BLOOM

Banks**, L**oads**,** and **O**utflow **O**bjectives for **M**arie Delarme
Watershed Management Plant

Group 2
UAPP411/611: Regional Watershed Management
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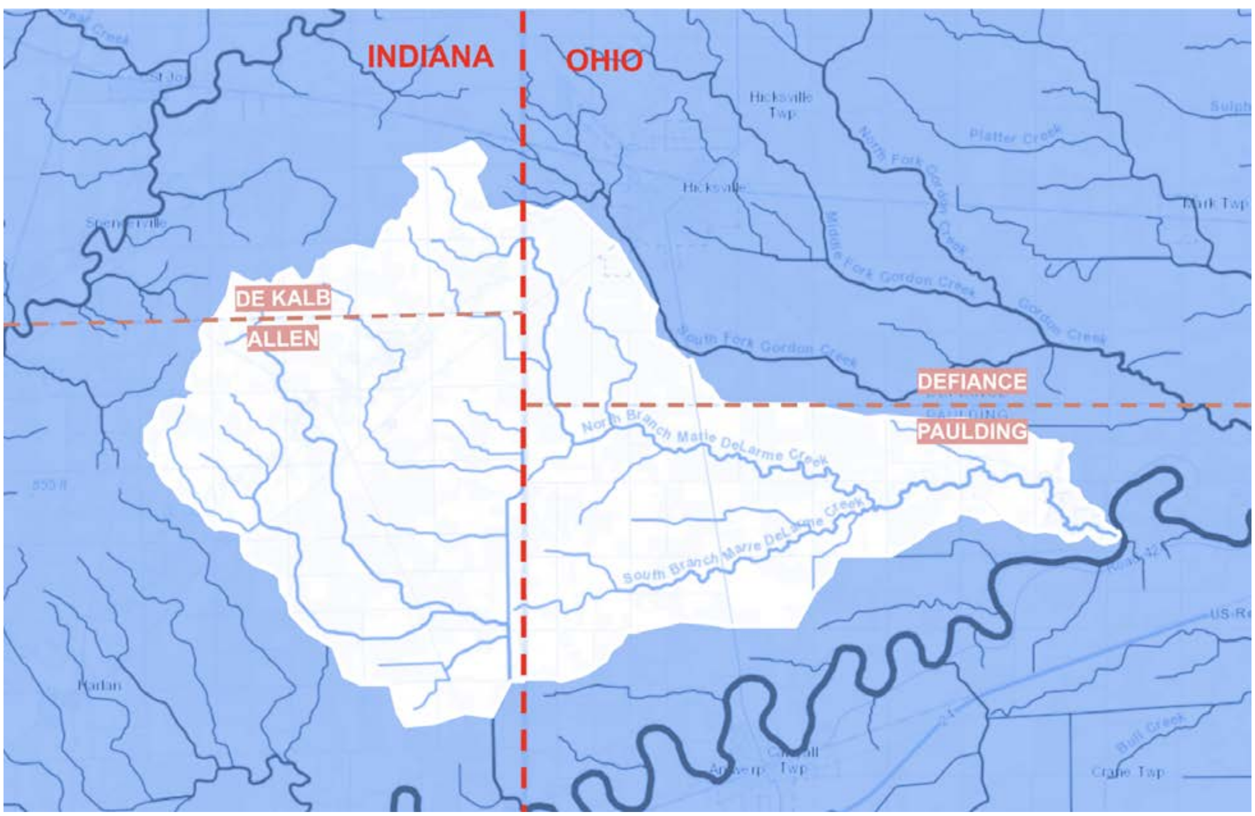

Map of Marie DeLarme Watershed (adapted from Model My Watershed)

OUTLINE

INTRODUCTION AND HISTORY

The Marie Delarme watershed is a 49.07 square mile watershed that sits on the border of Indiana and Ohio. It contains areas of DeKalb County, Allen County, Paulding County, and Defiance County. The main river in the Marie DeLarme watershed is Marie DeLarme Creek. The Marie DeLarme Creek has a history of meandering and shifting, and this movement made the creek itself relatively hard to drain, but much of the area was still converted to agriculture (Black Swamp Conservancy, 2023).

Marie DeLarme is especially important because it is a part of the Maumee River Basin, which provides drinking water for over 50,000 people in Defiance, Ohio (Quandt et. al., 2014). The Maumee River then flows into Lake Erie and is the largest river basin in the Great Lakes region. Lake Erie provides drinking water for around 11 million people (U.S. EPA, 2025). Importantly, the Maumee River Basin delivers less than 5% of the water in the Western Basin of Lake Erie, but it contributes around 48% of the total phosphorus in the Western Basin (Ohio EPA, 2025). Understanding Marie Delarme can help us understand a critical part of the Maumee River watershed.

The area was originally inhabited by the Miami Indians, who had to settle the headwaters of the Maumee River due to tribal warfare and European settlements. The Miami Indian also named the Maumee River (Ohio Department of Natural Resources, 2024). Additionally, the region used to be a part of the Great Black Swamp (Ohio Department of Natural Resources, 2024). The Great Black Swamp was a vast wetland formed by melting glaciers from the last ice age, which provided many resources to the tribes who lived there. (H2Ohio, n.d.). The extent of the Great Black Swamp and its drainage area is shown in Figure 1.

