THE COST TO MEET WATER QUALITY GOALS

in the Western Basin of Lake Erie

AUTHORS/ORGANIZATIONS:
Alliance for the Great Lakes
Ohio Environmental Council

TECHNICAL SUPPORT:
Delta Institute
LimnoTech

I. Executive Summary

The Western Basin of Lake Erie is an important regional resource providing drinking water to millions of residents and hundreds of millions of dollars in economic value. Excessive nutrient inputs to the Lake from municipal development and agricultural uses have led to chronic algal bloom growth which can harm human and ecological health as well as tourism and recreation in the region. In 2015, under the Great Lakes Water Quality Agreement, the United States and Canadian governments agreed to reduce total phosphorus (TP) entering the Western Basin of Lake Erie by 40% by 2025 to control algal bloom growth and improve Lake Erie's water quality. Since the agreement, and despite hundreds of millions of dollars spent in the watershed, water quality issues persist in the Western Basin. While municipal wastewater facilities have made significant improvements and reductions in total phosphorus discharges that enter the Western Basin, reducing agricultural phosphorus contributions remains an outstanding issue where much less progress has been made. The agricultural community, with support from public and nongovernmental entities, has implemented thousands of new conservation practices across the watershed to reduce agriculture's phosphorus loading to the Western Basin. Despite these investments, agricultural phosphorus losses to the Western Basin remain above targets set in 2015. The questions facing state and federal agencies and stakeholders across the region are how many conservation practices will it take to achieve the 40% total phosphorus reduction and, more importantly, how much will those practices cost? To answer these questions, the Alliance for the Great Lakes and Ohio Environmental Council – with technical support from LimnoTech and the Delta Institute – designed a process to estimate needed agricultural conservation practices in the Western Basin of Lake Erie watershed and the associated costs for both Michigan and Ohio to implement these needed practices. Our analysis found:

- Michigan and Ohio would need to increase spending on conservation by $40-65 million and $170-250 million annually, respectively, over current investments to meet water quality objectives in the Western Basin of Lake Erie.
- Michigan and Ohio need to implement and maintain from two to four in-field BMPs on virtually all agricultural acres along with structural BMPs to meet the load reduction target to meet water quality objectives in the Western Basin of Lake Erie.
- Annual, in-field conservation practices are not sufficient to meet water quality objectives and both Michigan and Ohio must significantly increase adoption of structural and semi-permanent conservation practices.

II. Introduction

The Western Basin of the Lake Erie (WB) watershed covers approximately seven million acres across Michigan, Ohio, and Indiana and is a valuable regional resource that supplies drinking water to millions of people and generates millions of dollars in tourism and recreational value. Because of its shallow depth, warm waters, sufficient residence time, and excessive input of nutrients from the surrounding land base, the Western Basin is particularly susceptible to chronic, annual algal blooms. On average, runoff from nonpoint sources is responsible for over 70 percent of the total phosphorus (TP) load entering Lake Erie each year (Scavia, et al. 2016). In the Western Basin of Lake Erie watershed specifically, nonpoint sources, largely from agricultural lands, are estimated to contribute upwards of 89 percent of the annual total phosphorus load.

The persistence of algal blooms has real impacts on residents who rely on the Lake. In 2014, Toledo famously was required to issue a “do not drink” order to over 500,000 residents due to algal toxins fouling the water intake supply and overwhelming their treatment capabilities. Since 2014 the City of Toledo – and other municipalities in Ohio – have updated antiquated infrastructure and implemented additional monitoring and treatment processes to ensure an event like 2014 does not happen again. While those processes are obviously vital to preserve human health, they come at a real cost to ratepayers. A 2022 analysis of public water supply system data provided to the Ohio Environmental Protection Agency found that a family of five in Toledo is paying nearly $100 annually to address harmful algal bloom (HAB) monitoring, treatment, and disposal (Alliance for the Great Lakes 2022).

Reducing nutrient pollution – particularly phosphorus – entering the WB is critical to reducing HABs and protecting public health and the WB’s economic value. 2020 marked the five-year benchmark for achieving the ten-year goal of a 40% reduction in phosphorus entering the WB by 2025, a binational target agreed upon by the Governors of Michigan and Ohio and the Premier of Ontario. Along with the overall 40% reduction target, Michigan and Ohio committed to meet an interim 20% reduction target by 2020, which was not achieved.

To combat agricultural runoff, state and federal agencies largely rely on the voluntary adoption of subsidized agricultural best management practices (BMPs) to control phosphorus entering the WB and its tributaries. In 2021 alone over $100 million of state and federal funding went to landowners in Michigan and Ohio to offset the cost of BMP implementation in the WB watershed. Despite significant investments in BMP implementation and wastewater treatment facility upgrades that have reportedly reduced annual TP loads by hundreds of metric tons per year (USA and Canada 2022), overall water quality in the WB and flow-normalized loads in its tributaries have remained largely unchanged since finalizing the GLWQA Annex 4 process (OLEC 2021, Rowland et al. 2021, GLWQA Annex Subcommittee, 2019).

Of particular interest to state and federal agencies is how best to address agricultural nonpoint source loading in the WB tributaries, which is the largest unregulated pollution source in the watershed. Until recently, state agencies and decision-makers faced challenges identifying specific BMP implementation strategies and funding levels needed to achieve the 40% TP reduction targets in the WB. Lacking more specific strategies, the default approach was generally to "get as many acres enrolled as possible," which has merit but presents challenges for tracking progress and identifying targeted locations for new BMP investments.

In an effort to determine more optimal BMP placement to achieve phosphorus reductions, the Michigan Department of Agriculture and Rural Development, Department of Environment Great Lakes and Energy, and Department of Natural Resources recently utilized the Agricultural Conservation Planning Framework (ACPF) – a tool developed by the US Department of Agriculture – to conduct a field-by-field assessment to prioritize and map fields for conservation implementation in Michigan's portion of the watershed based on physical characteristics and in-field management practices. The agencies are in the process of mapping all of Michigan's sub-watersheds in the WB watershed to provide a more strategic roadmap for BMP implementation. Similarly, Ohio is exploring strategies to implement BMPs more efficiently through the development of watershed plans, which may include the use of ACPF to improve siting of structural practices. Ohio also continues to invest substantially in wetland construction through the H2Ohio program and BMP implementation under the Ohio Agricultural Conservation Initiative (OACI) with the goal of curbing phosphorus inputs into the WB. What these new tools and planning efforts like the Annex 4 process did not define, or estimate, is the scale and associated cost of BMP implementation necessary to meet the 40% TP reduction target. Understanding the scale and cost is important for agency officials who are largely tasked with defining a plan to meet water quality goals. This information is also critical for taxpayers, and landowners who ultimately shoulder the burden of implementing additional conservation practices.

In an effort to quantify needed agricultural BMP implementation in the WB watershed and associated costs, the Alliance for the Great Lakes and the Ohio Environmental Council – with technical assistance from LimnoTech and the Delta Institute (the "project team") – designed a process to estimate these conservation targets and costs. **The goal of this report is to highlight the sizable gap between current spending in the WB watershed and the projected funding needed to achieve nonpoint source reduction targets in Michigan and Ohio.** Our expectation is that this report will also inform future decisions around BMP prioritization and implementation by state and federal agencies and conservation professionals.

The goal of this report is to highlight the sizable gap between current spending in the WB watershed and the projected funding needed to achieve nonpoint source reduction targets in Michigan and Ohio.

III. Best Management Adoption Scenarios

Previous efforts have explored anticipated changes to water quality that can result from the implementation of various BMPs in the WB watershed (Bosch et al. 2013, Scavia et al. 2016, Muenich et al. 2017, Martin et al. 2021, and others). One of the more comprehensive examples is Scavia et al. (2016), which modeled 11 scenarios with different cropping systems and BMP adoption rates (e.g., nutrient management planning on 25% of WB basin acres) and compared the phosphorus reductions achieved under each scenario relative to the Annex 4 goals. Unfortunately, previous efforts like Scavia et al. (2016) were largely dismissed by conservation practitioners and agency staff as being too theoretical.

The Project Team's analysis took a more targeted approach and constructed a series of BMP implementation scenarios that could (i.e., based on model predictions, not on probability of adoption or of obtaining funding) achieve the 40% reduction targets in the WB. Our project team also went beyond – to our knowledge – the literature by calculating the annual cost of each scenario over a 20-year implementation timeframe. Our project team believes our scenario design, coupled with estimated costs, provides a more comprehensive understanding of the actual financial investments needed to achieve the 40% TP reduction than most prior academic and agency efforts.

The following section outlines the core assumptions and methodology used to construct the BMP implementation scenarios. While our methodology description is, at times, granular, the details are important to building technically sound and reproducible results. The BMP scenario development process was also informed by numerous conversations with agency staff in Michigan and Ohio as well as with conservation practitioners.

An important note, the scenarios in this report only considered BMP implementation, and associated costs, in Michigan and Ohio. Analyzing Indiana and Ontario's portion of the watershed was outside the scope of this effort.

A. METHODOLOGY

The BMP implementation scenarios described in this report are framed around the recommendation that both Michigan and Ohio need to achieve a 40% TP reduction across all sources (i.e., point and nonpoint) in the WB watershed to meet the Annex 4 water quality targets. Our team acknowledges that Michigan, for example, asserts it has met at least a 20% TP reduction to the WB through reductions at wastewater treatment facilities – particularly upgrades at the Great Lakes Water Authority wastewater facility in Detroit (State of Michigan, 2021). Similarly, Ohio's modeling and estimates indicate a 10% reduction of nonpoint sources of phosphorus to date, largely through efforts with the H2Ohio program (IJC, 2022).

This report assumes – despite these reductions – that both Michigan and Ohio still need to reduce all sources, including nonpoint sources in the watershed by 40% to meet Annex 4 targets established for the River Raisin, Maumee tributaries, and Ottawa-Stony watersheds per the Annex 4 Task Team recommendations. Although other point and nonpoint sources contribute to the TP loading to the WB, the scenarios described in this analysis focus only on reductions of agricultural nonpoint source TP loads as they make up by far the largest percentage of the load.

The scenarios developed for this report only consider the impact that BMPs can have on total phosphorus (TP) reductions. While our project team recognizes the importance of addressing dissolved reactive phosphorus (DRP) because it is highly bioavailable and is a significant driver of algal bloom formation, our ability to estimate DRP reductions is limited by the availability of data needed for and of appropriate watershed models. Additionally, the underlying USGS SPARROW model used in this report is specific to TP and is not equipped to model DRP reductions. More complex Soil and Water Assessment Tool (SWAT) models that simulate both TP and DRP exist to an extent; however, running them was beyond the scope of this effort and, more importantly, we are unaware of an available SWAT model that covers all of the Michigan, Ohio, and Indiana basins. It is worth noting that while not estimated separately here, certain best management activities and projects that reduce TP also yield DRP reductions (Martin et al. 2021).

A.2 BACKGROUND ON BASELINE LOADING

The 40% TP reduction goal for tributaries discharging to the WB was determined by the Annex 4 subcommittee of the Great Lakes Water Quality Agreement (Annex 4 Objectives and Targets Task Team 2015). The Annex 4 subcommittee also defined 2008 as the baseline year against which phosphorus reductions are measured. Initial annual TP load estimates to Lake Erie were based on the work of Dolan and Chapra (2012) and later Maccoux et al. (2016). During the development of federal and state domestic action plans and adaptive management plans, baseline loads and loading targets were revisited and given more specificity (USEPA 2018; State of Michigan 2021; State of Ohio 2020). The baseline annual TP loads to which the 40% load reduction goals were applied are shown in Table 1 for the four U.S. tributaries evaluated in this effort. Note, although the Sandusky River is typically considered a Central Basin tributary, we included it in this effort due to its emphasis as a priority tributary in the federal and Ohio domestic action plans.

