections/Restorations	Projects in development	H2Ohio, HLEF, GLRI
Cedar Point Causeway Wetland – Sandusky Bay	City of Sandusky, ODNR	HLEF, GLRI
Carstensen/Herman Wetlands	DU, USFWS, USDA, GLFWRA	DU, USFWS, USDA, GLFWRA
Smith Wetlands	DU, USFWS, USDA, GLFWRA	DU, USFWS, USDA, GLFWRA
Western Lake Erie Basin, Inland		
Sandusky River, Redhorse Bend Wetland Restoration	Black Swamp Conservancy	H2Ohio
Fruth Outdoor Center, Wetland and Riparian Restoration	Seneca County Parks	H2Ohio
Crawford Park District, Sandusky Headwaters Preserve Wetland Restoration	Crawford Park District	H2Ohio
Central Lake Erie Basin		
Lorain In-Water Wetland	City of Lorain	U.S. Army Corps of Engineers
Cleveland Harbor Wetland/Nature-Based Shoreline	Cleveland Metroparks, ODNR, ODOT, Port of Cleveland, City of Cleveland	National Fish and Wildlife Foundation
Ashtabula Wetland	U.S. Army Corps of Engineers, Ashtabula Port	U.S. Army Corps of Engineers/HLEF
H2Ohio Statewide Projects		
Grand Lake St. Marys	Project in development	H2Ohio
Buckeye Lake, Brooks Park Nutrient Treatment Wetland	Fairfield/Perry SWCD	H2Ohio
Dillon Lake	U.S. Army Corps of Engineers	H2Ohio
East Fork Little Miami / Lake Harsha	U.S. Army Corps of Engineers	H2Ohio

HLEF = Healthy Lake Erie Fund, GLRI = Great Lakes Restoration Initiative, DU = Ducks Unlimited, GLFWRA = Great Lakes Fish & Wildlife Restoration Act
USDA = U.S. Department of Agriculture, USFWS = U.S. Fish and Wildlife Service

Maumee River Watershed Projects

Cullen Park Flow-Through Wetland Restoration/City of Toledo, Lucas County Port Authority

The Cullen Park Flow-through Wetland Restoration Project is located at the mouth of the Maumee River and will redirect Maumee River flow into the wetland to enhance nutrient processing. Low-relief sills and islands will be created to protect the wetland area from wave action while promoting water exchange between the river, wetland and the Lake. The establishment of quiet water conditions within the created wetland will promote a diverse wetland plant community which will trap and process nutrient-laden water and sediment. Locally dredged sediment will be used to create islands and shallow-water contours on the lakebed to maximize wetland surface area to promote sediment trapping and nutrient uptake by wetland plants while providing wildlife habitat. Flow-through wetlands direct river water into protected shallow-water areas that support different types of wetland vegetation that will trap sediment, process nutrients, and create fish and wildlife habitat. It is estimated that up to 1 percent of the Maumee River flow will through the Cullen Park wetland and up to 75 acres of flow-through wetland will be restored by this project. An estimated $5.08 million of H2Ohio funding has been allocated for this project.

Grassy Island Flow-Through Wetland Restoration/City of Toledo, Lucas County Port Authority

The Grassy Island flow-through wetland restoration project is strategically located at the mouth of the Maumee River and will redirect Maumee River flow through the opening between Grassy Island and the Cullen Park Causeway into the wetland to enhance nutrient processing. Low-relief sills and islands or other nature-based features will be created to protect the wetland area from wave action while promoting water exchange between the river, wetland and the Lake. Flow-through wetlands direct river water into protected shallow-water areas that support different types of wetland vegetation that will trap sediment, process nutrients, and create fish and wildlife habitat. It is estimated that up to 3 percent of the Maumee River will flow through the Grassy Island wetland and more than 100 acres of flow-through wetland will be restored at the mouth of the Maumee River by this project. An estimated $742,000 of H2Ohio funding has been allocated for the design and engineering phases of this project.

Maumee - St. Joseph's River Confluence Wetland Restoration/Black Swamp Conservancy

The Black Swamp Conservancy is purchasing a 140-acre property, of which 19.5 acres has been in row crop production and 28 acres in prairie. Thirteen acres of the row crop field and 20 acres of the prairie contain wet depressions and hydric soils. Projects planned for the site include interrupting the tile drainage, routing a small tributary through restored wetlands and enlarging existing wetland portions of the property. The result will be a complex of emergent sedge and herbaceous wetland, buttonbush-dominated scrub-shrub wetlands, and vernal pools in a deciduous forest. This will buffer the existing wetland complex, remove 20 acres of row crop production from the watershed and filter nutrients and sediment from 100 percent of the drainage area of a tributary flowing through the property. An estimated $730,000 of H2Ohio funding has been allocated for this project.

St. Joseph's River Wetland Restoration/Black Swamp Conservancy

The Black Swamp Conservancy is planning to purchase this property as part of their Food & Farm Initiative, which is designed to provide land access to new and beginning farmers, while safeguarding waterways by balancing cropland with natural habitats, requiring ecologically responsible practices, and encouraging the production of food for local consumption. This property is in an area of interest for sustainable farming and in proximity to several institutions that have a policy of sourcing locally grown food. The project offers an opportunity to protect and restore a considerable amount of natural forested wetland along the St. Joseph River, while retaining enough tillable acres to establish a small to mid-size sustainable farming operation. Fifty four acres of the property would be restored (27 acres of wetlands and 27 acres of non-hydric reforestation), 1,600 linear feet of channel restoration, 14 acres of agricultural land would be retained, and 26 acres of existing habitat would be protected. H2Ohio funding will be made available, with details to be determined.

Oak Openings Preserve/Metroparks Toledo

Project includes acquisition of a 48-acre property, of which 30 acres are in agricultural production. Upon acquisition, wetland restoration efforts include removing land from agricultural production, crushing or removing drainage tiles, and regrading landscape adjacent to Ai Creek to reestablish wetland hydrology to support newly created wetlands. At project completion, approximately 22 acres of new forested wetlands will be restored and eight acres of new upland prairie/savanna habitat will be created. When added to the existing 15 acres of forested wetlands, the total amount of wetlands on the project will be 37 acres. $867,000 in H2Ohio funding will be invested in this $1.4 million project.

Maumee – Forder Bridge Riparian Restoration / Black Swamp Conservancy

The Forder Bridge is a 54-acre parcel that provides public access to the Maumee Scenic River in Crane Township, Paulding County. Black Swamp Conservancy owns and manages the preserve. Two thousand six hundred linear feet of an intermittent headwater stream draining agricultural land, runs through the middle of Forder Bridge and into the Maumee River. The stream has a wooded buffer along most of its length, except where it first enters the property from a culvert on CR 424. The lower reach of the stream is severely eroding. A series of wetlands, stream stabilization and grade control structures will capture and treat runoff while addressing stream erosion issues. An estimated $513,000 of H2Ohio funding has been allocated for this project.

