UPPER MAUMEE WATERSHED SUMMARY

The Upper Maumee watershed is located in northwest Ohio in portions of Defiance and Paulding counties and in northeastern Indiana in Allen and DeKalb counties. 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.


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

Model results estimated that 75% of the Upper Maumee watershed contributes phosphorus outputs that range from 1.64 to 2.41 lbs/acre to the Maumee River on an annual basis. The Upper Maumee SWAT model was used to simulate phosphorus outputs if several agricultural BMPs were adopted at a rate of 50% 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:

- ***No single BMP provides optimal nutrient reduction everywhere.***
- ***Not every BMP is best-suited for an area, or as a stand-alone BMP.***
- ***For those areas where reduction goals are not met with one specific BMP or even a combination of the selected BMPs, an adoption rate of greater than 50% or alternative BMPs may be needed.***

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 Ohio or a Watershed Management Plan (WMP) in Indiana. In order to facilitate funding eligibility and fund projects that will make effective progress towards nutrient reduction, the development of NPS-IS plans and WMPs should be prioritized for the highest contributing subwatersheds in the Upper Maumee watershed.

- ***Fourteen Hydrologic Unit Code (HUC)-12 subwatersheds are in the Upper Maumee watershed.***
- ***The WMP written for the Upper Maumee watershed in Indiana covers the entire watershed across state borders and is considered an equivalent NPS-IS plan in Ohio; however, each HUC-12 must have an updated NPS-IS written. As of June 2019, no approved NPS-IS plans exist in the Ohio portion of the Upper Maumee watershed, though one is in development.***
- ***Of the top ten highest contributing HUC-12s, six subwatersheds are still in need of plan development in order to secure funding to implement Ohio projects.***

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 Upper Maumee watershed, as well as in Lake Erie.

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HUC – 04100005 UPPER MAUMEE MODEL ANALYSIS AND RECOMMENDATIONS

Upper Maumee Watershed Background

The Upper Maumee Watershed (Hydrologic Unit Code 8 (HUC-8) = 04100005, area = 388 sq. mi (248,344 acre)) is located in northwest Ohio in portions of Defiance and Paulding counties and in northeastern Indiana in Allen and DeKalb counties. The Maumee River is the largest river in this watershed, flowing generally north-eastward from its headwaters in the city of Fort Wayne to the city of Defiance. The Maumee River continues flowing into the Lower Maumee watershed out to Lake Erie from Maumee Bay. Major tributaries to the Maumee River in the Upper Maumee watershed include Snooks Run, Platter Creek, Gordon Creek, Sulphur Creek, Marie DeLarme Creek and South Creek.

The watershed is located mostly in the Eastern Corn Belt Plains (ECBP) Ecoregion, dominated by smooth plains, beech/maple hardwood forest and fertile cropland soils, with the easternmost portion located in the Huron-Erie Lake Plains Ecoregion, represented by a broad, flat-lying plain. Soils within the Upper Maumee watershed range from moderately fine-textured soils associated with glacial till to loam and sandy loam. Present day hydrology is much different than pre-settlement conditions. Most hardwood forests have been cleared and most natural wetlands have been drained and tiled for an extensive network of agricultural land use, the dominant land use within the region. Cities, towns and villages within the Upper Maumee watershed include: Antwerp, Cecil, Defiance, Harlan, Hicksville, Mark Center, New Haven, Sherwood and Woodburn.

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). The SWAT Model breaks a watershed down into small spatial units called hydrologic response units (HRUs) that contain a unique combination of land use/crop cover, soil properties and slope characteristics. For example, there are over 1,400 HRUs throughout the Upper Maumee HUC-8. Hydrologic and biologic processes (e.g. precipitation, evaporation, nutrient loss, and plant growth) are modeled in each HRU to increase accuracy and minimize uncertainty. 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, 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, such as runoff movement, sediment, nutrient and pesticide loadings. These outputs to the Maumee River and its tributaries are simulated by considering realistic physical processes.

Upper Maumee SWAT Model Methodology

Data inputs, include 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, USDA-NRCS Cropland Data Layer (CDL)

and USGS National Hydrography Dataset (NHD). These data were used to delineate the Upper Maumee HUC-8 and to estimate its loading contribution into Lake Erie.

SWAT Model Input Data

Non-Point Sources

The crops planted for a certain area (i.e., field, farm, or HRU) in a certain year (2014 to 2017) were taken from the USDA-NRCS CDL, which is the most readily available spatial data set. The crop rotation for an area was then estimated by overlaying the CDLs from these years. Tillage practices were identified using prevailing practice and published reports from the area (NRCS WLEB CEAP report). Example tillage practices in the area include: mainly no tillage on wheat and soybeans and approximately 80% conventional tillage (chisel plow) 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 values from the Nutrient Use Geographic Information System (NUGIS) nutrient balance report (IPNI, 2014).