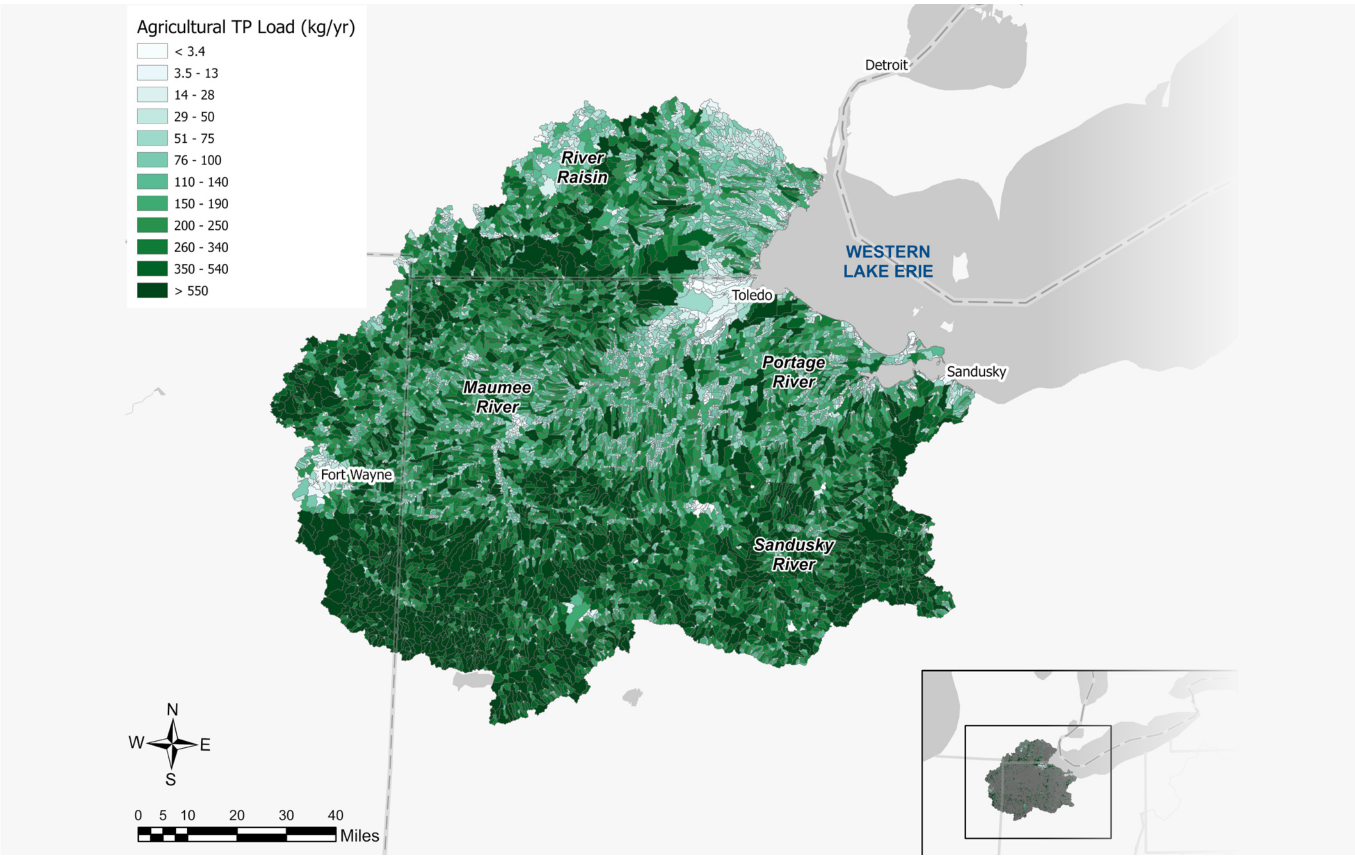
TABLE 1: BASELINE AND TARGET PHOSPHORUS LOADING

TRIBUTARY	WT 2008 LOAD (MT/YR)	TARGET LOAD (MT/YR)	REFERENCE
RAISIN	172	103	State of Michigan (2021)
MAUMEE (OVERALL)	3812	2287	State of Ohio (2020)
> MAUMEE (MI)	267	160	USEPA (2018)
> MAUMEE (IN)	724	435	USEPA (2018)
> MAUMEE (OH)	2821	1693	USEPA (2018)
PORTAGE	323	194	State of Ohio (2020)
SANDUSKY	1100	660	State of Ohio (2020)

Although the Annex 4 task team established the 40% annual and spring TP load reductions for WB tributaries, it did not provide a detailed breakdown of the load sources for each priority watershed, nor did it prescribe specific management strategies that could be used to achieve the load targets. To understand the nature of agricultural BMP implementation needed to meet the targets, we compiled a variety of resources that became available after the Annex 4 task team process was completed. This included a recent USGS study (Robertson and Saad 2019) that estimated the relative proportions of the TP load contributed by agricultural inputs (inorganic fertilizer and manure), urban runoff, natural sources, and wastewater discharges for the entirety of the U.S. Lake Erie watershed at a relatively fine (i.e., NHD+ catchment) spatial scale.

Figure 1 shows the model-estimated TP loading from agricultural sources for watersheds in the Western Lake Erie drainage basin. To achieve a baseline loading estimate equivalent to the 2008 water year loads used by the Annex 4 task team, our project team modified the Robertson and Saad (2019) TP loads, which represented the average hydrologic conditions for the 2000-2014 period, by proportionally scaling the nonpoint source categories while holding the point source contributions constant (because they are relatively constant year-to-year). Through this process of coupling the Annex 4 target setting work with the recent USGS study, we were able to establish more detailed estimates of baseline conditions necessary to complete our evaluation of alternatives for achieving phosphorus load reductions from agricultural nonpoint sources.

FIGURE 1: NHD+ Catchment Scale Agricultural TP Loads Estimated By USGS Sparrow Modeling (Robertson And Saad 2019) For Lake Erie Watersheds Considered In This Study.



Obtained From USGS Sparrow Mapper: https://Sparrow.Wim.Usgs.Gov/Sparrow-Midwest-2012/.

A.3 BMP SELECTION AND EFFICACY

The project team considered dozens of agricultural BMPs but ultimately selected four annual, in-field BMPs (subsurface nutrient placement, cover crops, conservation crop rotation, and continuous no-till) and four edge-of-field or downstream structural BMPs (filter strips, constructed wetlands, grassed waterways, and two-stage ditches) for this analysis. These BMPs are more common throughout the WB watershed and, in the case of the annual in-field practices, are among the most heavily promoted by state and federal programs.

The project team opted not to include nutrient management planning (NMP) as a standalone BMP given the umbrella of practices and management options that fall under the NMP framework. The broad nature of nutrient management planning is valuable but does not independently allow for defining a TP removal efficiency and associated costs, which inhibits our ability to accurately include the impact of NM in this analysis. The project team also opted to include continuous no-till and exclude reduced tillage. Relative to the 2008 baseline, research suggests most farms are likely practicing some form of reduced tillage so the percentage of eligible land available for implementing more reduced tillage is relatively low (USDA NRCS 2017). Similar to nutrient management planning, "reduced tillage" can take many different forms, which makes it difficult to assign both TP removal efficiencies and costs. Finally, this analysis assumes that subsurface injection involves minimal soil disturbance and is not synonymous with incorporation of fertilizer via tillage (conventional or strip) and thus is compatible with continuous no-till systems.

Several watershed models[1] have been developed, calibrated, and applied over the last decade to assess agricultural nutrient management strategies in the River Raisin, Maumee River, and other WB tributaries by researchers from a variety of academic and government institutions including Heidelberg University, Michigan State University, University of Notre Dame, Ohio State University, University of Michigan, University of Toledo, Texas A&M, USDA ARS, and USGS. These studies, along with the State of Ohio's 2020 Domestic Action Plan for Lake Erie (State of Ohio 2020), served as the basis for determining BMP efficacy for this project, as summarized in Table 2.

TABLE 2: BMP TOTAL PHOSPHORUS REMOVAL EFFICIENCY ESTIMATES

BEST MANAGEMENT PRACTICE	TOTAL PHOSPHORUS REMOVAL EFFICIENCY
SUBSURFACE PLACEMENT	20%
COVER CROPS	25%
CONSERVATION CROP ROTATION	25%
CONTINUOUS NO-TILL	30%
GRASSED WATERWAYS	20%
TWO-STAGE DITCHES	20%
FILTER STRIPS	35%
CONSTRUCTED WETLANDS	40%

[1] Bosch et al. 2011; Bosch et al. 2013; Bosch et al. 2014; Pyo et al. 2017; Sommerlot et al. 2013; Woznicki et al. 2015; Scavia et al. 2016; Wilson et al. 2017; Daggupati et al. 2015; USDA NRCS 2016; Keitzer et al. 2016; Yen et al. 2016; USDA NRCS 2017; Christopher et al. 2017; Merriman et al. 2018, Muenich et al. 2017; Martin et al. 2019; Martin et al. 2021

Notably, phosphorus removal efficiency can vary widely on a field-by-field basis due to physical and chemical characteristics of the farm, configuration of the BMP itself, and other factors. This is particularly true for farm fields where the majority of phosphorus loss occurs through subsurface drainage structures. Similarly, the effectiveness of BMPs at addressing phosphorus losses resulting from different types of commercial fertilizer or manure application were not explicitly considered in this effort. Although further refinement of the scenarios and removal efficiencies at a more localized, subwatershed scale could be done, the overall average removal efficiencies in Table 2 were deemed appropriate for the purposes and scale of this effort.

Current research and practical experience confirm that an individual BMP, even when implemented on 100% of cropland acres, is not sufficient to achieve the 40% TP reduction goals, nor is it realistic to assume 100% adoption of the same BMP across an entire watershed of this scale. Given that reality, this analysis combines multiple BMPs into one "scenario" and measures projected TP reductions based on varying BMP implementation rates in each scenario. This approach, often referred to as "stacking BMPs," uses a "multiplicative" approach, like that used in the Chesapeake Bay Program (CPB 2018), which assumed incremental rather than additive reductions of individual BMPs. For example, if a field loses an average of 2.0 lbs of TP/acre and BMP1 reduces the TP loss by 20% (now 1.6 lbs TP/acre of original loss) and BMP2 reduces the remaining TP loss by 30% (now 1.12 lbs TP/acre of original loss), the overall remaining loss is 56% of the original load and an overall TP reduction efficiency of 44% rather than a simple addition of the TP losses (i.e., 20% + (30% x 80%) rather than 20% loss + 30% loss = 50% loss and 50% remaining TP):

80% of original load×70%=56% or 1.12÷2.0=56%

A.4 BMP COST

Unit costs for individual BMPs were determined based on the 2022 Natural Resource Conservation Service's Practice Standard Payment Schedule for Michigan and Ohio Scenarios[2], and are summarized in Table 3.

A.5 CURRENT BMP ADOPTION RATES

Understanding current BMP usage is a necessary first step to estimating available acreage to implement new or additional BMPs in the WB watershed. The total cropland area for the watersheds considered in this study is approximately 680,000 acres for Michigan and 3.7 million acres for Ohio. Several resources informed the 2008 baseline BMP use condition and current rates of BMP adoption in the watershed. For example, the U.S. Department of Agriculture's Conservation Effects Assessment Project (CEAP) study reported continuous no-till use on 25% and 24% of WB cropland acres for the 2003-2006 and 2012 periods, respectively. The CEAP study also suggested the following adoption rates: cover crop use on 2% of cropland for 2003-2006 and 6% for 2012, and filter strips on 18% and 31% of cropped acres in 2003-2006 and 2012, respectively (USDA 2017). Note that the percent adoption levels for structural BMPs represents the percentage of cropland draining to that practice, whereas the adoption levels for in-field BMPs represents the proportion of cropland utilizing that practice.

[2] Note, the Scenario costs are updated annually. The unit costs used for this analysis are summarized in Table 3. Current year costs can be found here: Payment Schedules | Natural Resources Conservation Service (usda.gov)

A 2021 report by Martin et al. suggested average adoption rates on agricultural land across five different watershed models of 8% for cover crops, 31% for riparian buffer strips, and 32% for continuous no-till, while modeling described by Wilson et al. (2018) used adoption rates of 14% for cover crops, 30% for filter strips, and 32% for subsurface nutrient placement to represent current conditions. Those previous modeling studies relied on surveys[3] of farmers in the WB watershed to inform BMP adoption rates. The State of Ohio in its 2020 Domestic Action Plan for Lake Erie also compiled estimates of the acreage already utilizing conservation practices in the Maumee River watershed (Ohio 2020). Michigan has BMP usage identified in annual reports for the Michigan Agriculture Environmental Assurance Program, but unfortunately, that information is not geographically or practice-specific enough to include in this report. Because each of the resources described above only covered a subset of the BMPs and/or time periods used in our analyses, the available information was collectively used to determine the assumed adoption levels summarized in Table 3.

TABLE 3: SCENARIO BMP ASSUMPTIONS

BMP	TP REMOVAL EFFICIENCY	UNIT COST	BASELINE (2008) ADOPTION LEVEL	CURRENT (2020) ADOPTION LEVEL
CONTINUOUS NO-TILL	30%	$23 / acre	32%	32%
COVER CROPS	25%	$70 / acre	4%	8%
CONSERVATION CROP ROTATION	25%	$15 / acre	5%	5%
SUBSURFACE NUTRIENT PLACEMENT	20%	$10 / acre	30%	32%
FILTER STRIPS	35%	$251 / acre	25%	30%
CONSTRUCTED WETLANDS	40%	$15,184 / acre	0%	<1%
TWO-STAGE DITCH	20%	$12 / foot	0%	<1%
GRASSED WATERWAY	20%	$5 / foot	0%	<1%

[3] Wilson et al. 2013; Burnett et al. 2015; Prokupy et al. 2017; Beetstra et al. 2018; Burnett et al. 2018

B. BMP SCENARIOS DEVELOPMENT

The project team constructed several hypothetical BMP scenarios to illustrate the levels of benefit achieved by additional new BMP implementation and the combinations needed to achieve a 40% TP reduction. Developing several scenarios acknowledges the multiple paths that could be followed to achieve (modeled) TP reductions in the WB. The options presented in this report also highlight a degree of flexibility for meeting load reductions which may help state agencies and decision-makers update action plans for BMP implementation.

The initial set of four scenarios investigated impacts of applying a single, annual in-field management BMP to all available acres in the watershed (i.e., on agricultural land where the BMP is not already applied) to total 100% implementation. These scenarios demonstrate the theoretical, maximum potential benefit that might be realized through universal adoption of single in-field BMPs. This is an important demonstration as states, federal, and nongovernmental programs often focus on driving and cost-sharing implementation of a single BMP. Subsequent scenarios in this report considered combinations of stacked BMPs across the WB watershed until the 40% load reduction targets were met for each major tributary.