Maumee & Tiffin Rivers Riparian Protection

A project, still under development, would protect floodplain, currently in agricultural production, in the vicinity of the Maumee and Tiffin River confluence.

Hancock County Wetland Restoration

Two projects are being developed in the Blanchard River watershed, which would convert land currently in agricultural production into wetland and riparian habitat. Details are currently being finalized for H2Ohio funding.

Western Lake Erie Basin Projects

Maumee Bay State Park Wetland Reconnection/The Nature Conservancy, Ohio EPA, U.S. EPA

This project will enhance 130 acres of wetland habitat within Maumee Bay State Park near Oregon, Lucas County. The mouth of the wetland will be closed with a dike and a fish passage/water control structure. Drainage modifications will be made so that agricultural drainage can be pumped into the wetland before it reaches the Lake. The goal of the project is to restore a phragmites-dominated wetland that is usually not connected to Lake Erie due to a sand ridge. The restored wetland will be composed primarily of native species and will be connected to Lake Erie so that nutrient loading to the lake can be removed by the wetland vegetation. An estimated $2 million of H2Ohio funding has been allocated for this project.

Riverside Dredge Center for Innovation – AG Field Placement/Port of Toledo, Ohio Lake Erie Commission

The project is located on a 14-acre site on the west bank of the Maumee River in Toledo. Four separate containment cells and edge of field treatment systems were constructed to hold a total of 80,000 cubic yards of dredge material from the Maumee River and Toledo Federal Navigation Channel. The cells are designed to mimic farm field conditions and will be used to demonstrate agricultural use of dredge material by evaluating nutrient uptake and agricultural yields of different crops planted within the cells. The objective of this research is to develop agronomic and economic criteria to support placement of dredge material on farm fields to reduce and/or eliminate open-lake disposal of dredge material into Ohio Lake Erie waters, thereby improving Lake Erie water quality. Approximately $2.2 million in Healthy Lake Erie funds were invested during initial construction of this project. The Ohio Lake Erie Commission, in partnership with a broad stakeholder group, are managing ongoing agronomic research activities at the project site.

Five Lake Erie South Shore Wetland Reconnections, Lucas County

The goal of these projects is to reconnect diked wetlands to Lake Erie. This will allow water from the upstream watershed containing agricultural runoff – as well as lake water during high seiche events – to be diverted into the wetland unit. These projects will use water control structures to achieve nutrient reduction goals while also providing fish passage.

Eight Sandusky Bay Coastal Wetland Reconnections/Restorations

A variety of coastal or in-water wetland restoration projects are under development to reduce nutrient loading to Sandusky Bay. Examples of Sandusky Bay wetland reconnection or restoration projects include: the creation of low-relief, nature-based shoals and/or islands within the open waters of Sandusky Bay, in-water flow-through wetlands, restoration of historic in-water wetlands, and tributary floodplain wetland restoration to process nutrients and sediment loads derived from upstream agricultural fields. These projects will additionally address water quality degradation by attenuating wave action along the shoreline, trapping sediments, and nutrients, and reducing resuspension of fine sediments within Sandusky Bay. Moreover, shallow-water nursery and spawning habitats for native migratory fish communities that use both the Sandusky River and Sandusky Bay will be created or restored.

Cedar Point Causeway Wetland – Sandusky Bay/City of Sandusky, ODNR

The project is located on the eastern shore of outer Sandusky Bay along the west side of the Cedar Point Causeway. The proposed project will use fine-grained clean dredge material from the Sandusky Harbor Federal Navigation Channel to create a diverse 100 to 120-acre in-water emergent wetland complex with natural connections to the outer Sandusky Bay and an embayed channel providing a connection to East Sandusky Bay. Natural Lake Erie water level fluctuations between East Sandusky Bay and the Outer Bay will provide for the movement of water through the wetland complex that will facilitate nutrient and sediment processing and associated water quality improvements. The estimated cost of this project is $8 million with $5 million in Healthy Lake Erie funds and $3 million in Great Lakes Restoration Initiative funds to be invested in the project.

Sandusky River, Redhorse Bend Wetland Restoration/Black Swamp Conservancy

Redhorse Bend Nature Preserve (93 acres) lies along the Sandusky River on the north edge of Fremont. Project work on the property includes constructing wetlands on a portion of the parcel that is currently in grain production and creating a hydrologic connection to the Sandusky River as well as routing ditch flow into a seasonal floodplain wetland and prairie area. The preserve is owned by Black Swamp Conservancy and will be transferred to Sandusky County Parks to manage after restoration is complete. An estimated $976,000 of H2Ohio funding has been allocated for this project.

Fruth Outdoor Center, Wetland and Riparian Restoration/Seneca County Parks

The Seneca County Park District will acquire and restore wetlands on 23.6 acres of property in the headwaters of Wolf Creek, along Emerine Ditch. Restoration of a wet woods is planned, where a wooded wetland once existed. Breaking of tile to allow for hydrologic restoration below ground and planting of wetland vegetation above ground will help in the restoration process. The restoration of the proposed wetland will help filter agricultural runoff from surrounding farm fields. An estimated $309,000 of H2Ohio funding has been allocated for this project.

Crawford Park District, Sandusky Headwaters Preserve Wetland Restoration/Crawford Park District

The Crawford County Park District owns the 38-acre tract under consideration. The project will restore seven acres of wetlands, filtering agricultural runoff before flowing into the Sandusky River, in a current agricultural field with the remaining portion of the field to be planted in pollinator habitat. Additionally, a ditch will be re-routed through the wetland to filter out nutrients. The parcel also has riparian forest along the Sandusky River and forested uplands surrounding the agricultural field. Final details on H2Ohio funding will be available soon. An estimated $100,000 of H2Ohio funding has been allocated for this project.

Lake Erie Conservation Reserve Enhancement Program (CREP) and Great Lakes Fish and Wildlife Restoration Act (GLFWRA) Project Examples

The following two projects are examples of a wider array of wetland restoration projects under development through various partnerships between the ODNR Division of Wildlife Private Lands program, nongovernmental organizations, and state and federal partners.

Carstensen/Herman Wetlands/Lake Erie CREP/GLFWRA

This project includes restoration of two properties totaling 175 acres in agricultural production. Wetland restoration efforts included removing land from ag production, crushing or removing drainage tiles, and building dikes to re-establish wetland hydrology and adding connectivity to Crane Creek to allow for water level management. At project completion, approximately two wetland cells totaling 103 acres were restored and 62 acres of upland native grasses and wildflowers were established.

Smith Wetlands/Lake Erie CREP/GLFWRA

This project includes the restoration of three wetland cells totaling 51 acres which were in agricultural production. Wetland restoration efforts included removing land from agricultural production, crushing or removing drainage tiles, and building dikes to re-establish wetland hydrology and adding connectivity to Portage River to allow for water level management. Additionally, 30 acres of tiled agriculture drainage are pumped through two of the wetland cells before reaching the Portage River.