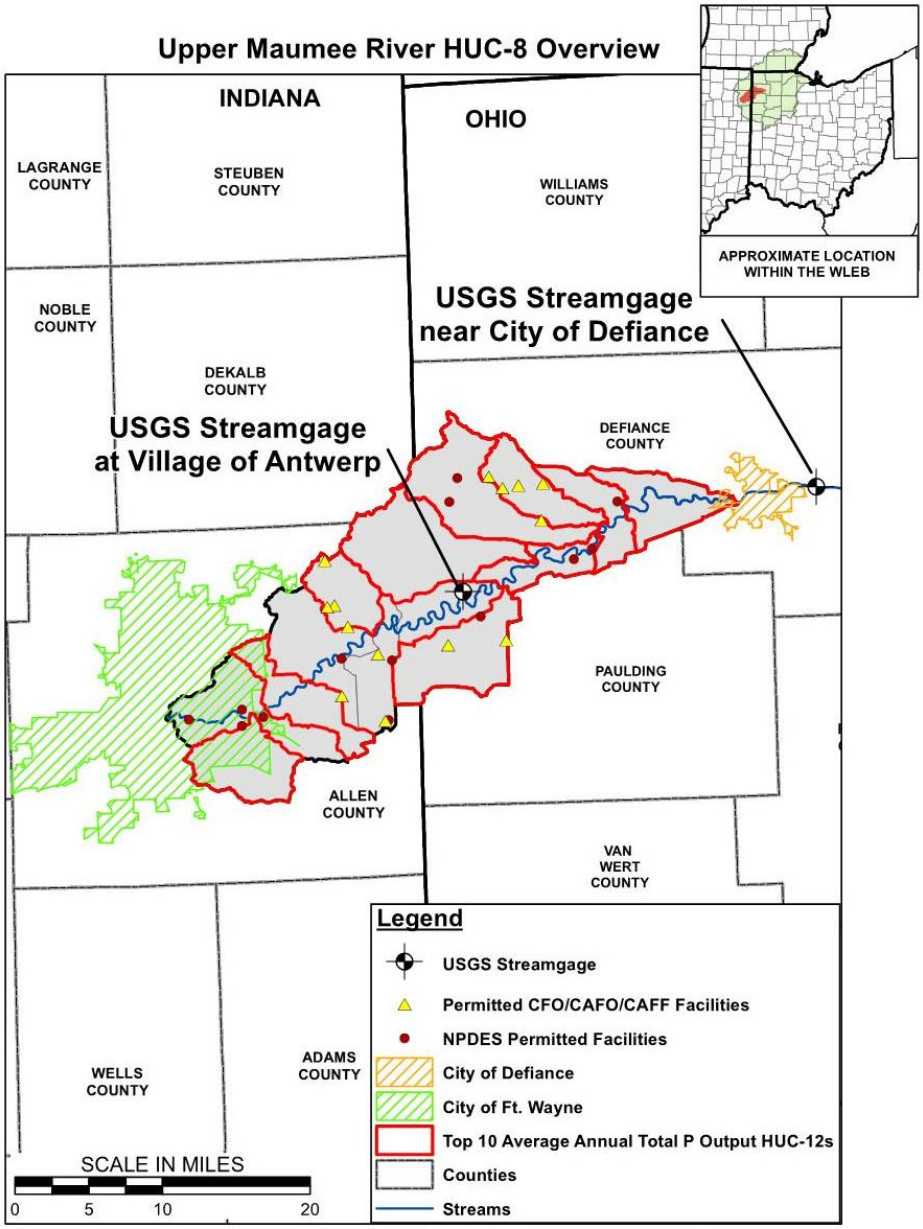

Figure 1: Upper Maumee watershed streamgages, point sources and priority HUC-12 subwatersheds.

Point Sources

The 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. Thirteen NPDES permits were located in the Upper Maumee watershed, at the time this model was prepared (July, 2019). 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 and Discharge Monitoring Reports (DMRs) submitted to the US EPA's ECHO Database (Figure 1).

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. Two MS4 communities exist within the Upper Maumee Watershed: Fort Wayne and Defiance.

Confined animal feeding operations (CAFOs) are considered point source pollutants due to their production of animal waste and are permitted at the federal level once they exceed specific thresholds of numbers of animals. Each state also maintains its own permitting process, threshold limits and naming system (Confined Animal Feeding Facility (CAFF) in Ohio and Confined Feeding Operation (CFO) in Indiana). Listings provided in 2016 from Indiana and 2019 from Ohio denote 14 permitted facilities in the Upper Maumee watershed.

Nutrients, Sediments, and Flow Observed Data

The SWAT model was calibrated for a three-year period (2014-2016) with the flow data, observed nutrients (phosphorus and nitrogen) and total suspended solids from USGS streamgages in the Maumee River at Antwerp and near Defiance (Figure 1). Streamgage data from the Auglaize River and Tiffin River were subtracted from the Maumee River station at Defiance to correctly account for the discharge and yield from the Upper Maumee.