As a result, the project team constructed three sets of stacked BMP scenarios using different combinations of BMPs (Table 4). Recognizing that adoption of BMPs is not uniform across the watershed, the analysis also considered variable adoption rates for each of the three BMP combinations. The first variation (high level of BMP adoption) assumed BMPs were implemented *randomly* throughout the landscape, thereby requiring the highest levels of adoption to meet the 40% target. The second variation (medium level of BMP adoption) placed stacked BMPs in targeted locations utilizing model predictions of agriculturally derived TP yields. This resulted in locating stacked BMPs, which have the highest TP removal efficiencies, in areas with the highest estimated TP losses, thereby requiring relatively lower levels of overall adoption.

TABLE 4: MATRIX OF BMPS REPRESENTED FOR DIFFERENT HYPOTHETICAL SCENARIOS

	SCENARIO NUMBER						
BMP	1	2	3	4	5a - 5c	6a - 6c	7a - 7c
CONTINUOUS NO-TILL	X				X	X	X
COVER CROPS		X			X	X	X
CONSERVATION CROP ROTATION			X		X	X	X
SUBSURFACE NUTRIENT PLACEMENT				X	X	X	X
FILTER STRIPS					X	X	X
CONSTRUCTED WETLANDS					X		X
TWO-STAGE DITCH						X	X
GRASSED WATERWAY						X	X

The third variation (low level of BMP adoption) also used a random BMP implementation strategy but assumed a relatively higher proportion of the baseline nonpoint source TP loading from *agricultural sources* and a lower proportion from natural sources. This resulted in the lowest levels of adoption needed to meet the 40% target, as each BMP was effectively assumed to reduce a greater amount of the TP load. Information generated for each scenario included the annual TP load delivered to Lake Erie, additional BMP acres or miles implemented, and the corresponding BMP costs (broken down by state and major watershed). In total, this stacked BMP analysis assessed nine different BMP implementation scenarios across the watershed.

C. BMP SCENARIO RESULTS

An important part of this report, and of particular interest to governmental agencies and decision-makers, is the cost to achieve a 40% TP reduction in the WB. Table 9 summarizes the annual BMP costs and anticipated TP load reductions for each scenario broken down by state. Appendix A provides a detailed breakdown of each scenario by state and major watershed.

TABLE 5: ANNUAL SPENDING ESTIMATES AND RESULTING TP LOAD REDUCTIONS FOR EACH SCENARIO BY STATE FOR AREAS DRAINING TO THE WESTERN BASIN

SCENARIO		MICHIGAN COST	MICHIGAN TP REDUCTION	OHIO COST	OHIO TP REDUCTION
1	CONTINUOUS NO-TILL (100%)	$11M	10%	$59M	13%
2	COVER CROPS (100%)	$44M	12%	$241M	16%
3	CONSERVATION CROP ROTATION (100%)	$9M	12%	$52M	16%
4	SUBSURFACE NUTRIENT PLACEMENT (100%)	$4M	7%	$25M	9%
5a	COMBINATION #1 – RANDOM BMP PLACEMENT	$52M	37%	$238M	40%
5b	COMBINATION #1 – TARGETED BMP PLACEMENT	$48M	37%	$208M	40%
5c	COMBINATION #1 – HIGH AG LOADING FIELDS	$45M	39%	$194M	40%
6a	COMBINATION #2 - RANDOM BMP PLACEMENT	$45M	36%	$249M	40%
6b	COMBINATION #2 - TARGETED BMP PLACEMENT	$42M	36%	$209M	40%
6c	COMBINATION #2 - HIGH AG LOADING FIELDS	$39M	39%	$185M	40%
7a	COMBINATION #3 - RANDOM BMP PLACEMENT	$64M	37%	$240M	40%
7b	COMBINATION #3 - TARGETED BMP PLACEMENT	$54M	37%	$220M	40%
7c	COMBINATION #3 - HIGH AG LOADING FIELDS	$45M	39%	$172M	40%

To illustrate the relative scale of BMP implementation needed, a set of maps was created for scenario 7b depicting the additional BMP acres needed for in-field management practices, aggregated at a county level (Figures 2-5). The map results demonstrate a hypothetical implementation scenario that is one of multiple pathways to achieving the TP reduction goals (based on modeling results). The maps, therefore, should not be interpreted as a prescription that certain BMPs be more widely adopted in certain counties or geographies. Rather, these maps are illustrative that a large magnitude of the agricultural landscape in every county (i.e., tens to hundreds of thousands of acres) would need to adopt each of these BMPs to reach the desired 40% TP reduction goal. Note the maps in Figures 2-5 do not include depictions of the structural practices included in 7b, only the annual in-field practices. Depicting structural practices on a map, at this scale, was not effective as those practices are more site specific as opposed to in-field practices which are generally more uniform across the landscape.

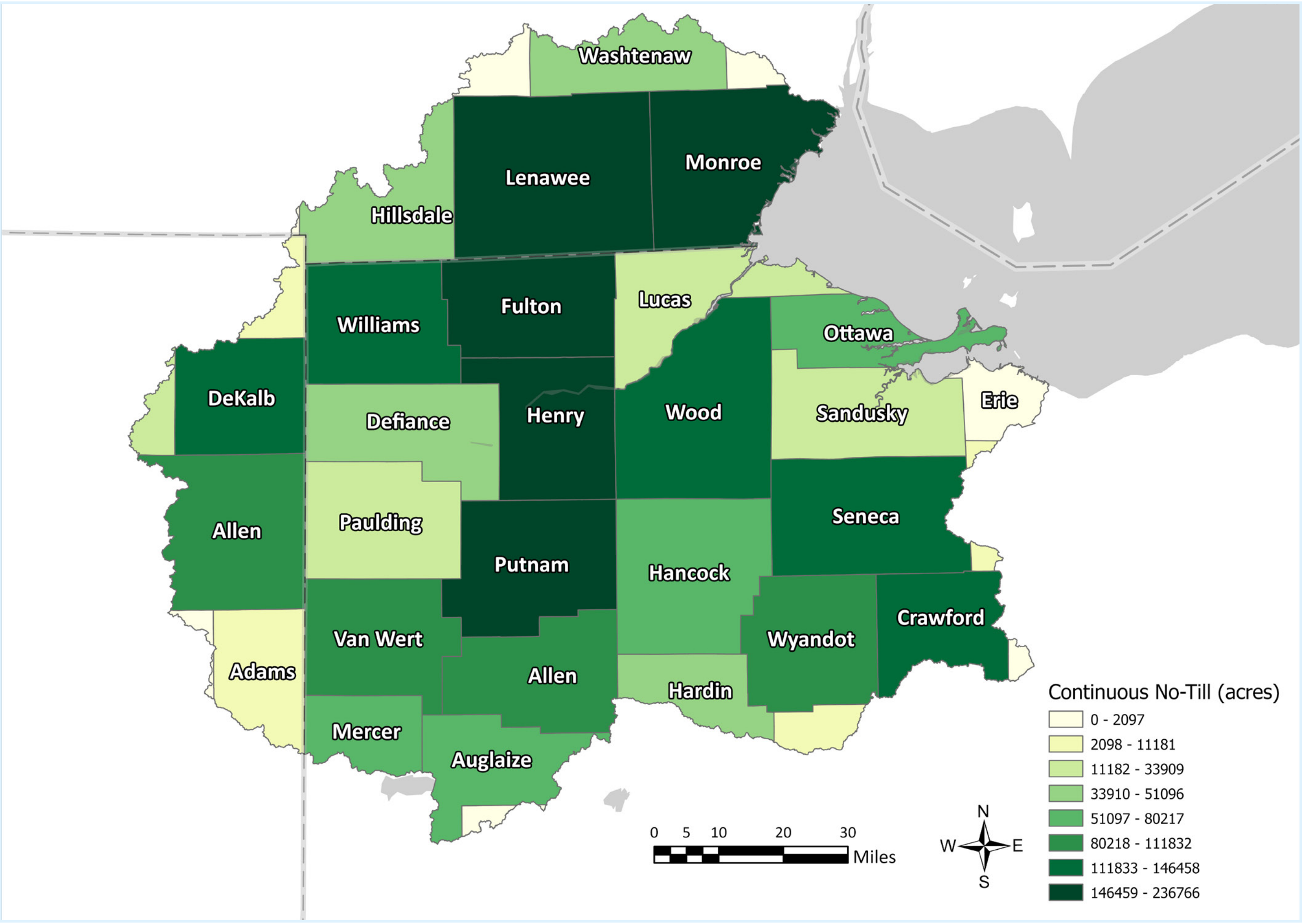


FIGURE 2: Illustration of additional continuous no-till acres needed beyond current adoption levels, targeted to high ag loading fields with the assumption of low natural TP loading, to achieve the 40% TP load reduction goal for counties draining to the WB under the hypothetical scenario 7b. Note, this is not intended to suggest a spatially appropriate prescription or strategy for implementing certain BMPs, but rather to illustrate the order of magnitude of adoption needed.

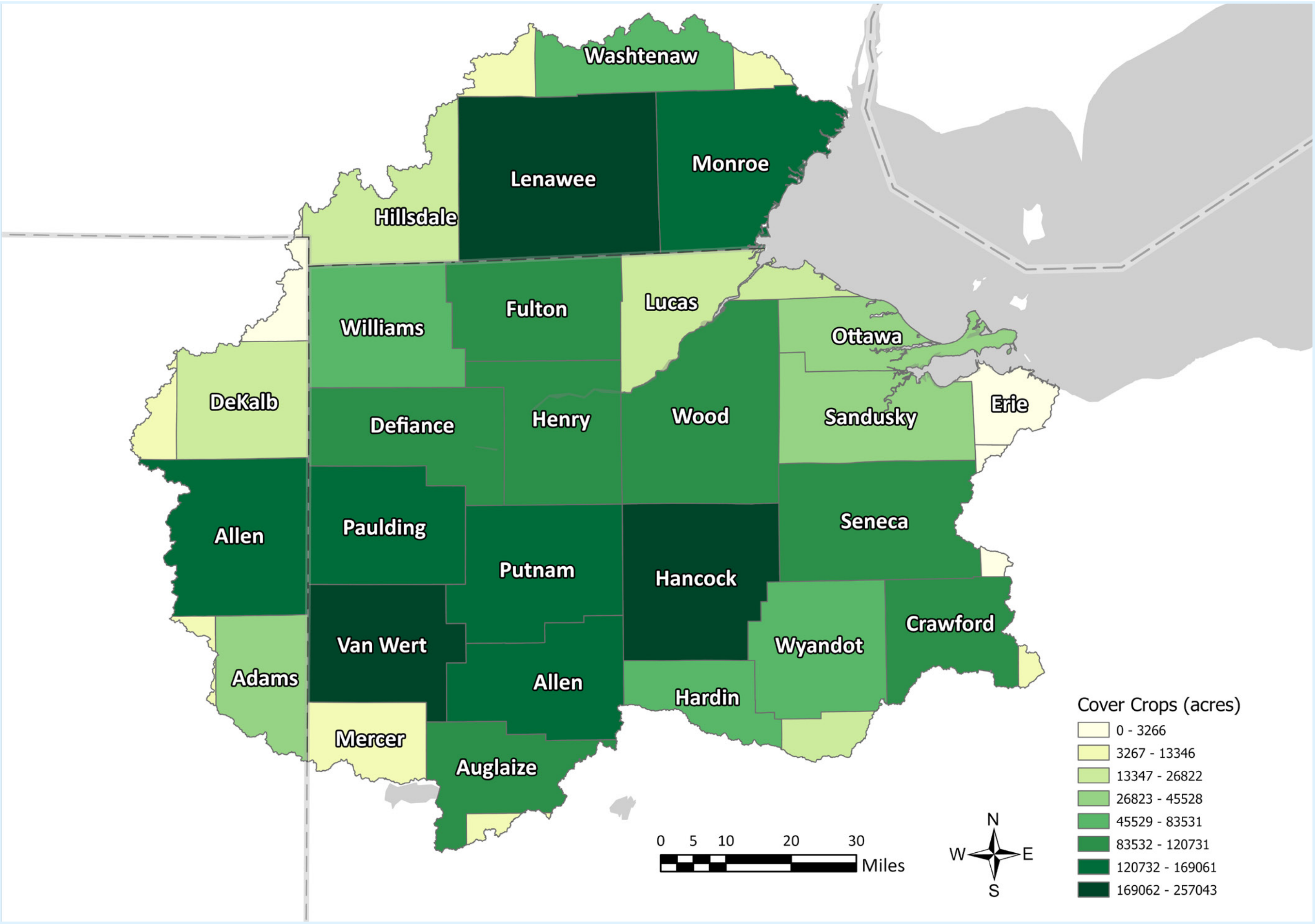


FIGURE 3: Illustration of additional cover crop acres needed above current adoption levels to achieve the 40% TP load reduction goal for counties draining to the WB under the hypothetical scenario 7b. Note, this is not intended to suggest a spatially appropriate prescription or strategy for implementing certain BMPs, but rather to illustrate the order of magnitude of adoption needed.

