LOWER MAUMEE WATERSHED SUMMARY

The Lower Maumee watershed is located in northwest Ohio in the counties of Defiance, Fulton, Hancock, Henry, Lucas, Putnam, and Wood. The Soil and Water Assessment Tool (SWAT) was used to estimate this watershed's contribution to nutrient loadings to the Western Basin of Lake Erie (WLEB), as well as simulate estimated nutrient outputs when specific best management practices (BMPs) were implemented.

LOWER MAUMEE RIVER WATERSHED (RED) APPROXIMATE LOCATION WITHIN THE WLEB (GREEN)

Model results estimated that 22% of the Lower Maumee watershed contributes phosphorus outputs that range from 1.82 to 2.68 lbs/acre to the Maumee River on an annual basis. The Lower Maumee SWAT model was used to simulate phosphorus outputs if several agricultural BMPs were adopted at a rate of 100% in the areas that have higher Total P contributions. The scenarios modeled were: 1) subsurface application of fertilizer, 2) no-till practices, 3) P-fertilizer application at half the Baseline scenario rate, and 4) a combination of subsurface application of fertilizer, half P-rate application, no-till practices, and use of cover crops.

Analysis of these scenarios shows:

- ***These scenarios assume 100% adoption of the BMPs across the entire HUC-8, which is likely unrealistic, but it demonstrates the importance of changes in agricultural practices.***
- ***Not every BMP is best-suited for an area, or as a stand-alone BMP.***
- ***Implementation of a combination of several BMPs provides greater nutrient reduction across the entire Lower Maumee watershed and could achieve the Great Lakes Water Quality Agreement 40% reduction goal in some Hydrologic Unit Code (HUC)-12 subwatersheds.***
- ***For those areas where nutrient reduction goals are not met with single BMP implementation, multiple BMPs or alternative BMPs may need to be implemented.***

State and federal funding is available for nonpoint source pollution reduction projects, but only if a sub-watershed has an approved Nine Element Plan, also known as a Nonpoint Source Implementation Strategy (NPS-IS). In order to facilitate funding eligibility and fund projects that will make effective progress towards nutrient reduction, the development of NPS-IS should be prioritized for the highest contributing subwatersheds in the Lower Maumee watershed.

- ***Forty-two HUC-12 subwatersheds are in the Lower Maumee watershed.***
- ***As of June 2019, 11 approved NPS-IS plans exist in the Lower Maumee watershed, though none are approved or in development for the top ten highest contributing watersheds.***

These planning efforts, and the subsequent implementation of nutrient reduction projects, are led by local stakeholders who are most knowledgeable of the needs of the watershed, such as county, city, township and village governments, soil and water conservation districts and non-governmental organizations. Collaboration between these stakeholders is essential to the implementation of watershed-scale nutrient reduction efforts that will improve water quality within the Lower Maumee watershed, as well as in Lake Erie.

This model summary was funded by the Board of Commissioners of Lucas County, City of Toledo, with modeling assistance from Civil & Environmental Consultants, Inc. under the guidance of Rem Confessor, Jr., Ph.D.

HUC – 0410009 LOWER MAUMEE SWAT MODEL SUMMARY

Lower Maumee Watershed Background

The Lower Maumee Watershed Hydrologic Unit Code (HUC)-8 (04100009) is located in northwest Ohio in the counties of Defiance, Fulton, Hancock, Henry, Lucas, Putnam, and Wood. The Maumee River is the largest river in this 1,081 square mile (692,040 acre) watershed, flowing generally north-eastward from its headwaters in the city of Defiance into Lake Erie from Maumee Bay. The largest land use classifications in the watershed are cultivated crops (78%), developed land (15%), and undeveloped natural land (7%). Prior to the original settlement of the area, the watershed was part of the Great Black Swamp, a region dominated by wetlands. Agriculture quickly became a dominant land use throughout the region when the natural wetlands were drained to reveal fertile soils. The watershed is almost entirely flat-lying, with an average slope of 2% or less, featuring very poorly to poorly drained soils overlaying Silurian-Devonian lime- and dolostone bedrock. The major cities contained entirely or partially in the watershed include Toledo, Maumee, Perrysburg, Rossford, and Bowling Green, along with many small towns, villages, and townships. The main tributaries to the lower Maumee River include South Turkeyfoot Creek, Beaver Creek, and Swan Creek.