Central Lake Erie Basin Projects

Lorain In-Water Wetland/City of Lorain

The proposed in-water wetland project is located on the Lake Erie shoreline east of the mouth of the Black River adjacent to the Dike 14 CDF. This is a U.S. Army Corps of Engineers (USACE) Continuing Authorities Program (CAP) 204 project that is currently undergoing a feasibility analysis by the USACE. To date, 100 percent of project costs have been covered by the USACE. Once approved, a cost share agreement is developed where the USACE covers 65 percent of the engineering, design and construction costs, and the non-federal sponsor covers 35 percent of the engineering, design and construction costs. Project size, type and costs have yet to be determined.

Cleveland Harbor Wetland, Nature-Based Shoreline/Cleveland Metroparks, ODNR, ODOT, Port of Cleveland, City of Cleveland

The proposed Cleveland Harbor project will examine the potential for the beneficial use of local dredge materials to create natural habitat such as emergent wetlands, shrub habitat and coastal mud flats along the shoreline to absorb wave energy, improve water quality, and create additional habitat for bird, fish and other species. This project will enhance coastal resiliency and coastal water quality by protecting the shoreline and nearby critical infrastructure from storm events, high winds and the impact of changing lake levels, which are currently at historic highs due to recent wet weather events. This is a NOAA-funded planning project administered by the National Fish and Wildlife Foundation. Estimated cost is $251,000, with $125,000 provided by NFWF and $126,000 non-federal match provided by Cleveland Metroparks, Port of Cleveland, city of Cleveland, ODNR, and Ohio Department of Transportation.

Ashtabula Wetland/U.S. Army Corps of Engineers, Ashtabula Port

The proposed project will use fine-grained clean dredge material from the Ashtabula Harbor Federal Navigation Channel to create an in-water wetland on a 30-acre site located on the inside of the northeast breakwater within Ashtabula Harbor. This is a USACE Continuing Authorities Program (CAP) 204 project that has recently completed a 100 percent funded feasibility study by the USACE Buffalo District. A cost share agreement has been developed between the Port of Ashtabula and USACE, where USACE covers 65 percent of the engineering, design and construction costs, and the non-federal sponsor covers 35 percent of the engineering, design and construction costs. Total estimated project cost $13.85 million with $9 million provided by the USACE and $4.85 million provided as Healthy Lake Erie pass-through funds to the Port of Ashtabula as the non-federal sponsor.

H2Ohio Statewide Projects

Plans are currently under development for wetland restorations, wetland treatment trains, and other similar approaches to address nutrient enrichment issues and harmful algal blooms on inland lakes across Ohio. These projects are being considered for implementation on state-owned or operated properties adjacent to Grand Lake St. Marys, Buckeye Lake, Dillon Lake and Harsha Lake.

Appendix G: Lake Erie Tributary Nutrient Monitoring Strategy

This appendix describes the nutrient monitoring strategy for Lake Erie tributaries. Water quality monitoring in the basin has been a focus for decades. Two principal pour points, on the Maumee and Sandusky Rivers, have near continuous nutrient loading records dating to the early 1970s. These stations were pivotal in documenting loading trends and identifying loading targets for nutrients following the resurgence of algal blooms in the western Lake Erie basin (WLEB). Recent efforts have focused on refining the monitoring to get data at secondary and tertiary locations particularly in the Maumee Watershed. The refined monitoring considers the recommendations made in a 2015 report from the Northeast-Midwest Institute completed in conjunction with U.S. Geological Survey (USGS) (Betanzo, 2015).

The Maumee River watershed in Ohio is more than 4 million acres of diverse landscape superimposed by one dominant land use: row crop production. Producers use a variety of management practices to ensure the productivity of their crops while preventing the loss of soil and nutrients from their fields. In the previous effort for the Collaborative Framework, watershed resources were analyzed considering the available data in the watershed. These data sources included water quality monitoring data, water quality modeling results from a comprehensive SWAT modeling effort, geographic soil distributions, analysis of soil slope, land use data and livestock inventories. A comprehensive summary of these data sources and how they were used is detailed later in this appendix.

Until recently there were 16 sites within the WLEB and Sandusky River watersheds that had sufficient water quality and flow data for nutrient load calculations. These sites are maintained by both the National Center for Water Quality Research (NCWQR) at Heidelberg University and the USGS. Funds for the load monitoring stations are from federal, state and local governments as well as private enterprises. These stations were chosen to better understand the impact of loading from different regions within the WLEB and provide data for nutrient loading trends. However, many of these stations have been added since 2007 – yielding a relatively brief dataset for trends analysis. Refer to the monitoring strategy, Appendix B, of the previous version of Ohio’s Domestic Action Plan for more information about the history and funding of these stations.

The amount of time needed to detect changes in water quality decreases with watershed size (Betanzo, 2015). Therefore, a special focus is on areas where monitoring exists at scales smaller than 50 mi^2. Seven of the sites in Table G1 fit into the <50 mi^2 category. These small monitored watersheds are termed “sentinel” watersheds in this report.

The reason for prioritization at sentinel watersheds in the basin is to understand more quickly if targets are being achieved and provide feedback to what actions are most effective.

Tables G1 and G2 outline list the monitoring stations draining to the WLEB/Sandusky River basin and central basin, respectively. These tables include the sampling agency and data collection timeframe. Figures G1 and G2 show maps of monitoring stations draining to WLEB and Sandusky/central basin, respectively. On Figure G1, stations currently being monitored by the states of Michigan and Indiana are noted in addition to the stations monitored by Ohio parties.

Table G1: List of existing load monitoring stations in the Western Lake Erie Basin and Sandusky Bay within Ohio.