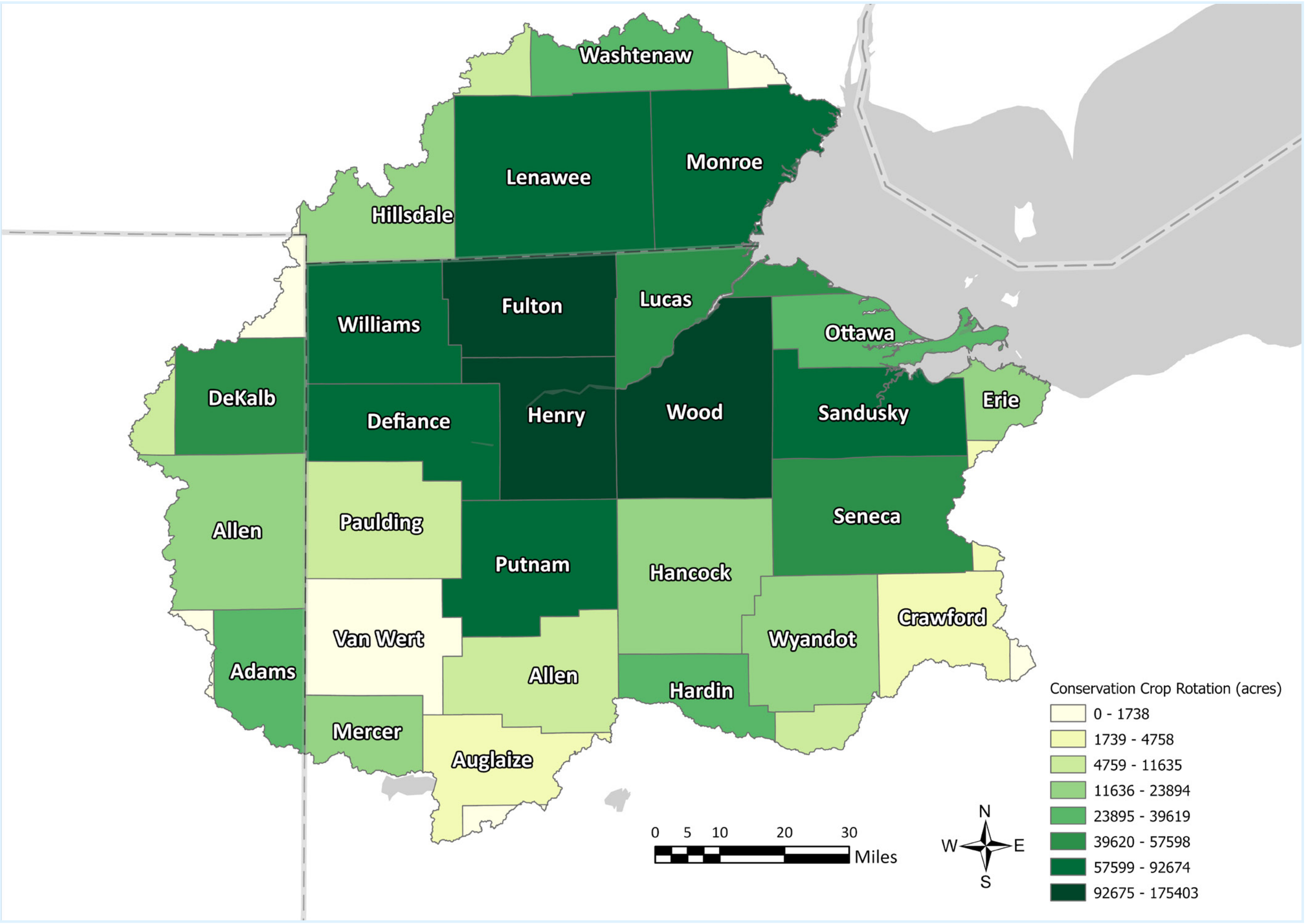


FIGURE 4: Illustration of additional conservation crop rotation acres needed above current adoption levels to achieve the 40% TP load reduction goal for counties draining to the WB under the hypothetical scenario 7b. Note, this is not intended to suggest a spatially appropriate prescription or strategy for implementing certain BMPs, but rather to illustrate the order of magnitude of adoption needed.

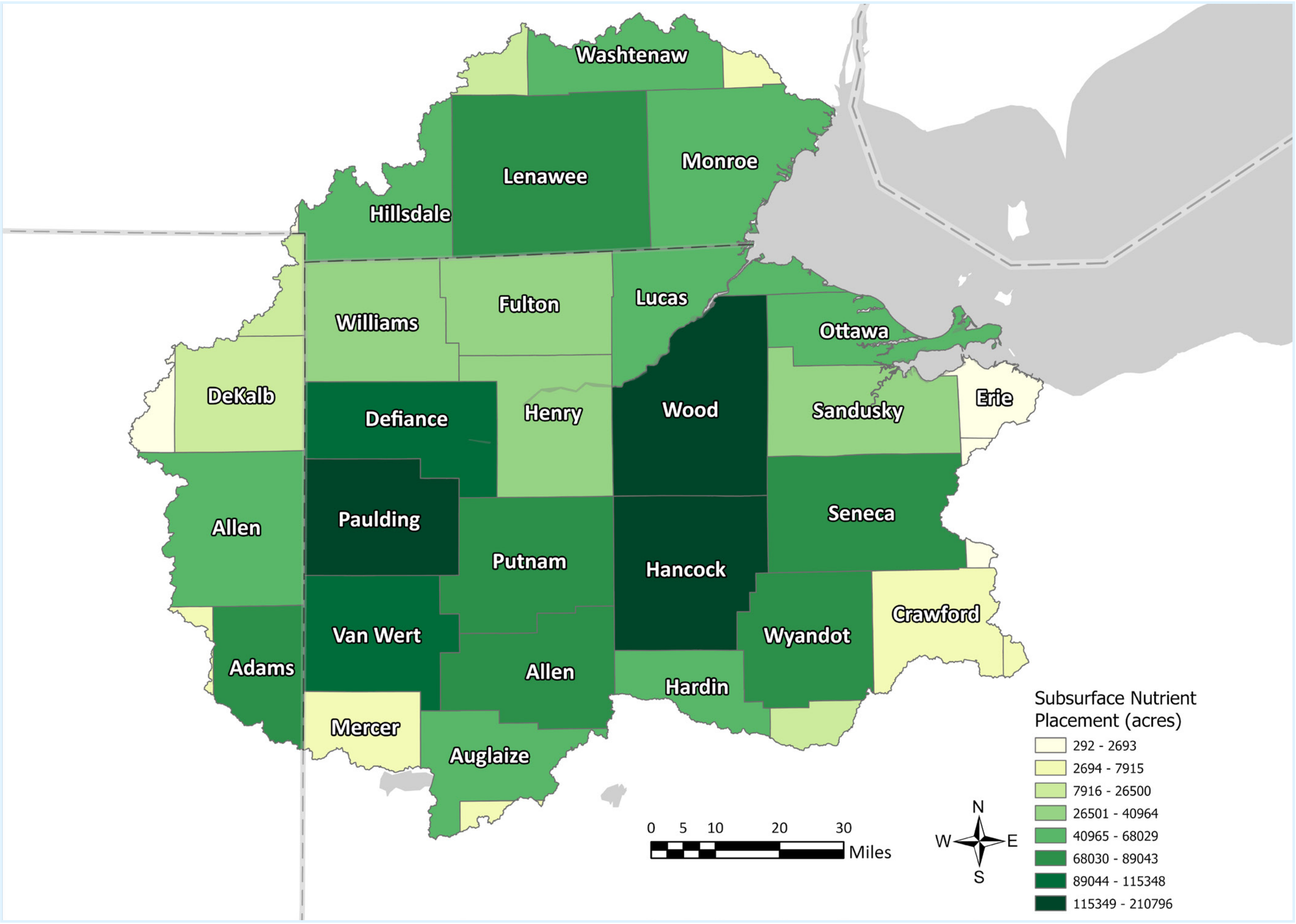


FIGURE 5: Illustration of additional subsurface nutrient placement acres needed above current adoption levels to achieve the 40% TP load reduction goal for counties draining to the WB under the hypothetical scenario 7b. Note, this is not intended to suggest a spatially appropriate prescription or strategy for implementing certain BMPs, but rather to illustrate the order of magnitude of adoption needed.

IV. Current Conservation Spending in the Western Basin of Lake Erie Watershed

The results of Section III suggest that significant additional funds need to be invested in Michigan and Ohio for BMP implementation throughout the WB watershed. It is important to assess that investment need relative to current spending by state and federal agencies. To our knowledge, no recent report has attempted to quantify current federal, state, and local conservation spending in the WB watershed. Aggregating all spending is an illustrative approach for communicating with decision-makers and advocates in the region about the relative contributions to reducing nutrient reductions in the region by each funding source. This spending aggregation also provides a starting point as agencies look to appropriate additional resources based on new information like the BMP scenarios described in Section III.

A. METHODOLOGY

The project team identified relevant federal, state, and local programs that provide resources for conservation adoption in Michigan and Ohio. The project team shared the list of relevant programs – both state and federal – with state agency representatives to verify inclusion of all applicable programs and funding sources. In addition to the list of programs the project team generated, agency staff in Michigan and Ohio provided data on additional spending sources for inclusion in this analysis. Though requested, county conservation districts provided limited information on sources and amounts of spending. In the few instances when publicly available data differed from data provided by state agency staff, the project team deferred to information supplied by the agency.

Our analysis focused on 2020 and 2021 spending data for counties located in the WB watershed. Hillsdale, Lenawee, and Monroe counties were included in the Michigan analysis. Although a portion of Jackson, Wayne, and Washtenaw counties in Michigan also fall within the watershed, these counties have relatively small acreage in the WB watershed and/or a greater proportion of suburban land use, therefore the project team excluded these counties, which provides a more conservative approach to this assessment. For Ohio, the analysis included 19 counties, all of which have at least 50 percent of their landmass within the WB watershed. Ohio counties included: Allen, Auglaize, Crawford, Defiance, Erie, Fulton, Hancock, Henry, Huron, Lucas, Ottawa, Paulding, Putnam, Sandusky, Seneca, Van Wert, Williams, Wood, and Wyandot.

Through this exercise, several gaps in available spending data at the county level were identified. In some cases, county-level spending was only available through a certain year. Here, historic spending data (typically the most recently available five years of data) were used to estimate current spending. In other cases, data were suppressed to protect privacy. Estimates were not made in instances where data were suppressed. Data on local spending were only available for Lenawee County Conservation District. Specific assumptions for each program and state are outlined later in this report.

B. RESULTS

In 2021, an estimated $108,727,000 was spent on conservation throughout the WB watershed spanning Michigan and Ohio, with H2Ohio being the largest spending source at $55,000,000. During that year, over 90 percent of spending took place in Ohio, in part because of its larger geographic coverage of the WB watershed, as well as the sizable amount of funding coming through the H2Ohio Program. Table 6 contains compiled information for 2020 and 2021 spending in the WB watershed between federal, state, and, where available, local sources.

TABLE 6: TOTAL WESTERN BASIN WATERSHED SPENDING, 2020-2021

NAME	2020	2021
FEDERAL SPENDING	$34,373,592	$31,595,758
STATE OF MICHIGAN AND LOCAL SPENDING	$1,836,897	$1,423,566
STATE OF OHIO SPENDING	$48,791,873	$75,707,621
TOTAL	**$85,002,362**	**$108,726,972**

In 2021, $7,631,807 was spent in the Michigan portion of the watershed through multiple funding sources and program types. Table 7 summarizes Michigan's BMP spending in 2020 and 2021, broken down by level of government and program.

TABLE 7: MICHIGAN SPENDING, 2020-2021

NAME	2020	2021
TOTAL FEDERAL SPENDING	**$6,826,551**	**$6,208,241**
Conservation Reserve Enhancement Program (CREP)	$0	$157,534
Conservation Reserve Program (CRP)	$3,290,331	$3,525,669
Conservation Stewardship Program (CSP)	$1,703,995	$736,176
Environmental Quality Incentives Program (EQIP)	$738,754	$1,245,798
Great Lakes Restoration Initiative (GLRI)	$405,937	$0
Regional Conservation Partnership Program (RCPP)	$687,534	$543,064
TOTAL STATE SPENDING	**$1,728,472**	**$1,315,141**
Edge of Field Studies	$190,110	$278,602
Fertilizer Research Fund	$222,142	$88,865
Michigan Agriculture Environmental Assurance Program (MAEAP) Technical Assistance Grants	$417,760	$412,129
Michigan Department of Agriculture & Rural Development (MDARD) Fertilizer Grants	$3,536	$3,536
Michigan Department of Agriculture & Rural Development (MDARD) Staff Time	$48,888	$52,369
Michigan Department of Environment, Great Lakes, & Energy (EGLE) Grants	$562,135	$323,864
Phosphorus Initiative	$56,886	$0
Soil Testing to Reduce Agriculture Nutrient Delivery (STRAND) Program	$227,014	$155,776
TOTAL LOCAL SPENDING	**$108,425**	**$108,425**
Private Grant Support to Soil Conservation Districts (SCDs)	$100,095	$100,095
Soil Conservation District Education & Outreach	$8,330	$8,330
TOTAL SPENDING	**$8,663,448**	**$7,631,807**

Conservation spending in Ohio in 2021 totaled $101,095,138. Table 8 contains data for 2020 and 2021 funding across the Ohio portion of the WB watershed.