SWAT Model

The Soil and Water Assessment Tool (SWAT) was developed by the United States Department of Agriculture - Agricultural Research Service (USDA-ARS) "to predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over a long period of time" (Neitsch et al., 2011). As a spatially distributed, physically-based, and continuous-event hydrologic model, the processes (e.g. precipitation, evaporation, nutrient loss, and plant growth) are implemented in the smallest spatial area possible to increase accuracy and minimize uncertainty. This smallest spatial unit is called the hydrologic response unit (HRU), a unique combination of land use/crop cover, soil properties, and slope. A geographic information system (GIS) interface is used to enter and designate land use, soil, weather, groundwater, water use, management, pond and stream water quality data, and the simulation period (DiLuzio et al., 2002). GIS input files include a digital elevation model (DEM), land use/land cover and soil properties layers, and a daily weather database.

SWAT is one of many tools available for assessing watersheds and is regarded as the most versatile and customizable tool available to best achieve real-world scenarios for evaluating best management practices (BMPs) employed within a watershed. It is the most appropriate model to test the effects of BMPs on crop yield and environmental outputs. Runoff movement, sediment, nutrient, and pesticide loadings to the main channel in each subbasin are simulated by considering realistic physical processes.

Lower Maumee SWAT Model Methodology

In order to best represent actual conditions within the Lower Maumee HUC-8 watershed, USGS streamgages (active, continuously functioning measuring devices in streams that measure the height of water to calculate average daily streamflow), local weather data, point source nutrient contributors, knowledge of agricultural practices and land management procedures were used in conjunction with the USDA Cropland Data Layer (CDL) to isolate the HUC-8 and determine the actual contribution of its loading into Lake Erie.

HUC – 0410009 LOWER MAUMEE SWAT MODEL SUMMARY

SWAT Model Input Data

Non-Point Sources

The actual crop rotations and land management practices utilized across the watershed are estimated in some cases due to the lack of current data. The crop planted for a certain area (i.e., field, farm, or HRU) in a certain year was taken from the USDA CDL, which is the most accurate data set available. The crop rotation (2010 to 2015) for an area was then estimated by overlaying the CDLs from these years. Tillage practices were identified using the prevailing practice and published reports from the area (NRCS WLEB CEAP report). An example of tillage practices in the area include, but are not limited to, mainly no tillage on wheat and soybeans and approximately 80% conventional tillage on corn. Fertilizer and manure rate applications were based on the Tri-State Fertility Guide developed by Michigan State University, The Ohio State University and Purdue University in 1995 and from the Nutrient Use Geographic Information System (NUGIS) nutrient balance report (IPNI, 2012).

Point Sources

National Pollutant Discharge Elimination System (NPDES) permit locations represent point sources that discharge pollutants to waters of the United States. Created in 1972 by the Clean Water Act, the NPDES permit program is authorized to state governments by the US Environmental Protection Agency (EPA) to perform many permitting, administrative, and enforcement aspects of the program. There are 84 NPDES permits (77 Individual and seven General permits) located in the Lower Maumee watershed, at the time this model was prepared. Nutrient loading data from each of the permitted locations are included in the SWAT model with data provided from the Ohio EPA Mass Balance Study (Figure 1).