Geographic location	Monitoring Program Name	Sampling Agency	Timeframe
Maumee River near Waterville	Heidelberg Tributary Loading Program	NCWQR	1/10/1975-9/30/1978; 10/13/1981-current
Maumee River near Waterville	GLRI	USGS	continuous 2011-current – misc. WQ to ‘67
Sandusky River near Fremont	Heidelberg Tributary Loading Program	NCWQR	10/2/1974-current
Portage River at Woodville	Heidelberg Tributary Loading Program	NCWQR	8/30/2010-current
Blanchard River near Findlay	Heidelberg Tributary Loading Program	NCWQR	7/9/2007-current
Tiffin River at Stryker	Heidelberg Tributary Loading Program	NCWQR	7/9/2007-current
Honey Creek at Melmore	Heidelberg Tributary Loading Program	NCWQR	1/28/1976-current
Eagle Creek above Findlay	GLRI/city of Findlay	USGS	August 2012-current
Maumee River at Antwerp	WLEB ODNR and WLEB Ohio EPA (continuous probes)	USGS	2013 to current – misc. WQ back to 1952
Tiffin River near Evansport	WLEB ODNR	USGS	2013-current
Blanchard River near Dupont	WLEB ODNR	USGS	2013-current – misc. WQ back to 1966
Ottawa River near Kalida	WLEB ODNR	USGS	2013-current – misc. WQ back to 1966
Auglaize River near Defiance	WLEB ODNR	USGS	2013-current – misc. WQ back to 1952
Maumee River near Defiance	WLEB ODNR	USGS	2013-current – misc. WQ back to 1952
Auglaize River near Fort Jennings	WLEB ODNR	USGS	2013-current – misc. WQ back to 1965
Little Auglaize River at Melrose	WLEB Ohio EPA	USGS	2015-current
Auglaize River near Kossuth	WLEB Ohio EPA	USGS	March 2017-current
St. Marys River near Willshire	WLEB Ohio EPA	USGS	March 2017-current
St. Joseph River near Newville	WLEB Ohio EPA	USGS	March 2017-current
Sentinel watershed monitoring stations (draining areas less than 50 square miles)			
Unnamed Trib to Lost Ck nr Farmer	Heidelberg Tributary Loading Program	NCWQR	10/1/1981-9/30/1993; 10/1/2007-current
Rock Creek at Tiffin	Heidelberg Tributary Loading Program	NCWQR	October 1982-current
Little Flatrock near Junction	WLEB Ohio EPA	USGS	March 2017-current
Platter Creek near Sherwood	WLEB Ohio EPA	USGS	March 2017-current
Wolf Creek near Toledo at Holland	Expanded Heidelberg Tributary Loading Program	NCWQR	Begin October 2017
S. Turkeyfoot Creek near Shunk	Expanded Heidelberg Tributary Loading Program	NCWQR	Begin October 2017
Rock Creek near Republic	Expanded Heidelberg Tributary Loading Program	NCWQR	Begin October 2017
West Creek near Hamler	Expanded Heidelberg Tributary Loading Program	NCWQR	Begin October 2017

Table G2: List of existing load monitoring stations in the central Lake Erie basin within Ohio.

Geographic location	Monitoring Program Name	Sampling Agency	Timeframe
Sites in the Central Basin			
Cuyahoga River at Independence	Expanded Heidelberg Tributary Loading Program	NCWQR	1981-current
Vermillion River near mouth	GLRI	USGS	2011-current
Black River at Elyria	GLRI	USGS	2011-current
Old Woman Creek near Huron	NOAA	NOAA?	May 2016-current
Grand River near Painesville	GLRI	USGS	Begin 2017
Huron River at Milan	GLRI/Expanded Heidelberg Tributary Loading Program	USGS/ NCWQR	2014-current / Begin October 2017

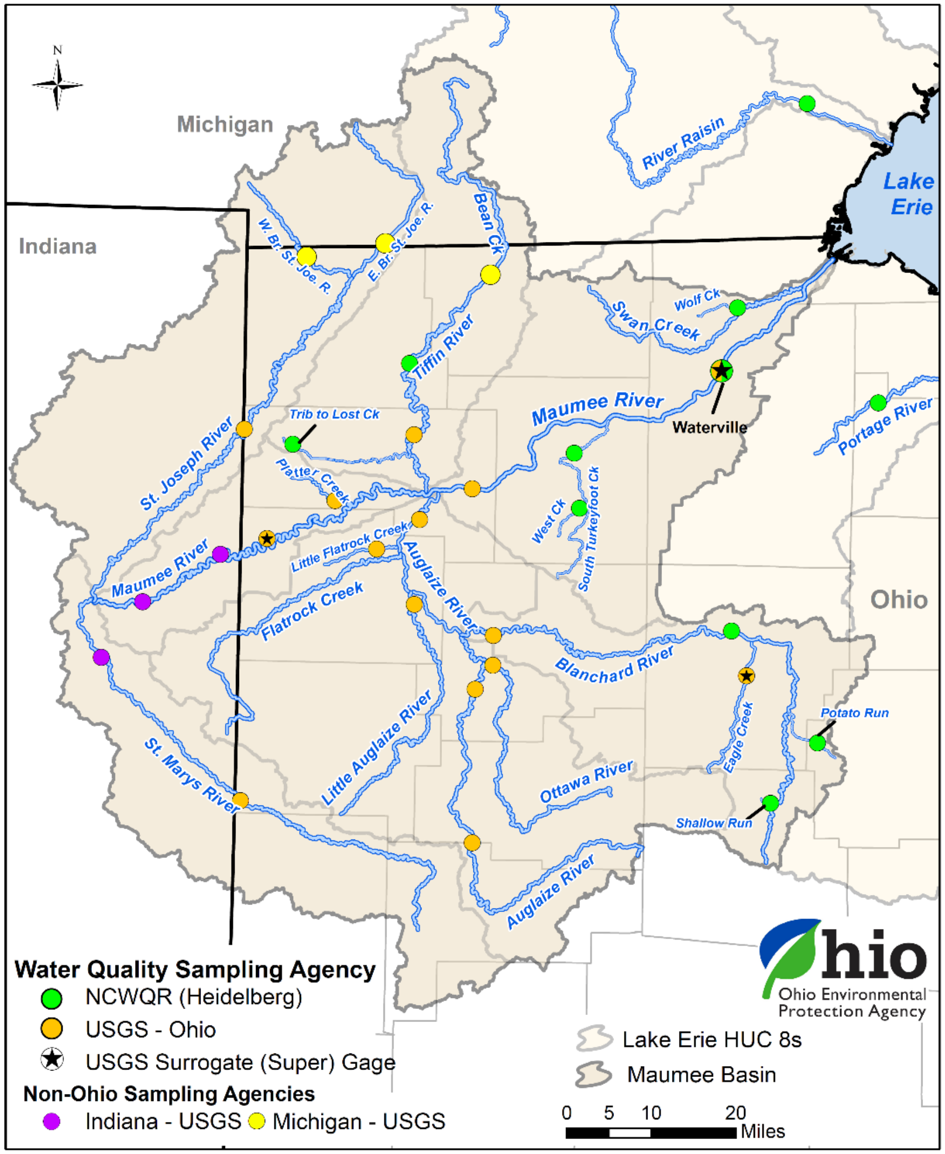


Figure G1: Existing load monitoring stations draining to the western Lake Erie basin.