TABLE 8: OHIO CONSERVATION SPENDING, 2020-2021

NAME	2020	2021
TOTAL FEDERAL SPENDING	**$27,547,040**	**$25,387,517**
Conservation Reserve Program (CRP)	$15,961,670	$17,344,832
Conservation Stewardship Program (CSP)	$568,942	Data Suppressed
Environmental Quality Incentives Program (EQIP)	$6,527,572	$5,260,931
Great Lakes Restoration Initiative (GLRI)	$4,488,857	$2,781,754
TOTAL STATE SPENDING	**$48,791,873**	**$75,707,621**
Ohio Department of Agriculture (ODA) H2Ohio	$30,300,000	$55,000,000
Ohio Department of Natural Resources (ODNR) H2Ohio	$18,491,873	$20,707,621
TOTAL SPENDING	**$76,338,913**	**$101,095,138**

C. DATA GAPS, ASSUMPTIONS, AND SOURCES

Table 9 summarizes gaps, assumptions, notes, and sources for the data sets used in this analysis. In addition to parameters in Table 4, all data was subject to the aforementioned county constraints.

TABLE 9: GAPS, ASSUMPTIONS, NOTES, AND SOURCES

NAME	GAPS AND ASSUMPTIONS	SOURCE(S)
FEDERAL SPENDING PROGRAMS		
Conservation Reserve Program (CRP)[4,5]	County-level data needed to understand Ohio spending was unavailable for 2020 and 2021 but spending for the entire state was available. The proportion of spending in WB watershed from 2015-2019 was calculated and used to estimate 2020 and 2021 WLEB spending.	MDARD, Farm Service Agency (FSA)
Conservation Stewardship Program (CSP)[6]	Data were suppressed to protect privacy in all but two Ohio counties in 2020. Data were suppressed in all of Ohio's WB watershed counties in 2021.	MDARD, Farmers.gov
Environmental Quality Incentives Program (EQIP)[7]	Data were suppressed to protect privacy in six Ohio counties in 2020 and 2021.	MDARD, Farmers.gov
Great Lakes Restoration Initiative (GLRI)[8]	Projects included based on year and county and limited to projects supporting GLRI's "Focus Area 3 – Nonpoint Source Pollution Impacts on Nearshore Health."	GLRI
Regional Conservation Partnership Program (RCPP)[9]	No assumptions to report for Michigan. RCPP spending did occur in Ohio, but information was suppressed for all counties to protect privacy.	MDARD
MICHIGAN STATE AND LOCAL SPENDING PROGRAMS		
Michigan Department of Environment, Great Lakes, & Energy (EGLE) Grants	Match funding data were omitted due to uncertainty about match funding sources.	MI EGLE
Private Grant Support to Soil Conservation Districts (SCDs)	Match funding data were omitted due to uncertainty about match funding sources. Data were only available for one county.	Lenawee SCD
Soil Conservation District Education & Outreach (SCDs)	Match funding data were omitted due to uncertainty about match funding sources. Data were only available for one county.	Lenawee SCD

[4] Farm Service Agency - USDA. "Conservation Reserve Program Statistics - CRP Enrollment and Rental Payments by County, 1986-2019." Farm Service Agency - USDA. N.D., https://www.fsa.usda.gov/programs-and-services/conservation-programs/reports-and-statistics/conservation-reserve-program-statistics/index.

[5] Farm Service Agency - USDA. "Conservation Reserve Program Statistics - CRP Contract Summary and Statistics." Farm Service Agency - USDA. N.D., https://www.fsa.usda.gov/programs-and-services/conservation-programs/reports-and-statistics/conservation-reserve-program-statistics/index.

[6] Farmers.gov. "NRCS Financial Assistance Program Data." Farmers.gov. January 1, 2022, https://www.farmers.gov/data/financial-assistance/overview.

[7] Farmers.gov. "NRCS Financial Assistance Program Data."

[8] Great Lakes Restoration Initiative. "Great Lakes Restoration Initiative Projects." Great Lakes Restoration Initiative. January 26, 2022, https://epa.maps.arcgis.com/apps/webappviewer/index.html?id=329f1bb23cc84a65b213d83e64574548

[9] Farmers.gov. "NRCS Financial Assistance Program Data."

V. Barriers to Conservation Adoption

Our scenario results suggest that millions of additional acres of BMPs are needed across Michigan and Ohio to meet the 40% TP reduction target for the WB. The scale of new BMPs will require state and federal agencies to identify sources of substantial additional resources and deploy more effective programs and targeted funding across the WB watershed to capture much larger swaths of agricultural producers. When designing larger and more effective spending plans, it is vital that state and federal agencies understand the barriers that farmers face when adopting (new) conservation practices in their operations. Fortunately, several academic researchers and NGOs have recently explored barriers to BMP adoption in the WB watershed, and those findings help define an actionable roadmap for decision-makers and agency staff. Here we provide an overview of identified barriers as well as the findings from a recent roundtable in south central Michigan that was convened to discuss the preliminary findings of our BMP scenario results.

WHY AREN'T MORE FARMERS ADOPTING CONSERVATION PRACTICES?

Agriculture is more than a complex agronomic or ecological system: it is a highly complex social system (Reimer et al. 2017) that in the Midwestern U.S., primarily involves individuals farming privately owned land with few regulations to manage around. There are a complex and dynamic suite of barriers ranging from field to national scales (Reimer et al. 2022) that are limiting more conservation agriculture in Michigan, including markets, social networks, human capital, and conservation programs.

- **Markets.** There are few value-added markets or certification programs that economically value crops grown in conservation-oriented ways, especially for corn and soy, which dominate the WB landscape. Robust markets for crops such as small grains and perennials would allow more flexibility in management and support practices that increase plant diversity and conserve soil and water resources.

- **Social networks.** Farmers may not often talk to each other within a community, which limits the transfer of knowledge and information and slows the growth of social acceptance around conservation. In addition, much of the arable land in the Midwest is rented, and perceived (and real) competition for this land creates tension among neighboring farmers, limits robust social networks for sharing, and disincentivizes the operator from investing in conservation on land they do not own.

- **Human capital.** While farmers have indicated the need for more skills training and education regarding conservation practices, they also articulate the need for empowerment of individual farmers, both in terms of more market power and for systems that support on-farm experimentation and innovation (Reimer et al., 2022). Beliefs and efficacy play a role in human capital as well. Keys to increasing conservation practices for WLEB farmers include 1) a belief that the farmer's land will benefit, 2) a belief that the farmer will contribute to nutrient loss reduction within the watershed, and 3) the extent to which a farmer identifies as a conservationist and has personal environmental stewardship goals (Schwab et al., 2021, Beetstra et al., 2022).

- **Conservation programs.** Incorporation of BMPs into a farmer's current cropping system adds actual costs and risks to the farmer that cannot be recovered by selling their agricultural commodity at a higher price. While existing state and federal level programs offer some financial support for BMPs, they would better meet conservation goals if they were longer-term, not focused on a single management practice, had less onerous paperwork and sign-up requirements, and provided larger payments. Increasing flexibility and adaptability of these programs would also help support long-term adoption of practices and on-farm innovation (Reimer et al., 2022; Téllez et al., 2021).

These are challenges that do not exist in silos; rather, they are interconnected at multiple scales and will need to be addressed simultaneously to make significant headway toward widespread adoption of conservation practice. These barriers should be considered collectively as decision makers allocate additional resources and programs aimed at spurring greater adoption of conservation practices.

FARMERS' TAKE ON CONSERVATION AGRICULTURE

Following the format of Reimer et al. 2022, we hosted a roundtable discussion with farmers from the WB watershed in December of 2022. We recruited 15 conservation-oriented farmers to reflect on current barriers and challenges to increased conservation agriculture in the watershed. Much of what we heard reflected previous conversations held in Michigan (Reimer et al. 2022), discussed in the previous section.

Participants were particularly keyed in on the broader agricultural system and the need to stop pollution at the source, specifically through limiting fertilizer applications. Participants suggested that instead of spending millions of dollars on practices to mop up lost nutrients, why not put more effort into reducing fertilizer use in the first place: "Don't put as much on in the first place, then there isn't as much to catch," as one farmer stated. They noted the need for nutrient management plans to be part of every farm receiving funding and for updated and more relevant "Tri-state Fertilizer Recommendations, stating that the current recommendations were developed using models devoid of any biology in the system (e.g., cover crops, improved soil health). Most of the farmers noted that the current recommendations did not serve them.

Economically, farmers noted the importance of supporting the purchase of equipment. They reflected that in the face of high input costs and expenses such as health care, it's a trade-off when it comes to investing in conservation, especially for older farmers who may not have many years left to farm and see the soil health or water quality benefits. They expressed frustration that current markets don't reward "good behavior" and noted that "until we have a stable market, conservation practices will not be a long-term priority for most farmers."

While mainstream agricultural operators and industry groups often express concern about increased environmental regulation, these farmers noted that they were not afraid of regulation, already having conservation goals and management as core parts of their operations. They also noted that "you can't improve what you're not monitoring" and that they would like to see funds allocated for outcomes, not just the process of putting in a BMP. They discussed the need for farmer groups meeting to share data and knowledge around conservation practices and the important role the landowner (leaser) plays in this discussion: It's not enough for just the farmer to want conservation on rented acres; the landowner has an important role to play as well.

It is important to hear the perspectives of farmers in this region to groundtruth the practices and programs that might work before investing additional funds into conservation support. Farmers and farmer advisors who are already invested in conservation practices have a keen interest in being informed on potential programs and policies and in turn have powerful insights that can help shape practical, relevant programs for the region.

VI. Discussion

Our analysis indicates that millions of acres of additional annual in-field practices and tens of thousands of acres of permanent/semi-permanent BMPs are needed across the WB watershed of Michigan and Ohio to achieve the 40% TP load reduction from agricultural nonpoint sources. Furthermore, the analysis found that virtually all agricultural acres will need to implement and maintain from two to four in-field BMPs along with structural BMPs to meet the load reduction target. This presents a massive challenge as state and federal programs and conservation professionals struggle to get some farmers to implement a single BMP. Even with these aggressive levels of agricultural BMP implementation, the model estimates suggested a 40% TP load reduction could not be met for the Ottawa-Stony watershed without significant point source and urban BMP implementation due to a relatively greater estimated loading from point sources and urban nonpoint sources. In addition to the current (2021) spending levels, Michigan and Ohio will need to increase conservation spending between $40-65 million and $170-250 million per year, respectively, to meet the 40% TP reduction goals for the WB.

The scale of investment required highlights the importance of maintaining consistent, dedicated funding for conservation and water quality projects in the watershed. The Michigan legislature recently appropriated $25 million of one-time funding to the Michigan Department of Agriculture and Rural Development to accelerate conservation adoption and water quality improvements in the watershed. While this investment helps bring additional attention to the issue, the relatively small sum of money, and the fact it is one-time, does not lend itself to systemic changes in the watershed. Ohio has invested heavily through the H2Ohio program, with over $80 million allocated toward nutrient reduction efforts in 2020 and 2021. And while there is strong support for the program among the current Administration and legislature, the program funding is appropriated within a biennial budget. This leaves future investments in water quality up to the discretion of future legislatures in Ohio, which may not have the same priorities for water quality as the current Administration. Moving forward it is vital that the Ohio Administration, legislature, and stakeholders secure long-term funding for the H2Ohio program.

Significant additional funding for BMP implementation is clearly needed to achieve water quality goals in the WB. However, it is important to highlight that investing more money in the same conservation programming, which is typically focused on cost-sharing of annual, in-field practices, is unlikely to yield substantial water quality improvements. The scenarios in this report clearly illustrate that annual, in-field practices alone are highly unlikely to result in a 40% TP reduction. A more targeted BMP implementation and investment strategy that prioritizes multiple cost-effective TP reduction practices, including edge-of-field and structural practices, is necessary in both Michigan and Ohio. Farmers in our December 2022 roundtable echoed this conclusion and voiced support for government programs to focus more on a “systems approach” and more robust technical assistance rather than cost-sharing a particular BMP. The results described in Section III and detailed in Appendix A also highlight that targeted implementation of BMPs results in a lower overall cost compared to a more randomized strategy. This finding supports the ongoing efforts by Michigan and Ohio to identify priority locations for annual and structural BMPs.

State and federal programs that focus entirely on increasing the use of annual in-field practices have obvious merits, but practitioners should be realistic about the extent that these practices can provide scalable water quality improvements, which this report quantifies. Collectively, stakeholders should acknowledge that to meet water quality targets, Michigan and Ohio will need to install and maintain structural, landscape changes (i.e., constructed wetlands, two stage-ditches, etc) throughout the watershed. These practices will most certainly require permanent conservation easements and land retirement, which the project team recognizes are politically, economically, and socially controversial topics. Taking land permanently out of production also involves an additional cost that Michigan and Ohio would incur. While not calculated for every scenario, we can look at the wetland acreage needed in the Maumee in Scenario 5a (see Appendix A) as an example. Michigan could face an additional, upfront cost of approximately $7.5 million while Ohio faces a cost of nearly $153 million. This assumes land is purchased outright at a price of $5,000/acre, which the project team acknowledges would vary widely throughout the watershed. The states would also likely incur annual costs, in perpetuity, to the farmer to compensate for lost crop revenue. Of course, not all semi-permanent practices require land to be permanently retired and the structure of easement payments could lower overall costs, but regardless, both Michigan and Ohio face a substantial upfront cost to secure structural practices in the watershed. This is important to note because while the costs presented in Section III may seem excessive to some, we believe Section III is actually an underestimate of the true cost when factoring in land retirement and easement payments.