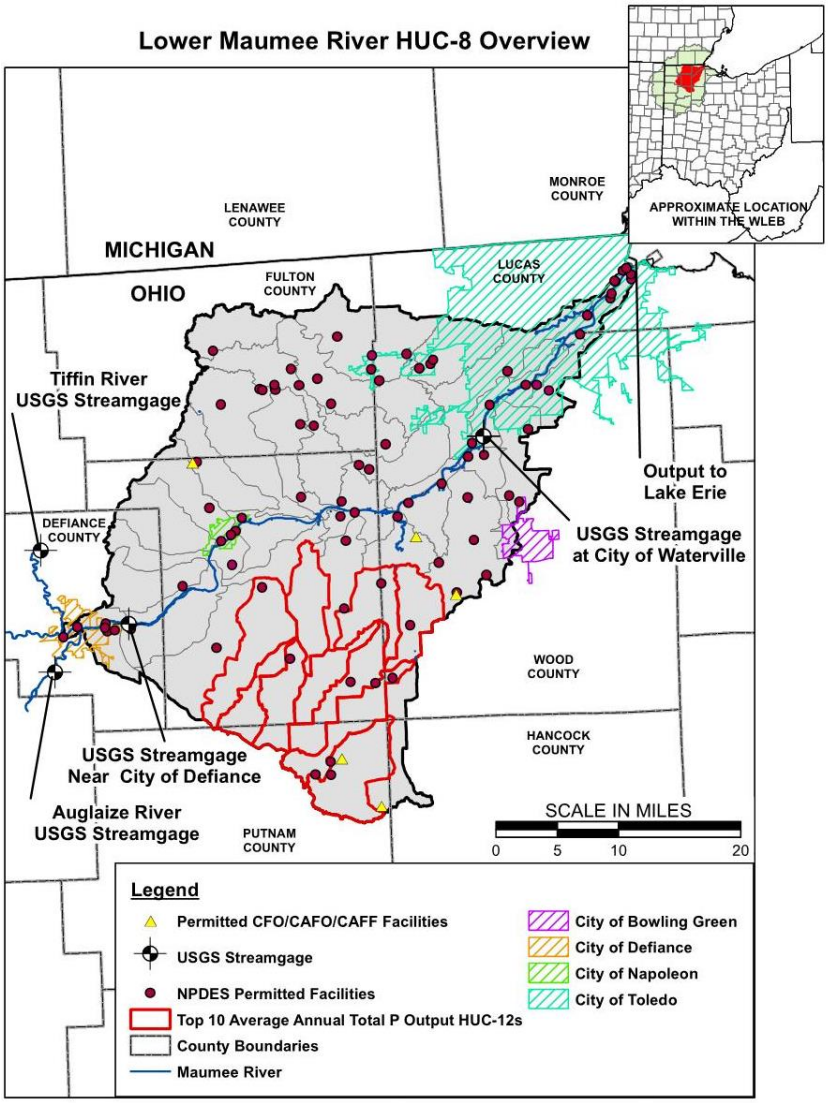

Figure 1: Lower Maumee HUC-8 streamgages, point sources and priority HUC-12s.

Some entities also have Municipal Separate Storm Sewer Systems (MS4) NPDES permits, regulating stormwater runoff using six minimum control measures expected to reduce discharge of pollutants to the receiving waterbody. The Ohio EPA has grouped the MS4-permitted entities into two categories (Phase 1 or Phase 2) based upon population and amount of combined sewers within the community. The City of Toledo is the only Phase 1 MS4 community within the Lower Maumee watershed. The list of Phase 2 MS4 permittees that are wholly or partially contained in the Lower Maumee watershed includes the City of Defiance, the City of Bowling Green, the City of Perrysburg, the City of Rossford, the City of Northwood, the Village of Swanton the University of Toledo, Wood County (with others), and Lucas County (with others).

Confined animal feeding operations (CAFOs) are considered point source pollutants due to their production of animal waste. Currently, no CAFOs with NPDES permits are present in the Lower Maumee Watershed; however, most recent estimates cite the watershed is home to over 400 confined livestock operations of varying sizes (NRCS, 2009). The waste generated by the confined livestock operations in the watershed is estimated to supply 16 percent of the total phosphorus needed to fertilize crops in the watershed (NRCS, 2009).

Nutrients, Sediments, and Flow Observed Data

The SWAT model was calibrated for a two year period (2013-2015) with the observed nutrients (phosphorus and nitrogen) and total suspended solids from Heidelberg's water quality monitoring station and the USGS streamgage (Station No. 04193500) in the Maumee River at Waterville (Figure 1). Nutrient and sediment data upstream of the Lower Maumee watershed were provided by the Ohio EPA Mass Balance Study, and flow data was provided from USGS streamgages downstream of Defiance, just below the Lower Maumee-Upper Maumee watershed boundary.

Lower Maumee SWAT Model Findings

Table 1 lists the HUC-12 watersheds with the ten highest Total Phosphorus (Total P) and Dissolved Reactive Phosphorus (DRP) simulated yield from the Lower Maumee SWAT model. These priority watershed locations are outlined in Figure 1.