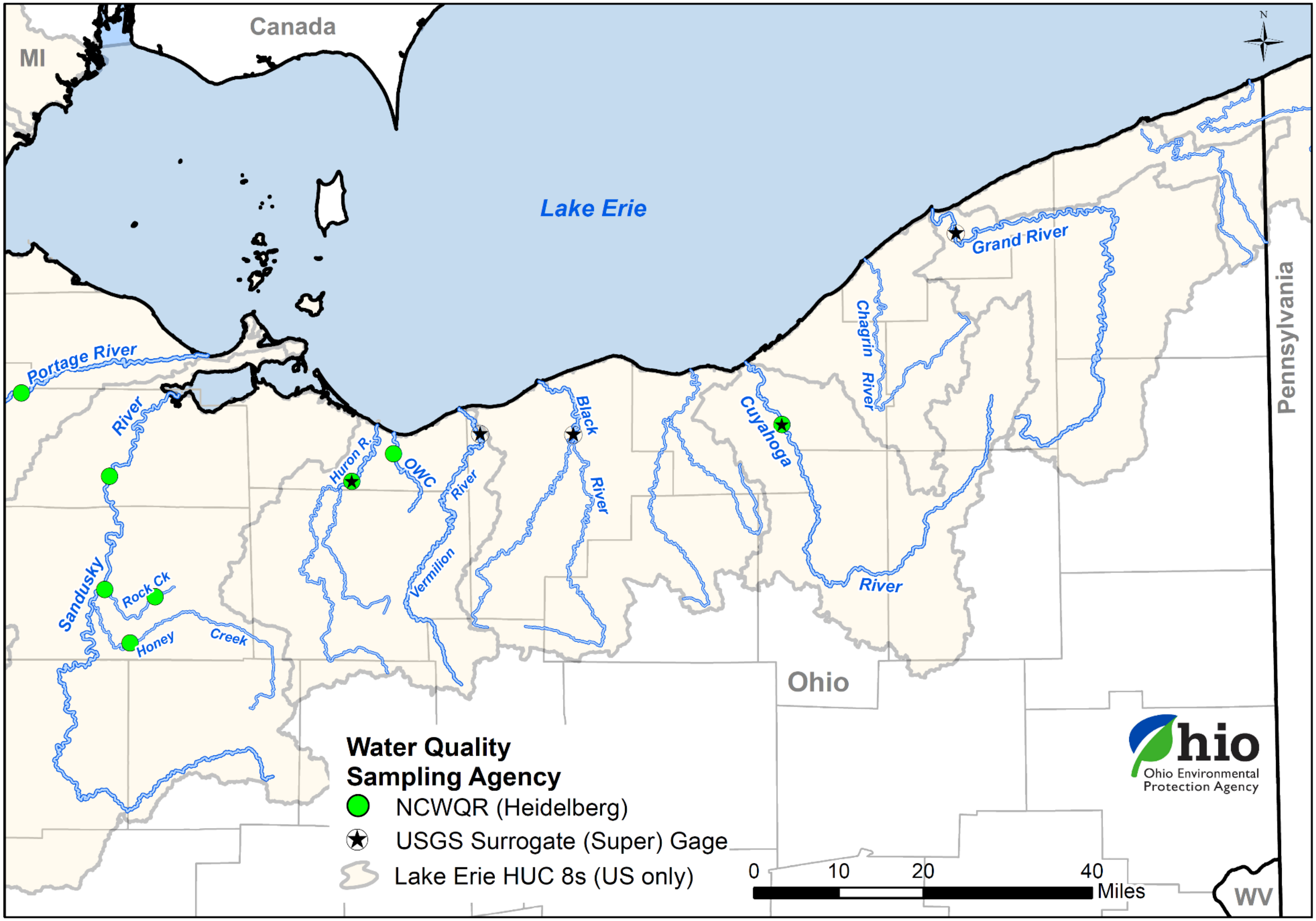


Figure G2: Existing load monitoring stations draining to the Sandusky Bay and central Lake Erie basins.

Sentinel Watersheds

A brief discussion of each sentinel watershed follows.

Unnamed Tributary to Lost Creek

This monitoring site drains a relatively small area that is less than five square miles within the Tiffin River watershed. Row-crop agriculture is the majority land use in this watershed, with some forest areas throughout; row crops do not dominate the land use as in many of the other sentinel watersheds. What makes this location unique is it has been monitored for greater than ten years. Among other reasons, this period of record could be useful in understanding hydrologic changes over time.

Little Flatrock Creek

Previous modeling efforts (Scavia, 2016) identified Little Flatrock Creek as a critical source area for dissolved reactive phosphorus (DRP). The influence of intense drainage practices and a high proportion of the land use dedicated to row crop agriculture were identified as the driving factors elevating DRP loading. Additionally, enhanced monitoring by Ohio EPA identified nutrient concentrations in Little Flatrock Creek that were consistently elevated above the three other sites monitored in the same program. Further, the size of Little Flatrock Creek (it drains 15 square miles at the monitoring location) makes it an ideal candidate for priority funding to assess watershed scale BMP implementation efforts on phosphorus loading.

Platter Creek

Manure management is often identified as an important component of phosphorus loading in the WLEB. Managing manure efficiently involves different challenges from using inorganic nutrients for row crop production. This can affect both the rate and timing of applications. Also, there is little watershed scale data that can be used to understand loadings in areas with higher portions of the land area being influenced by manure applications. Platter Creek has several large Concentrated Animal Feeding Operations (CAFOs) and is a good area to understand the influence of manure management on watershed loading. Further, the relatively small size of Platter Creek (it drains 19.5 square miles at the monitoring location) makes it an ideal candidate for priority funding to assess watershed scale BMP implementation efforts on phosphorus loading.

Wolf Creek

Wolf Creek differs from most of the focused monitoring areas because the land use is dominated by suburban development. While row crop agriculture dominates the greater basin and bears the largest share of the nutrient load, it is important to understand the role of the urban and suburban community. This subwatershed was also part of the Natural Resouce Conservation Service's (NRCS) Regional Conservation Partnership Program (RCPP) and continued monitoring will serve to understand the influence of a different subset of BMPs on phosphorus loading in the Maumee Basin.

South Turkeyfoot Creek/West Creek

These two watersheds have been a part of the RCPP administered by NRCS. They are also representative of an area that has a very high portion of the land use dedicated to row crop agriculture. The soils are highly productive and generally respond well to tile drainage. Prior monitoring in the basin and its representativeness of a large segment of the agriculture in the basin are reasons for continuing the monitoring effort at these sites. The West Creek sampling station is nested within the South Turkeyfoot Creek Watershed. The understanding of scale and nutrient routing through the basin was a deciding factor in deciding to nest this gaging station. Further, the size of West Creek (it drains 15.5 square miles at the monitoring location) makes is an ideal candidate for priority funding to assess watershed scale BMP implementation efforts of phosphorus loading.

Rock Creek

The Rock Creek monitoring station is the only sentinel watershed within the Sandusky River Basin. Like the West Creek monitoring station, the Rock Creek station is nested within a downstream monitoring station also on Rock Creek. This again serves to understand the influence of scale on interpreting nutrient loads. Further, due to the size the upper Rock Creek monitoring station (it drains 15 square miles here) it makes it an ideal candidate for priority funding to assess watershed scale BMP implementation efforts on phosphorus loading.

Other Monitoring

The state of Ohio is also investing in additional monitoring with funding from H2Ohio. This work involves expanding the Ohio River watersheds included in Ohio's Nutrient Mass Balance Study and expanding the rain gage network in northern Ohio. Twenty new rain gages will fill a critical gap that the National Weather Service has identified. In northwest Ohio, centered on the Maumee River watershed, precipitation data is relatively coarse due to the distance from regional Doppler weather radars and a current lack of rain gage density. Figure G3 shows the location of the new rain gages. These data will be used to improve rainfall and flooding forecasting. Additionally, the data will provide for better water quality modeling accuracy and agricultural nutrient management.