Of note, the scenarios and cost projections outlined in Section III do not address source reduction of commercial and manure phosphorus sources and instead assume Michigan and Ohio only implement BMPs to capture and retain phosphorus already applied to a given field. Farmers in our December 2022 Roundtable were vocal about the need to reduce fertilizer levels in the region. They asked for updated recommendations that consider the biology of the soil, noting that the “Tri-State Recommendations” are not relevant to their systems that have prioritized soil health. Updated recommendations need to be a priority for source reduction of TP. Both Michigan and Ohio are attempting to tackle source reductions through pilot programs that incentivize reductions in commercial and manure phosphorus applications and programs like the 4R Nutrient Stewardship Certification Program. Source reduction efforts must continue in both Michigan and Ohio, but their limitations should be noted. Decades of work via state and federal agencies, University Extension, and Soil and Water Conservation Districts has yielded limited success in reducing fertilizer application levels. As discussed previously, there are a myriad of reasons for this, but the reality is that only reducing in-field phosphorus applications is not scalable at a pace needed to improve water quality.

As water quality issues persist in the Western Basin of Lake Erie and its tributaries, we must collectively recognize the scale of the problem and what it will take to meet phosphorus targets. The relatively modest investments and the scattered approach to implementing conservation across the watershed to date leave us far behind where we need to be to meet the nonpoint source agricultural load in the watershed. Moving forward we must rethink our conservation strategies, messaging, and engagement with landowners, and how we prioritize funding to those practices that are quantifiable and cost-effective. Taking an integrated, proactive approach now to reduce phosphorus loading is needed to have a chance at meeting water quality goals in the Western Basin of Lake Erie.

VII. Acknowledgments

This analysis and report were made possible through support by The Fred A. and Barbara M. Erb Family Foundation and The Joyce Foundation.

VIII. References

Alliance for the Great Lakes (AGL). 2022. Western Lake Erie Basin Drinking Water Systems: Harmful Algal Bloom Cost of Intervention. Accessed ag New Study: Downstream Water Users Bear Financial Burden of Upstream Pollution - Alliance for the Great Lakes

Annex 4 Objectives and Targets Task Team. 2015. Recommended Phosphorus Loading Targets for Lake Erie. Annex 4 Objectives and Targets Task Team Final Report to the Nutrients Annex Subcommittee (of the 2012 Great Lakes Water Quality Agreement), May 11, 2015.

Beetstra, M., C. Tellez, and R.S. Wilson. 2018. 4R Nutrient Stewardship in the Western Lake Erie Basin Part II: A Panel Study. Columbus, OH: The Ohio State University, School of Environment and Natural Resources.

Beetstra, M., R. S. Wilson, and R. Doidge. 2022. Conservation Behavior over time: Examining a Midwestern farmer sample. *Journal of Land Use Policy*, 115.

Bosch, N.S., J.D. Allan, D.M. Dolan, H. Han, and R.P. Richards. 2011. Application of the Soil and Water Assessment Tool for six watersheds of Lake Erie: Model parameterization and calibration. *Journal of Great Lakes Research*, 37: 263-271.

Bosch, N.S., J.D. Allan, J.P. Selegan, and D. Scavia. 2013. Scenario-testing of agricultural best management practices in Lake Erie watersheds. *Journal of Great Lakes Research*, 39: 429-436.

Bosch, N.S., M.E. Evans, D. Scavia, and J.D. Allan. 2014. Interacting effects of climate change and agricultural BMPs on nutrient runoff entering Lake Erie. *Journal of Great Lakes Research*, 40: 581-589.

Burnett, E.A., R.S. Wilson, B. Roe, G. Howard, E. Irwin, W. Zhang, and J. Martin. 2015. Farmers, phosphorus and water quality: Part II. A descriptive report of beliefs, attitudes and best management practices in the Maumee watershed of the western Lake Erie basin. Columbus, OH: The Ohio State University, School of Environment and Natural Resources.

Burnett, E., R.S. Wilson, A. Heeren, and J. Martin. 2018. Farmer adoption of cover crops in the western Lake Erie Basin. *Journal of Soil and Water Conservation*, 73(2): 143–155.

Chesapeake Bay Program (CBP). 2018. Chesapeake Bay Program Quick Reference Guide for Best Management Practices (BMPs): Nonpoint Source BMPs to Reduce Nitrogen, Phosphorus and Sediment Loads to the Chesapeake Bay and its Local Waters. CBP/TRS-323-18.

Christopher, S.F., Tank J.L., Mahl U.H., Yen H., Arnold J.G., Trentman M.T., Kelly-Gerreyn B.A., and Royer T.V. 2017. Modeling nutrient removal using watershed-scale implementation of the two-stage ditch. *Ecological Engineering*, 108: 358-369.

Daggupati, P., H. Yen, M.J. White, R. Srinivasan, J.G. Arnold, C.S. Keitzer, and S.P. Sowa. 2015. Impact of model development, calibration, and validation on decisions on hydrological simulations in the Western Lake Erie Basin. *Hydrological Processes*, 29(26): 5307-5320.

Dolan, D. and S. Chapra. 2012. Great Lakes total phosphorus revisited: 1. Loading analysis and update (1994–2008). *Journal of Great Lakes Research*, 38: 730-740.

Great Lakes Water Quality Agreement Nutrients Annex Subcommittee. 2019. Lake Erie Binational Phosphorus Reduction Strategy. https://binational.net/wp-content/uploads/2019/06/19-148_Lake_Erie_Strategy_E_accessible.pdf

International Joint Commission. 2022. Great Lakes Water Quality Agreement. Accessed at https://ijc.org/en/who/mission/glwqa/annex4.

Keitzer, S.C., Ludsin, S.A., Sowa, S.P., Annis, G., Daggupati, P., Froelich, A., Herbert, M., Johnson, M.V., Yen, H., White, M., Arnold, J.G., Sasson, A., and Rewa, C. 2016. Thinking outside the lake: how might Lake Erie nutrient management benefit stream conservation in the watershed? *Journal of Great Lakes Research*, 42: 1322–1331.

Maccoux, M.J., A. Dove, S.M. Backus, and D.M. Dolan. 2016. Total and soluble reactive phosphorus loadings to Lake Erie: A detailed accounting by year, basin, country, and tributary. *Journal of Great Lakes Research*, 42: 1151-1165.

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.

Martin, J.F., M.M. Kalcic, N. Aloysius, A.M. Apostel, M.R. Brooker, G. Evenson, J.B. Kast, H. Kujawa, A. Murumkar, R. Becker, C. Boles, R. Confesor, A. Dagnew, T. Guo, C.M. Long, R.L. Muenich, D. Scavia, T. Redder, D.M. Robertson, and Y.C. Wang. 2021. Evaluating management options to reduce Lake Erie algal blooms using an ensemble of watershed models. J*ournal of Environmental Management*, 280: 111710.

Merriman, K.R., P. Daggupati, R. Srinivansan, C. Toussant, A.M. Russel, and B. Hayhurst. 2018. Assessing the Impact of Site-Specific BMPs Using a Spatially Explicit, Field-Scale SWAT Model with Edge-of-Field and Tile Hydrology and Water-Quality Data in the Eagle Creek Watershed, Ohio. *Water*, 10: 1299.

Muenich, R.L., M.M. Kalcic, J. Winsten, K. Fisher, M. Day, M., G. O'Neil, Y.C. Wang, and D. Scavia. 2017. Pay-for-performance conservation using SWAT highlights need for field-level agricultural conservation. *Transactions of the ASABE*, 60(6):1925-1937.

Ohio Lake Erie Commission (OLEC). 2021. Western Lake Erie Tributary Water Monitoring Summary for March 1, 2021 to July 31, 2021. Accessed at lakeerie.ohio.gov

Petrzelka, P., Barnett, M.J., Roesch-McNally, G. and Filipiak, J., 2021. Advancing understanding of conservation practices on rented land. *Journal of Soil and Water Conservation*, 76(2): 35A-40A.

Prokup, A., R. Wilson, C. Zubko, A. Heeren, and B. Roe, B. 2017. 4R Nutrient Stewardship in the Western Lake Erie Basin, The Ohio State University, Columbus, OH.

Pyo, J., S.S. Baek, M. Kim, S. Park, H. Lee, J.S. Ra, and K.H. Cho. 2017. Agricultural best management practices in a Lake Erie watershed. *Journal of the American Water Resources Association*, 53(6): 1281-1292.

Reimer, A., J.E. Doll, B. S.T. Marquart-Pyatt, P.G. Robertson, D. Stuart, and J. Zhao. 2017. Moving toward sustainable farming systems: Insights from private and public sector dialogues on nitrogen management. *Journal of Soil and Water Conservation*, 72(1):5A-9A.

Reimer, A., J.E. Doll, T.J. Boring, and T. Zimnicki. 2022. Scaling up conservation agriculture: An exploration of challenges and opportunities through a stakeholder engagement process. *Journal of Environmental Quality*, 1-11.

Rowland, F., C. Stow, L. Johnson, R. Hirsch. 2021. Lake Erie tributary nutrient trend evaluation: Normalizing concentrations and load to reduce flow variability. *Journal of Ecological Indicators*, 125.

Scavia, D., M. Kalcic, R. Logsdon Muenich, N. Aloysius, C. Boles, R. Confesor, J. DePinto, M. Gildow, J. Martin, J. Read, T. Redder, S. Sowa, Y.-C. Wang and H. Yen. 2016. Informing Lake Erie agriculture nutrient management via scenario evaluation. Compiled by the University of Michigan Water Center with funding from the Fred A. and Barbara M. Erb Family Foundation. Ann Arbor, MI.

E. R. Schwab, Wilson, R., Kalcic, M. 2021. Exploring the mechanisms behind farmers' perceptions of nutrient loss risk. *Agriculture and Human Values* 38:839-850.

Sommerlot, A.R., A.P. Nejadhashemi, S.A. Woznicki, S. Giri, and M.D. Prohaska. 2013. Evaluating the capabilities of watershed-scale models in estimating sediment yield at fieldscale. *Journal of Environmental Management*, 127: 228–236.

State of Michigan. 2021. Michigan's Adaptive Management Plan to Reduce Phosphorus Loading into Lake Erie. December 2021.

State of Ohio. 2020. Promoting Clean and Safe Water in Lake Erie: Ohio's Domestic Action Plan 2020 to Address Nutrients.

Téllez, C., H. Walpole, and R.S. Wilson. 2021. Overcoming barriers to program participation for interested farmers. *Journal of Soil and Water Conservation*, vol. 76 no. 6.

U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). 2016. Effects of Conservation Practice Adoption on Cultivated Cropland Acres in Western Lake Erie Basin, 2003-06 and 2012.

USDA NRCS 2017. Conservation Practice Adoption on Cultivated Cropland Acres: Effects on Instream Nutrient and Sediment Dynamics and Delivery in Western Lake Erie Basin, 2003-06 and 2012.

U.S. Environmental Protection Agency (USEPA). 2018. U.S. Action Plan for Lake Erie: 2018-2023 Commitments and Strategy for Phosphorus Reduction. United States Environmental Protection Agency, Great Lakes National Program Office, February 2018.

USA and Canada. 2022. Progress Report of the Parties. Accessed at https://binational.net/wp-content/uploads/2022/07/2022-Progress-Report-of-the-Parties.pdf

Wilson, R.S., L. Burnett, T. Ritter, B. Roe, and G. Howard. 2013. Farmers, phosphorus and water quality: A descriptive report of beliefs, attitudes and practices in the Maumee Watershed of northwest Ohio. The Ohio State University, School of Environment and Natural Resources.

Wilson, R.S., D.A. Schlea, C.M.W. Boles, and T.M. Redder. 2018. Using models of farmer behavior to inform eutrophication policy in the Great Lakes. *Water Research*, 139: 38-46.

Woznicki, S.A., A.P. Nejadhashemi, D.M. Ross, Z. Zhang, L. Wang, and A.H. Esfahanian. 2015. Ecohydrological model parameter selection for stream health evaluation. *Science of the Total Environment*, 511: 341-353.

Yen, H., M.J. White, J.G. Arnold, S.C. Keitzer, M.V. Johnson, J.D. Atwood, P. Daggupati, M.E. Herbert, S.P. Sowa, S.A. Ludsin, D.M. Robertson, R. Srinivasan, and C.A. Rewa. 2016. Western Lake Erie Basin: Soft-data-constrained, NHDPlus resolution watershed modeling and exploration of applicable conservation scenarios. *Science of the Total Environment*, 569-570: 1265-1281.

ALLIANCE for the GREAT LAKES

For more information about this report, contact Tom Zimnicki, Alliance for the Great Lakes Agriculture and Restoration Policy Director, at tzimnicki@greatlakes.org.