TABLE 1

HUC-12 watersheds with highest simulated Total P and DRP yield

HUC-12 Number	HUC-12 Name	Area (acres)	Total P yield (lbs/acre)	DRP yield (lbs/acre)
04100009 0 504	Upper Yellow Creek	22,158.64	2.68	2.26
04100009 01 02	Upper South Turkeyfoot Creek	13,455.26	2.29	1.96
04100009 0 505	Brush Creek	10,066.99	2.08	1.83
04100009 05 02	Hammer Creek	16,053.80	2.14	1.89
04100009 01 01	West Creek	10,209.37	2.02	1.70
04100009 05 03	Upper Beaver Creek	10,690.29	1.99	1.76
04100009 05 07	Cutoff Ditch	14,111.06	1.96	1.61
04100009 01 04	Middle South Turkeyfoot Creek	23,192.91	1.95	1.69
04100009 05 08	Middle Beaver Creek	15,006.54	1.83	1.62
04100009 01 05	Little Turkeyfoot Creek	14,792.62	1.82	1.58

Recommendations

As outlined in the previous section, the Lower Maumee SWAT Model shows the ten HUC-12 watersheds that have the highest potential to contribute the largest loading of Total P within the Lower Maumee watershed. In order to meet the goal of a 40% reduction in nutrient loadings coming from the Lower Maumee watershed, attention must be focused on implementing BMPs within these HUC-12 watersheds. In lieu of regulations that would require the implementation of nutrient reduction BMPs, a key "first step" to implementing BMPs is to identify land stakeholders within these HUC-12 watersheds. A list of organizational stakeholders working in and around these prioritized HUC-12s in the Lower Maumee watershed are listed in Table 2.

TABLE 2	
Stakeholders Located or Working in the HUC 12 Watersheds	
Organization Name	**Type of Organization**
Partners for Clean Streams	Non-government Organization
Toledo Metropolitan Area Council of Governments (TMACOG)	Government
Ohio Pheasants Forever	Non-government Organization
Black Swamp Conservancy	Non-government Organization
The Nature Conservancy	Non-government Organization
Soil and Water Conservation Districts (Defiance, Fulton, Hancock, Henry, Lucas, Putnam, and Wood)	Government
Boards of County Commissioners (Defiance, Fulton, Hancock, Henry, Lucas, Putnam, and Wood)	Government
Cities, Towns and Villages (Bowling Green, Defiance, Toledo, Maumee, Perrysburg, Rossford, Holland, Leipsic, Deshler, Hamler, Whitehouse, Swanton, Delta, Liberty Center, Grand Rapids, Waterville, Napoleon, Wauseon, North Baltimore, McComb, Weston,)	Government
Townships (Adams, Clinton, Damascus, Flatrock, Freedom, Henry, Liberty, Marion, Milton, Monclova, Napoleon, Pleasant, Providence, Richmond, Springfield, Swancreek, Van Buren, Westerville, Weston, York)	Government

An important next step toward implementing BMPs within the prioritized HUC-12s is to develop an approved watershed plan for these areas that includes projects that incorporate the recommended BMPs. An approved watershed plan follows the Nonpoint Source-Implementation Strategy (NPS-IS) planning document from Ohio EPA and meets the nine key elements identified by the US EPA. NPS-IS plans that have the required nine elements are strategic planning documents meant to identify critical areas that affect water quality impairment, outline goals and objectives to attain water quality standards and describe projects meant to reduce causes and sources of water quality impairment. ***The need for the preparation of approved NPS-IS plans in the Lower Maumee watershed is evident in the fact that of the 42 HUC-12s, 11 have approved plans in place; however, none of these address the top ten highest contributing watersheds. Once the plans are approved, the projects detailed within each plan become eligible for nonpoint source funding opportunities through government agencies, potentially reducing costs of implementation.***

The Lower Maumee SWAT model also includes scenarios of agricultural BMPs that would dramatically reduce the loading of Total P coming from the Lower Maumee watershed. The scenarios consisted of subsurface application of fertilizer, no-till practices, fertilizer application at half the Baseline scenario rate and a combination of subsurface application of fertilizer and no-till practices. ***These scenarios assume 100% adoption of the BMPs across the entire HUC-8, which is likely unrealistic, but it demonstrates the importance of changes in agricultural practices. Not every BMP is best-suited for an area, or as a stand-alone BMP. Implementation of a combination of several BMPs provides greater nutrient reduction across the entire Lower Maumee watershed and could achieve the Great Lakes Water Quality Agreement 40% reduction goal in some Hydrologic Unit Code (HUC)-12 subwatersheds. For those areas where nutrient reduction goals are not met with single BMP implementation, multiple BMPs or alternative BMPs may need to be implemented. Agricultural practitioners should be strongly encouraged to adopt the most effective BMPs for their respective farms.***

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