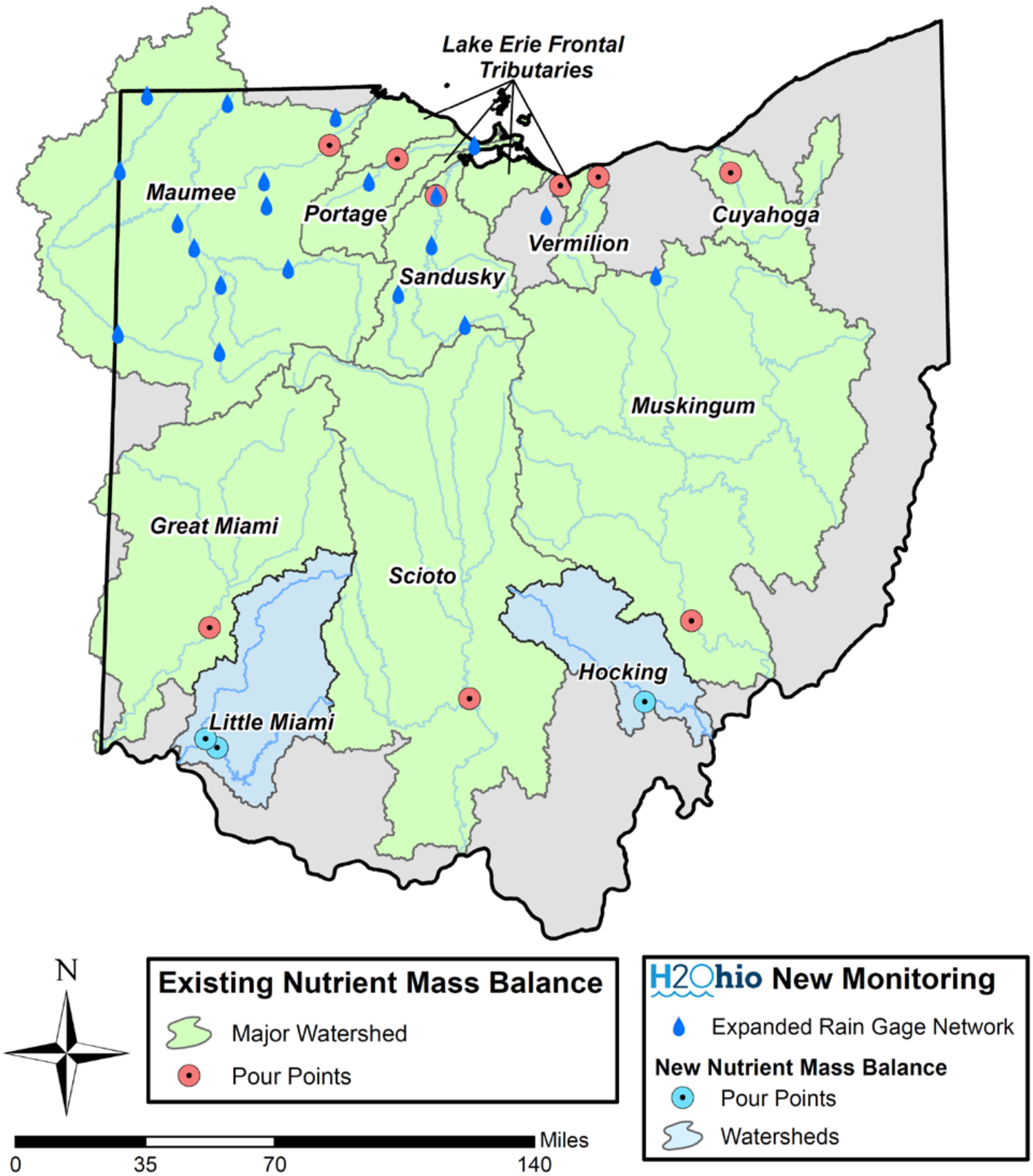


Figure G3: H2Ohio monitoring investment starting in 2020.

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Appendix H: Portage River Targets Methodology

Introduction

For the Portage River, no total phosphorus (TP) or soluble reactive phosphorus (SRP) target loads to address harmful algal blooms (HABs) (i.e., spring, March-July load) have been developed to meet the goals of the 2012 Great Lakes Water Quality Agreement - Annex 4. The current Portage River water year[27] 2008 TP load estimate and 40 percent reduction annual target load to address hypoxia goals are 359 and 215 metric tons per annum (mta), respectively (U.S. EPA 2018). These loads include the other western Lake Erie tributaries between the mouth of the Maumee and Portage rivers, of which the Toussaint River is the largest. We have calculated the flow weighted mean concentration (FWMC) for these 2008 and target load at the Portage River U.S. Geological Survey (USGS) gage to be 0.24 and 0.15 mg/L, respectively. As explained below, Ohio EPA believes these values are too low. If used to set targets they would be unreasonably low.

These loads were derived in a study that employed the Stratified Beale's Ratio Estimator based on thirteen 2008 grab samples collected by Ohio EPA (Maccoux, 2016). Due to the relatively few samples used in this calculation, the temporal manner with which these samples were collected (e.g., little attention to monitoring storm flows) and known issues with Ohio EPA's TP laboratory analysis of the time, Ohio EPA here proposes refining the annual target load for the Portage River. Also, this document includes proposed spring TP and SRP target loads for the Portage River.

Heidelberg's National Center for Water Quality Research (NCWQR) began frequent water quality monitoring at the Portage River at Woodville USGS gage (number 04195500) in 2010. Data from this monitoring is available for the complete water years(wy) 2011 through 2017. This document intends to use these water quality data to develop a more refined annual TP target load and a new TP and SRP spring target loads. We propose target loads and resulting FWMC calculated to the USGS gage and for the entire Portage River watershed. The Lake Erie tributaries between the Maumee and Portage rivers are not included in these targets.

Development of New Target

Water year 2008 has been determined the baseline year by which to calculate the Annex 4 springtime HAB TP and DRP and annual TP hypoxia targets. U.S. EPA (2018) notes that high confidence in the lake-wide and some tributaries, like the Maumee, total loads for wy 2008 exist. However, some tributaries, like the Portage, have estimated 2008 loads based on very limited data.

Given the proximity, ecoregion, and similar land use of the Portage and Maumee river watersheds (both with about 80 percent agricultural land), a comparison of these two watersheds is reasonable. The streamflow water yield at each river's monitoring gage is very similar; a median from 1998 to 2017 of 13.5 and 13.9 inches respectively (Ohio EPA, 2018). Table H1 shows the annual and spring average streamflow rankings for each wy 2002 through 2017. This time span has been determined to be representative of the current magnitude of nutrient export (U.S. EPA, 2018). Note that annual stream flow in wy 2008 is the ranked highest in both watersheds.