IX. Appendix A

Combination Scenario 5a: Random BMP Placement

Estimates of additional BMP adoption needed by watershed and by state (Michigan):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	131	31%	101,800	43,000	76,600	91,200	2,670	4,150	0	0
Raisin	172	105	39%	281,800	117,100	164,000	171,800	7,300	8,930	0	0
Maumee	3,812	2,288	40%	82,900	52,600	39,700	66,300	1,250	1,510	0	0
Cedar-Portage	595	354	40%	0	0	0	0	0	0	0	0
Sandusky	1,100	663	40%	0	0	0	0	0	0	0	0
Total additional BMP acres and miles for Michigan:				**466,500**	**212,700**	**280,300**	**329,300**	**11,220**	**14,590**	**0**	**0**

Estimates of additional BMP adoption needed by watershed and by state (Ohio):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	131	31%	32,500	13,700	24,500	29,100	850	1,320	0	0
Raisin	172	105	39%	8,300	3,400	4,800	5,000	210	260	0	0
Maumee	3,812	2,288	40%	1,199,300	731,200	685,200	903,600	28,630	30,480	0	0
Cedar-Portage	595	354	40%	270,600	259,700	67,700	269,900	8,020	7,490	0	0
Sandusky	1,100	663	40%	336,600	458,600	218,900	467,800	8,480	7,660	0	0
Total additional BMP acres and miles for Ohio:				**1,847,300**	**1,466,600**	**1,001,100**	**1,675,400**	**46,190**	**47,210**	**0**	**0**

Combination Scenario 5a: Random BMP Placement

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Michigan):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$2.4	$3.0	$1.1	$0.9	$0.1	$5.4	$0.0	$0.0	**$12.8**
Raisin	$6.5	$8.2	$2.4	$1.7	$0.2	$11.5	$0.0	$0.0	**$30.5**
Maumee	$1.9	$3.7	$0.6	$0.6	$0.0	$1.9	$0.0	$0.0	**$8.8**
Cedar-Portage	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Sandusky	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Total additional BMP cost for Michigan:	**$10.8**	**$14.9**	**$4.1**	**$3.2**	**$0.2**	**$18.8**	**$0.0**	**$0.0**	**$52.0**

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Ohio):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$0.7	$1.0	$0.4	$0.3	$0.0	$1.7	$0.0	$0.0	**$4.1**
Raisin	$0.2	$0.2	$0.1	$0.0	$0.0	$0.3	$0.0	$0.0	**$0.9**
Maumee	$27.7	$51.3	$10.0	$8.7	$0.6	$39.3	$0.0	$0.0	**$137.7**
Cedar-Portage	$6.2	$18.2	$1.0	$2.6	$0.2	$9.7	$0.0	$0.0	**$37.9**
Sandusky	$7.8	$32.2	$3.2	$4.5	$0.2	$9.9	$0.0	$0.0	**$57.7**
Total additional BMP cost for Ohio:	**$42.6**	**$102.9**	**$14.6**	**$16.2**	**$1.0**	**$61.0**	**$0.0**	**$0.0**	**$238.3**

Combination Scenario 5b: Targeted BMP Placement

Estimates of additional BMP adoption needed by watershed and by state (Michigan):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	131	31%	101,800	43,000	76,600	91,200	2,340	3,220	0	0
Raisin	172	103	40%	281,800	117,100	164,000	171,700	6,570	7,570	0	0
Maumee	3,812	2,282	40%	82,900	52,500	25,400	62,200	1,250	1,010	0	0
Cedar-Portage	595	358	40%	0	0	0	0	0	0	0	0
Sandusky	1,100	650	41%	0	0	0	0	0	0	0	0
Total additional BMP acres and miles for Michigan:				**466,500**	**212,600**	**266,000**	**325,100**	**10,160**	**11,800**	**0**	**0**

Estimates of additional BMP adoption needed by watershed and by state (Ohio):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	131	31%	32,500	13,700	24,500	29,100	750	1,030	0	0
Raisin	172	103	40%	8,300	3,400	4,800	5,000	190	220	0	0
Maumee	3,812	2,282	40%	1,156,900	818,200	633,400	897,700	27,460	22,280	0	0
Cedar-Portage	595	358	40%	270,600	155,700	67,700	202,200	8,020	5,410	0	0
Sandusky	1,100	650	41%	336,600	286,100	218,900	342,700	8,480	7,660	0	0
Total additional BMP acres and miles for Ohio:				**1,804,900**	**1,277,100**	**949,300**	**1,476,700**	**44,900**	**36,600**	**0**	**0**

Combination Scenario 5b: Targeted BMP Placement

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Michigan):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$2.4	$3.0	$1.1	$0.9	$0.0	$4.2	$0.0	$0.0	**$11.6**
Raisin	$6.5	$8.2	$2.4	$1.7	$0.1	$9.8	$0.0	$0.0	**$28.7**
Maumee	$1.9	$3.7	$0.4	$0.6	$0.0	$1.3	$0.0	$0.0	**$7.9**
Cedar-Portage	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Sandusky	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Total additional BMP cost for Michigan:	**$10.8**	**$14.9**	**$3.9**	**$3.1**	**$0.2**	**$15.2**	**$0.0**	**$0.0**	**$48.2**

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Ohio):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$0.7	$1.0	$0.4	$0.3	$0.0	$1.3	$0.0	$0.0	**$3.7**
Raisin	$0.2	$0.2	$0.1	$0.0	$0.0	$0.3	$0.0	$0.0	**$0.8**
Maumee	$26.7	$57.4	$9.3	$8.7	$0.6	$28.8	$0.0	$0.0	**$131.4**
Cedar-Portage	$6.2	$10.9	$1.0	$1.9	$0.2	$7.0	$0.0	$0.0	**$27.3**
Sandusky	$7.8	$20.1	$3.2	$3.3	$0.2	$9.9	$0.0	$0.0	**$44.4**
Total additional BMP cost for Ohio:	**$41.7**	**$89.6**	**$13.9**	**$14.2**	**$1.0**	**$47.2**	**$0.0**	**$0.0**	**$207.6**

Combination Scenario 5c: High Ag Loading Fields

Estimates of additional BMP adoption needed by watershed and by state (Michigan):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	121	36%	102,100	43,000	76,600	91,000	2,340	4,400	0	0
Raisin	172	104	40%	111,400	117,100	164,000	342,200	6,570	5,640	0	0
Maumee	3,812	2,299	40%	68,600	52,600	25,400	55,300	1,250	1,340	0	0
Cedar-Portage	595	355	40%	0	0	0	0	0	0	0	0
Sandusky	1,100	656	40%	0	0	0	0	0	0	0	0
Total additional BMP acres and miles for Michigan:				**282,100**	**212,700**	**266,000**	**488,500**	**10,160**	**11,380**	**0**	**0**

Estimates of additional BMP adoption needed by watershed and by state (Ohio):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	121	36%	32,600	13,700	24,500	29,000	750	1,400	0	0
Raisin	172	104	40%	3,300	3,400	4,800	10,000	190	170	0	0
Maumee	3,812	2,299	40%	1,054,600	731,200	825,300	848,400	22,880	21,510	0	0
Cedar-Portage	595	355	40%	234,300	150,600	176,700	306,200	3,610	3,330	0	0
Sandusky	1,100	656	40%	164,100	286,100	172,500	734,200	8,480	4,380	0	0
Total additional BMP acres and miles for Ohio:				**1,488,900**	**1,185,000**	**1,203,800**	**1,927,800**	**35,910**	**30,790**	**0**	**0**

Combination Scenario 5c: High Ag Loading Fields

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Michigan):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$2.4	$3.0	$1.1	$0.9	$0.0	$5.7	$0.0	$0.0	**$13.1**
Raisin	$2.6	$8.2	$2.4	$3.3	$0.1	$7.3	$0.0	$0.0	**$23.9**
Maumee	$1.6	$3.7	$0.4	$0.5	$0.0	$1.7	$0.0	$0.0	**$7.9**
Cedar-Portage	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Sandusky	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Total additional BMP cost for Michigan:	**$6.5**	**$14.9**	**$3.9**	**$4.7**	**$0.2**	**$14.7**	**$0.0**	**$0.0**	**$44.9**

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Ohio):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$0.8	$1.0	$0.4	$0.3	$0.0	$1.8	$0.0	$0.0	**$4.2**
Raisin	$0.1	$0.2	$0.1	$0.1	$0.0	$0.2	$0.0	$0.0	**$0.7**
Maumee	$24.3	$51.3	$12.1	$8.2	$0.5	$27.8	$0.0	$0.0	**$124.2**
Cedar-Portage	$5.4	$10.6	$2.6	$3.0	$0.1	$4.3	$0.0	$0.0	**$25.9**
Sandusky	$3.8	$20.1	$2.5	$7.1	$0.2	$5.7	$0.0	$0.0	**$39.3**
Total additional BMP cost for Ohio:	**$34.4**	**$83.2**	**$17.6**	**$18.6**	**$0.8**	**$39.7**	**$0.0**	**$0.0**	**$194.2**

Combination Scenario 6a: Random BMP Placement

Estimates of additional BMP adoption needed by watershed and by state (Michigan):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	135	29%	94,400	73,200	81,500	63,500	3,830	0	102	415
Raisin	172	108	37%	179,300	213,100	150,400	191,800	8,990	0	221	1,320
Maumee	3,812	2,299	40%	68,600	38,200	57,900	29,900	2,640	0	30	673
Cedar-Portage	595	364	39%	0	0	0	0	0	0	0	0
Sandusky	1,100	652	41%	0	0	0	0	0	0	0	0
Total additional BMP acres and miles for Michigan:				**342,300**	**324,500**	**289,800**	**285,200**	**15,460**	**0**	**353**	**2,408**

Estimates of additional BMP adoption needed by watershed and by state (Ohio):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	135	29%	30,100	23,300	26,000	20,300	1,220	0	33	132
Raisin	172	108	37%	5,300	6,300	4,400	5,600	260	0	6	39
Maumee	3,812	2,299	40%	1,168,900	1,149,900	824,400	910,900	37,590	0	574	12,342
Cedar-Portage	595	364	39%	275,700	148,700	171,700	271,800	8,930	0	185	2,903
Sandusky	1,100	652	41%	383,000	348,000	297,500	476,200	13,380	0	128	5,707
Total additional BMP acres and miles for Ohio:				**1,863,000**	**1,676,200**	**1,324,000**	**1,684,800**	**61,380**	**0**	**926**	**21,123**

Combination Scenario 6a: Random BMP Placement

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Michigan):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$2.2	$5.1	$1.2	$0.6	$0.1	$0.0	$0.5	$0.9	**$10.7**
Raisin	$4.1	$15.0	$2.2	$1.8	$0.2	$0.0	$1.2	$2.9	**$27.4**
Maumee	$1.6	$2.7	$0.8	$0.3	$0.1	$0.0	$0.2	$1.5	**$7.1**
Cedar-Portage	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Sandusky	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Total additional BMP cost for Michigan:	**$7.9**	**$22.8**	**$4.2**	**$2.7**	**$0.3**	**$0.0**	**$1.9**	**$5.3**	**$45.2**

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Ohio):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$0.7	$1.6	$0.4	$0.2	$0.0	$0.0	$0.2	$0.3	**$3.4**
Raisin	$0.1	$0.4	$0.1	$0.1	$0.0	$0.0	$0.0	$0.1	**$0.8**
Maumee	$27.0	$80.7	$12.1	$8.8	$0.8	$0.0	$3.0	$27.4	**$159.7**
Cedar-Portage	$6.4	$10.4	$2.5	$2.6	$0.2	$0.0	$1.0	$6.4	**$29.5**
Sandusky	$8.8	$24.4	$4.4	$4.6	$0.3	$0.0	$0.7	$12.7	**$55.8**
Total additional BMP cost for Ohio:	**$43.0**	**$117.6**	**$19.4**	**$16.2**	**$1.3**	**$0.0**	**$4.9**	**$46.8**	**$249.3**

Combination Scenario 6b: Targeted BMP Placement

Estimates of additional BMP adoption needed by watershed and by state (Michigan):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	134	29%	101,800	83,100	71,600	56,100	3,830	0	90	638
Raisin	172	107	38%	281,800	109,800	253,800	89,300	8,990	0	215	1,421
Maumee	3,812	2,284	40%	68,600	38,200	39,500	29,900	2,530	0	30	673
Cedar-Portage	595	361	39%	0	0	0	0	0	0	0	0
Sandusky	1,100	654	41%	0	0	0	0	0	0	0	0
Total additional BMP acres and miles for Michigan:				**452,200**	**231,100**	**364,900**	**175,300**	**15,350**	**0**	**335**	**2,732**

Estimates of additional BMP adoption needed by watershed and by state (Ohio):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	134	29%	32,500	26,500	22,900	17,900	1,220	0	29	204
Raisin	172	107	38%	8,300	3,200	7,500	2,600	260	0	6	42
Maumee	3,812	2,284	40%	1,168,900	837,800	664,300	859,600	37,440	0	562	12,342
Cedar-Portage	595	361	39%	275,700	216,400	104,000	271,800	8,930	0	50	2,903
Sandusky	1,100	654	41%	383,000	183,800	360,300	280,000	13,380	0	128	3,010
Total additional BMP acres and miles for Ohio:				**1,868,400**	**1,267,700**	**1,159,000**	**1,431,900**	**61,230**	**0**	**775**	**18,501**

Combination Scenario 6b: Targeted BMP Placement

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Michigan):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$2.4	$5.8	$1.0	$0.5	$0.1	$0.0	$0.5	$1.4	**$11.7**
Raisin	$6.5	$7.7	$3.7	$0.9	$0.2	$0.0	$1.1	$3.2	**$23.3**
Maumee	$1.6	$2.7	$0.6	$0.3	$0.1	$0.0	$0.2	$1.5	**$6.8**
Cedar-Portage	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Sandusky	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Total additional BMP cost for Michigan:	**$10.4**	**$16.2**	**$5.3**	**$1.7**	**$0.3**	**$0.0**	**$1.8**	**$6.1**	**$41.8**