Upper Maumee SWAT Model Findings

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

Table 1: HUC-12 subwatersheds 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)
041000050208	Snooks Run-Maumee River	15967.97	2.41	0.59
041000050204	Gordon Creek	28276.03	2.39	0.50
041000050101	Trier Ditch	18078.35	2.27	0.45
041000050207	Sulphur Creek-Maumee River	11662.88	2.26	0.71
041000050206	Platter Creek**	13883.69	2.08	0.53
041000050203	Marie DeLarme Creek	31409.50	2.07	0.49
041000050205	Sixmile Cutoff-Maumee River	15491.76	1.93	0.62
041000050104	Black Creek	12305.94	1.84	0.35
041000050103	Sixmile Creek-Maumee River	15491.76	1.74	0.51
041000050201	Zuber Cutoff	23608.29	1.64	0.77

* All Upper Maumee HUC-12s are included in an Indiana Watershed Management Plan; however, Nonpoint Source Implementation Strategies need to be developed for those subwatersheds that are within or cross state of Ohio boundaries

**Nonpoint Source Implementation Strategy (Ohio) under development

Recommendations

As outlined in the previous section, the Upper Maumee SWAT Model shows the ten HUC-12 watersheds that have the highest potential to contribute the largest loading of Total P within the Upper Maumee watershed. ***In order to make progress towards the goal of a 40% reduction in nutrient loadings coming from the Upper***

Maumee watershed, attention should be focused on prioritizing BMP implementation within these HUC-12 watersheds. A key "first step" to implementing BMPs is to identify and coordinate with stakeholders within these HUC-12 watersheds. A list of organizational stakeholders working in and around these prioritized HUC-12s in the Upper Maumee watershed are listed in Table 2.

Table 2: Stakeholders Located or Working in the Upper Maumee Watershed

Organization Name	Type of Organization
Upper Maumee Watershed Partnership	Non-governmental Organization
Maumee Watershed Alliance	Non-governmental Organization
Save Maumee	Non-governmental Organization
Ohio Pheasants Forever	Non-governmental Organization
Black Swamp Conservancy	Non-governmental Organization
The Nature Conservancy	Non-governmental Organization
West Central Ohio Land Conservancy	Non-governmental Organization
Maumee River Valley Conservancy	Non-governmental Organization
Colleges and Universities (Defiance College)	Higher Education Institution
Soil and Water Conservation Districts (Ohio: Defiance and Paulding; Indiana: Adams and DeKalb)	Government
Boards of County Commissioners (Ohio: Defiance and Paulding; Indiana: Adams and DeKalb)	Government
Cities, Towns and Villages (Antwerp, Cecil, Defiance, Harlan, Hicksville, Mark Center, New Haven, Sherwood and Woodburn)	Government
Townships (Carryall, Delaware, Hicksville and Mark)	Government

Implementation of BMPs within the prioritized HUC-12s can be facilitated through the development of Nine Element Plans, called Nonpoint Source-Implementation Strategies (NPS-IS) in Ohio and Watershed Management Plans (WMPs) in Indiana, which are watershed planning documents that include the nine key elements required by the US EPA for nonpoint source pollution projects. Nine Element Plans delineate critical areas in the watershed that affect water quality, outline goals and objectives to attain water quality standards and describe projects meant to reduce impairment from nonpoint source pollution, both within the streams of the HUC-12 (near-field) and Lake Erie (far-field). ***Of the 14 constituent HUC-12 subwatersheds in the Upper Maumee watershed, all are included in the WMP drafted for the state of Indiana in 2014. While this WMP is considered to be an equivalent Nine Element Plan in Ohio, NPS-IS developed for the Ohio HUC-12s are considered updates to this plan. One NPS-IS is under development in the Ohio portion of the Upper Maumee watershed for Platter Creek. Once the plans (or updates) are approved, the projects detailed within become eligible and prioritized for nonpoint source funding opportunities through government agencies and other funding sources, reducing costs of implementation and expediting the implementation of projects.***

The Upper Maumee SWAT model also includes scenarios of agricultural BMPs that would reduce the loading of Total P coming from the Upper Maumee watershed. The scenarios are: 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. Within the model, these scenarios were implemented to the top 50% of HRUs that have the highest Total P output across the entire HUC-

8. This approach includes a realistic adoption rate, and focuses implementation efforts in the areas that could most benefit from those efforts for maximum Total P reduction. ***The selection and implementation of BMPs is a complex process, and no single BMP provides optimal nutrient reduction everywhere. Not every BMP is best-suited for an area, or as a stand-alone BMP, as evidenced by the increase in Total P loads in some HUC-12s with only no-till practices in place. For those areas where reduction goals are not met with one specific BMP or even a combination of the selected BMPs, an adoption rate of greater than 50% or alternative BMPs may be needed.***

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