[27] A water year (wy) is a 12-month period that starts on October 1 of each year and is named for the year of its September-ending date. The beginning of a water year differs from the calendar year so that precipitation and its associated subsequent runoff are accounted for in the same 12-month period. Late autumn and winter snowfall that may accumulate in the ensuing months will not drain and discharge until the following spring (or summer) snowmelt.

Table H1: Spring (April through July) and annual streamflow rank and percentile in parenthesis for the last 16 water years of the Portage River at Woodville and Maumee River at Waterville USGS gages. Highest flow is ranked 1 in each column.

	Portage River Streamflow Rank (Percentile)		Maumee River Streamflow Rank (Percentile)	
Water Year	Spring	Annual	Spring	Annual
2002	13, (20th)	11, (33rd)	11, (33rd)	6, (66th)
2003	5, (73rd)	12, (26th)	4, (80th)	10, (40th)
2004	14, (13th)	14, (13th)	10, (40th)	11, (33rd)
2005	15, (6th)	5, (73rd)	15, (6th)	8, (53rd)
2006	11, (33rd)	9, (46th)	14, (13th)	12, (26th)
2007	12, (26th)	3, (86th)	13, (20th)	2, (93rd)
2008	3, (86th)	1, (100th)	5, (73rd)	1, (100th)
2009	8, (53rd)	13, (20th)	9, (46th)	13, (20th)
2010	7, (60th)	16, (0th)	6, (66th)	15, (6th)
2011	1, (100th)	2, (93rd)	2, (93rd)	5, (73rd)
2012	16, (0th)	4, (80th)	16, (0th)	7, (60th)
2013	6, (66th)	10, (40th)	8, (53rd)	14, (13th)
2014	10, (40th)	6, (66th)	7, (60th)	9, (46th)
2015	2, (93rd)	7, (60th)	1, (100th)	4, (80th)
2016	9, (46th)	15, (6th)	12, (26th)	16, (0th)
2017	4, (80th)	8, (53rd)	3, (86th)	3, (86th)

Figures H1 and H2 show the Portage and Maumee annual FWMC for TP and SRP, respectively. These plots contain all the years that Heidelberg's NCWQR data is available for the Portage River. Of the seven years, the average FWMC's in mg/L of TP and SRP are very similar at 0.36 and 0.10 for the Portage and 0.36 and 0.09 for the Maumee. Due to the similarity of hydrology and concentrations, it is reasonable to assume that the load exported from the Portage River in wy 2008, like the Maumee River, would be appropriate to index reductions.

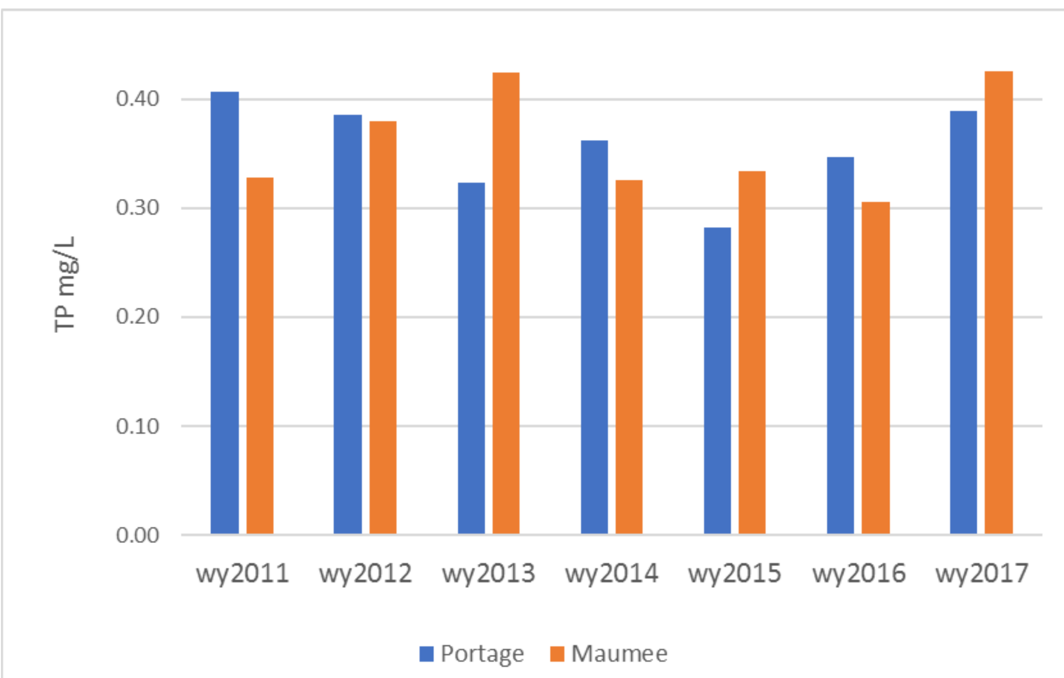

Figure H1: Flow weighted mean TP concentration for the Portage River at Woodville and Maumee River at Waterville calculated used USGS flow data and Heidelberg NWQRC data.

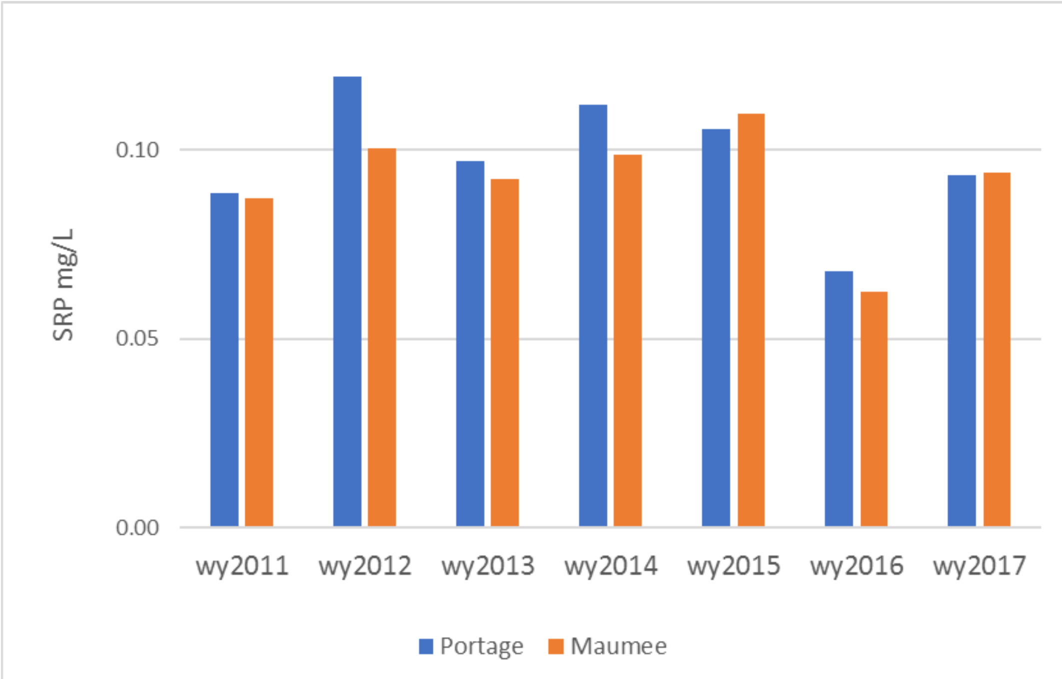

Figure H2: Flow weighted mean SRP concentration for the Portage River at Woodville and Maumee River at Waterville calculated used USGS flow data and Heidelberg NWQRC data.