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Ohio):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$0.7	$1.9	$0.3	$0.2	$0.0	$0.0	$0.2	$0.5	**$3.7**
Raisin	$0.2	$0.2	$0.1	$0.0	$0.0	$0.0	$0.0	$0.1	**$0.7**
Maumee	$27.0	$58.8	$9.7	$8.3	$0.8	$0.0	$3.0	$27.4	**$134.9**
Cedar-Portage	$6.4	$15.2	$1.5	$2.6	$0.2	$0.0	$0.3	$6.4	**$32.6**
Sandusky	$8.8	$12.9	$5.3	$2.7	$0.3	$0.0	$0.7	$6.7	**$37.3**
Total additional BMP cost for Ohio:	**$43.1**	**$89.0**	**$17.0**	**$13.8**	**$1.3**	**$0.0**	**$4.1**	**$41.0**	**$209.3**

Combination Scenario 6c: High Ag Loading Fields

Estimates of additional BMP adoption needed by watershed and by state (Michigan):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	123	35%	101,800	82,800	71,900	56,100	3,820	0	89	638
Raisin	172	103	40%	281,800	80,900	282,700	89,300	8,270	0	139	1,421
Maumee	3,812	2,272	40%	68,600	33,900	62,300	55,400	1,660	0	16	417
Cedar-Portage	595	356	40%	0	0	0	0	0	0	0	0
Sandusky	1,100	658	40%	0	0	0	0	0	0	0	0
Total additional BMP acres and miles for Michigan:				**452,200**	**197,600**	**416,900**	**200,800**	**13,750**	**0**	**244**	**2,476**

Estimates of additional BMP adoption needed by watershed and by state (Ohio):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	123	35%	32,500	26,400	22,900	17,900	1,220	0	29	204
Raisin	172	103	40%	8,300	2,400	8,300	2,600	240	0	4	42
Maumee	3,812	2,272	40%	1,048,700	815,700	882,600	966,300	29,560	0	542	7,897
Cedar-Portage	595	356	40%	176,800	151,900	168,500	266,700	6,210	0	80	887
Sandusky	1,100	658	40%	125,000	183,800	336,600	734,200	8,120	0	171	2,257
Total additional BMP acres and miles for Ohio:				**1,391,300**	**1,180,200**	**1,418,900**	**1,987,700**	**45,350**	**0**	**826**	**11,287**

Combination Scenario 6c: High Ag Loading Fields

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Michigan):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$2.4	$5.8	$1.1	$0.5	$0.1	$0.0	$0.5	$1.4	**$11.7**
Raisin	$6.5	$5.7	$4.1	$0.9	$0.2	$0.0	$0.7	$3.2	**$21.2**
Maumee	$1.6	$2.4	$0.9	$0.5	$0.0	$0.0	$0.1	$0.9	**$6.5**
Cedar-Portage	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Sandusky	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Total additional BMP cost for Michigan:	**$10.4**	**$13.9**	**$6.1**	**$1.9**	**$0.3**	**$0.0**	**$1.3**	**$5.5**	**$39.4**

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Ohio):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$0.7	$1.9	$0.3	$0.2	$0.0	$0.0	$0.2	$0.5	**$3.7**
Raisin	$0.2	$0.2	$0.1	$0.0	$0.0	$0.0	$0.0	$0.1	**$0.6**
Maumee	$24.2	$57.2	$12.9	$9.3	$0.6	$0.0	$2.9	$17.5	**$124.7**
Cedar-Portage	$4.1	$10.7	$2.5	$2.6	$0.1	$0.0	$0.4	$2.0	**$22.3**
Sandusky	$2.9	$12.9	$4.9	$7.1	$0.2	$0.0	$0.9	$5.0	**$33.9**
Total additional BMP cost for Ohio:	**$32.1**	**$82.8**	**$20.8**	**$19.2**	**$1.0**	**$0.0**	**$4.3**	**$25.0**	**$185.2**

Combination Scenario 7a: Random BMP Placement

Estimates of additional BMP adoption needed by watershed and by state (Michigan):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	131	31%	83,300	137,900	16,800	74,600	3,830	2,840	13	29
Raisin	172	104	40%	245,700	312,700	50,900	125,500	8,990	6,480	40	53
Maumee	3,812	2,294	40%	68,600	57,200	46,000	51,100	2,010	1,210	16	483
Cedar-Portage	595	355	40%	0	0	0	0	0	0	0	0
Sandusky	1,100	652	41%	0	0	0	0	0	0	0	0
Total additional BMP acres and miles for Michigan:				**397,600**	**507,800**	**113,700**	**251,200**	**14,830**	**10,530**	**69**	**565**

Estimates of additional BMP adoption needed by watershed and by state (Ohio):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	131	31%	26,600	44,000	5,400	23,800	1,220	910	4	9
Raisin	172	104	40%	7,200	9,200	1,500	3,700	260	190	1	2
Maumee	3,812	2,294	40%	1,014,000	1,070,600	924,600	1,095,900	33,270	13,680	401	3,825
Cedar-Portage	595	355	40%	217,500	148,700	229,900	271,800	8,930	6,040	0	700
Sandusky	1,100	652	41%	383,000	325,200	297,500	303,600	12,790	3,280	171	2,697
Total additional BMP acres and miles for Ohio:				**1,648,300**	**1,597,700**	**1,458,900**	**1,698,800**	**56,470**	**24,100**	**577**	**7,233**

Combination Scenario 7a: Random BMP Placement

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Michigan):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$1.9	$9.7	$0.2	$0.7	$0.1	$3.7	$0.1	$0.1	**$16.4**
Raisin	$5.7	$21.9	$0.7	$1.2	$0.2	$8.4	$0.2	$0.1	**$38.4**
Maumee	$1.6	$4.0	$0.7	$0.5	$0.0	$1.6	$0.1	$1.1	**$9.5**
Cedar-Portage	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Sandusky	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Total additional BMP cost for Michigan:	**$9.2**	**$35.6**	**$1.7**	**$2.4**	**$0.3**	**$13.6**	**$0.4**	**$1.3**	**$64.4**

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Ohio):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$0.6	$3.1	$0.1	$0.2	$0.0	$1.2	$0.0	$0.0	**$5.2**
Raisin	$0.2	$0.6	$0.0	$0.0	$0.0	$0.2	$0.0	$0.0	**$1.1**
Maumee	$23.4	$75.1	$13.5	$10.6	$0.7	$17.7	$2.1	$8.5	**$151.6**
Cedar-Portage	$5.0	$10.4	$3.4	$2.6	$0.2	$7.8	$0.0	$1.6	**$31.0**
Sandusky	$8.8	$22.8	$4.4	$2.9	$0.3	$4.2	$0.9	$6.0	**$50.3**
Total additional BMP cost for Ohio:	**$38.0**	**$112.1**	**$21.3**	**$16.4**	**$1.2**	**$31.1**	**$3.0**	**$16.0**	**$239.3**

Combination Scenario 7b: Targeted BMP Placement

Estimates of additional BMP adoption needed by watershed and by state (Michigan):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	131	31%	101,800	119,400	35,300	56,100	3,830	1,530	38	502
Raisin	172	104	39%	281,800	184,200	179,300	89,300	8,990	3,280	87	1,421
Maumee	3,812	2,275	40%	68,600	42,900	41,700	32,700	2,000	640	16	483
Cedar-Portage	595	355	40%	0	0	0	0	0	0	0	0
Sandusky	1,100	661	40%	0	0	0	0	0	0	0	0
Total additional BMP acres and miles for Michigan:				**452,200**	**346,500**	**256,300**	**178,100**	**14,820**	**5,450**	**141**	**2,406**

Estimates of additional BMP adoption needed by watershed and by state (Ohio):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	131	31%	32,500	38,100	11,300	17,900	1,220	490	12	160
Raisin	172	104	39%	8,300	5,400	5,300	2,600	260	100	3	42
Maumee	3,812	2,275	40%	1,014,000	900,400	926,800	995,800	30,870	12,860	401	3,825
Cedar-Portage	595	355	40%	275,700	148,700	171,700	204,100	8,930	3,330	0	1,500
Sandusky	1,100	661	40%	383,000	325,200	172,500	178,600	8,480	3,280	171	2,697
Total additional BMP acres and miles for Ohio:				**1,713,500**	**1,417,800**	**1,287,600**	**1,399,000**	**49,760**	**20,060**	**587**	**8,224**

Combination Scenario 7b: Targeted BMP Placement

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Michigan):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$2.4	$8.4	$0.5	$0.5	$0.1	$2.0	$0.2	$1.1	**$15.2**
Raisin	$6.5	$12.9	$2.6	$0.9	$0.2	$4.2	$0.5	$3.2	**$31.0**
Maumee	$1.6	$3.0	$0.6	$0.3	$0.0	$0.8	$0.1	$1.1	**$7.5**
Cedar-Portage	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Sandusky	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Total additional BMP cost for Michigan:	**$10.4**	**$24.3**	**$3.8**	**$1.7**	**$0.3**	**$7.0**	**$0.7**	**$5.3**	**$53.7**

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Ohio):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$0.7	$2.7	$0.2	$0.2	$0.0	$0.6	$0.1	$0.4	**$4.8**
Raisin	$0.2	$0.4	$0.1	$0.0	$0.0	$0.1	$0.0	$0.1	**$0.9**
Maumee	$23.4	$63.2	$13.6	$9.6	$0.7	$16.6	$2.1	$8.5	**$137.6**
Cedar-Portage	$6.4	$10.4	$2.5	$2.0	$0.2	$4.3	$0.0	$3.3	**$29.1**
Sandusky	$8.8	$22.8	$2.5	$1.7	$0.2	$4.2	$0.9	$6.0	**$47.2**
Total additional BMP cost for Ohio:	**$39.5**	**$99.5**	**$18.8**	**$13.5**	**$1.1**	**$25.9**	**$3.1**	**$18.2**	**$219.6**

Combination Scenario 7c: High Ag Loading Fields

Estimates of additional BMP adoption needed by watershed and by state (Michigan):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	120	37%	101,800	119,600	35,100	56,100	3,820	1,530	37	502
Raisin	172	103	40%	199,400	109,800	253,800	171,700	8,270	1,920	64	1,421
Maumee	3,812	2,283	40%	20,100	25,900	77,100	49,200	2,000	640	16	483
Cedar-Portage	595	356	40%	0	0	0	0	0	0	0	0
Sandusky	1,100	655	40%	0	0	0	0	0	0	0	0
Total additional BMP acres and miles for Michigan:				**321,300**	**255,300**	**366,000**	**277,000**	**14,090**	**4,090**	**117**	**2,406**

Estimates of additional BMP adoption needed by watershed and by state (Ohio):

Watershed Group	Baseline Load (MT/yr)	Scenario Load (MT/yr)	Reduction	Continuous No-Till (acres)	Cover Crops (acres)	Crop Rotation (acres)	Subsurface Placement (acres)	Filter Strips (acres)	Wetlands (acres)	Two Stage Ditches (miles)	Grassed Waterways (miles)
Ottawa-Stony	190	120	37%	32,500	38,200	11,200	17,900	1,220	490	12	160
Raisin	172	103	40%	5,900	3,200	7,500	5,000	240	60	2	42
Maumee	3,812	2,283	40%	604,200	683,200	1,147,000	711,500	34,420	10,280	311	7,759
Cedar-Portage	595	356	40%	171,700	49,800	206,100	164,600	6,330	1,290	80	1,500
Sandusky	1,100	655	40%	196,100	129,100	343,900	351,100	7,320	3,280	171	1,719
Total additional BMP acres and miles for Ohio:				**1,010,400**	**903,500**	**1,715,700**	**1,250,100**	**49,530**	**15,400**	**576**	**11,180**

Combination Scenario 7c: High Ag Loading Fields

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Michigan):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$2.4	$8.4	$0.5	$0.5	$0.1	$2.0	$0.2	$1.1	**$15.2**
Raisin	$4.6	$7.7	$3.7	$1.7	$0.2	$2.5	$0.3	$3.2	**$23.8**
Maumee	$0.5	$1.8	$1.1	$0.5	$0.0	$0.8	$0.1	$1.1	**$5.9**
Cedar-Portage	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Sandusky	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Total additional BMP cost for Michigan:	**$7.4**	**$17.9**	**$5.4**	**$2.7**	**$0.3**	**$5.3**	**$0.6**	**$5.3**	**$44.9**

Estimates of cost (millions of dollars) associated with additional BMP adoption by watershed and by state (Ohio):

Watershed Group	Continuous No-Till	Cover Crops	Crop Rotation	Subsurface Placement	Filter Strips	Wetlands	Two Stage Ditches	Grassed Waterways	Sub-Total
Ottawa-Stony	$0.7	$2.7	$0.2	$0.2	$0.0	$0.6	$0.1	$0.4	**$4.8**
Raisin	$0.1	$0.2	$0.1	$0.0	$0.0	$0.1	$0.0	$0.1	**$0.7**
Maumee	$13.9	$47.9	$16.8	$6.9	$0.7	$13.3	$1.6	$17.2	**$118.4**
Cedar-Portage	$4.0	$3.5	$3.0	$1.6	$0.1	$1.7	$0.4	$3.3	**$17.6**
Sandusky	$4.5	$9.1	$5.0	$3.4	$0.2	$4.2	$0.9	$3.8	**$31.1**
Total additional BMP cost for Ohio:	**$23.3**	**$63.4**	**$25.1**	**$12.1**	**$1.1**	**$19.9**	**$3.0**	**$24.8**	**$172.6**