The LOADEST Tool

We investigated using the LOADEST tool to determine wy 2008 Portage River phosphorus loads. LOADEST is a tool used for estimating constituent loads in streams (Runkel, 2014). It uses a time series of streamflow and constituent concentrations as inputs. LOADEST outputs regression models that can be used to estimate the constituent's load based on a flow record. The tool works by employing statistical estimation methods. Several predefined models that consider different weightings of hydrologic and/or temporal factors are calculated.

LOADEST was run with the seven years of Heidelberg's NCWQR of TP concentrations and USGS flows entered. The results of all nine models were subsequently examined, and a similar pattern was noted. The regressions developed all had very acceptable fit statistics but were overestimating the highest loads. To test this, the two best fitting models were used to predict TP for wys 2011-2017. Since those are the same years that TP concentrations were input to develop the models, the fit expectations are high. Figure H3, however, shows on an annual scale that the modeled load overpredicts observed loads by 77 percent, on average. The highest FWMC of these years equals 1.18 mg/L, a value well over the 0.41 mg/L calculated from our calculations of Heidelberg's data.

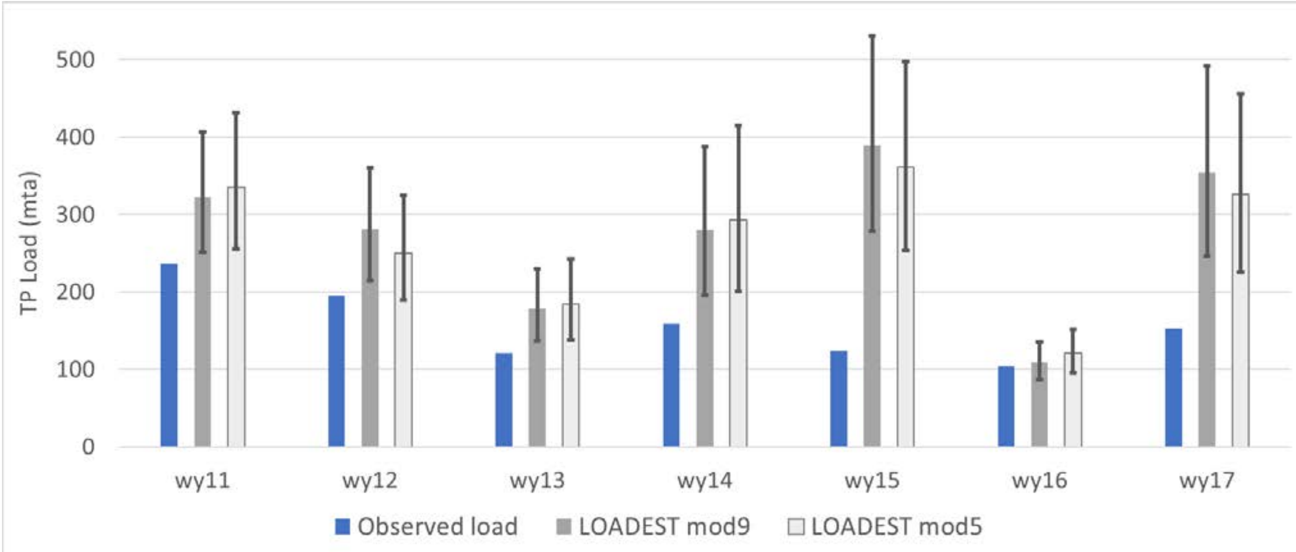

Figure H3: Portage River at Woodville annual TP calculated observed loads (from Heidelberg's NCWQR data) and predicted (from two LOADEST models).

Target Selection

Due to the overprediction from LOADEST, we considered basing targets on one of the years monitored by NCWQR, wys 2011-2017. Of the past 16 years of streamflow wy 2011 is notable for being the second highest annual and highest spring streamflow, see Table H1. As seen in Figure H3, wy 2011 has the greatest TP load of the seven years of Portage River monitoring. Due to its hydrologic similarity to wy 2008, the loads and FWMCs of Portage's wy 2011 were compared to Maumee's wy 2008 (Table H2). The FWMC's of all values compared are similar with the spring SRP identical for the two basins. Based on this, the Annex 4 spring TP and SRP targets to address HABs and annual TP target to address central basin hypoxia for the Portage River will be based on wy 2011 at the Woodville USGS gage. Following the 40 percent load reduction outlined by Annex 4, Table H3 shows the target loads and FWMCs for the Portage River at the monitoring location. Table H4 shows the Annex 4 target loads for the Portage River complete watershed. The target annual and spring TP loads downstream of the gage were calculated via the same methods applied in Ohio's nutrient mass balance report (Ohio EPA, 2018). The spring SRP load downstream of the gage was calculated by using the yield of wy 2011 annual SRP to TP and applying it to spring calculating TP load. Because of this, the same flow weighted mean concentration targets are recommended for at the monitoring location and for the complete watershed.

Table H2: Existing loads and flow weighted mean concentrations for the Portage and Maumee rivers at each stream's monitoring gage.

Tributary (at gage)	Spring (March-July) Load (MTA)	FWMC (mg/L)	Annual Load (MTA)	FWMC (mg/L)
Portage River (based on wy 2011)	195 TP	0.45 TP	237 TP	0.41 TP
	37 SRP	0.08 SRP		
Maumee River (based on wy 2008)	1,415 TP	0.38 TP	3561 TP	0.44 TP
	303 SRP	0.08 SRP		

Table H3: Target loads and flow weighted mean concentrations for the Portage River at the stream monitoring gage.

Tributary (at gage)	**Spring Targets (March-July)** Load (MTA)	FWMC (mg/L)	**Annual Targets** Load (MTA)	FWMC (mg/L)
Portage River (based on wy 2011)	117 TP	0.27 TP	142 TP	0.24 TP
	22 SRP	0.05 SRP		

Table H4: Target loads and flow weighted mean concentrations for the Portage River complete watershed.

Tributary	Spring Targets (March-July)		Annual Targets	
	Load (MTA)	FWMC (mg/L)	Load (MTA)	FWMC (mg/L)
Portage River (based on wy 2011)	159 TP	0.27 TP	194 TP	0.24 TP
	30 SRP	0.05 SRP		

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