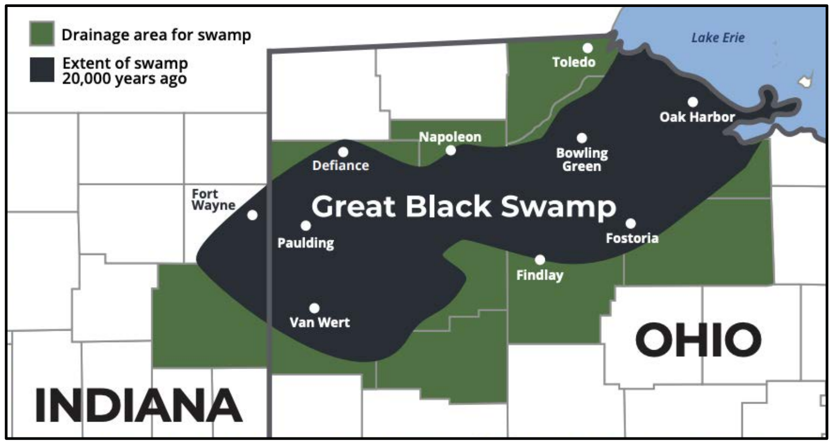

Figure 1. Map of Great Black Swamp Extent (Source: H2Ohio)

When Europeans began to settle, the region was drained in order to increase agricultural productivity (Ohio Department of Natural Resources, 2024). While the Marie DeLarme Creek lived on due to its meandering nature, many other waterways did not, and the area was transformed. Over time, due to human impact, the watershed has been altered from its past state. The agriculturally dominant landscape is what encompasses the watershed, and we recognize the region as it is today. Currently, the area has the following characteristics:

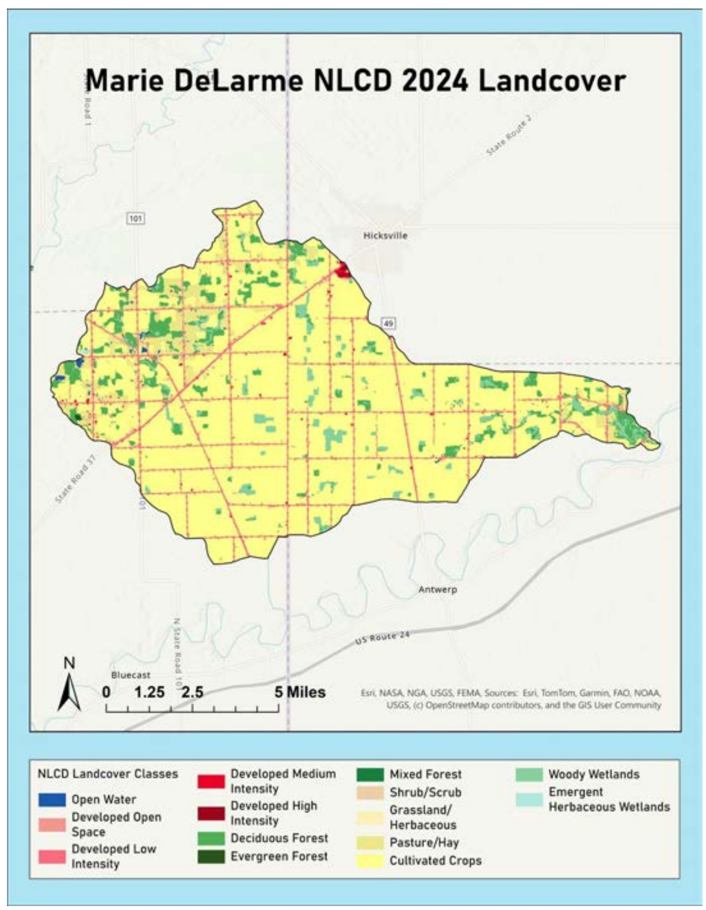

Figure 2. Map of Marie DeLarme Landcover (Created in ArcGIS Pro)

Landcover: The land cover of the Marie Delarme watershed is mainly agricultural, with very few developed areas. In fact, 77% of the watershed's land cover is specifically cultivated crops (Model My Watershed, n.d.). A map of the watershed's land cover is shown below in Figure 2. The area is very rural, and agriculture is extremely important to many people's livelihoods in the region.

Inhabitants: The area has a relatively low population of 2,444 residents due to its rural nature. The population was calculated from the 2020 census blocks within the watershed boundary. The area is also extremely important for native wildlife. The Forrest Woods Nature Preserve sits at the intersection of the Marie DeLarme watershed and the Maumee River, and this area alone is a habitat for more than 30 rare or endangered species and is home to a mature growth tract of swamp woods (Black Swamp Conservancy, n.d.).

Water Quality: Unfortunately, relatively little is known about the current water quality of the Marie DeLarme Creek. The last time samples were taken downstream in the creek was 2015; however, these samples were comprehensive, covering metals, nutrients, biological and algal activity, as well as physical characteristics (U.S. EPA, 2021). This sampling was done after the drafting of the 2014 Maumee River Watershed Report (Maumee River Basin Commission, 2014). Despite the ambition of this watershed plan, Marie DeLarme has remained without sampling for over 10 years, indicating a critical gap in watershed monitoring and management.

IDENTIFIED PROBLEMS

Currently, major concerns for the watershed include nutrient loading, sedimentation, and failing sewage infrastructure, which are detailed further in the table below:

Problem	Description	Causes
Problem 1: Banks – Sediment Deposition and Erosion	Marie Delarme was marked as one of the priority areas for sedimentation concerns in the 2014 Maumee River Watershed Report. However, total suspended solids were never measured for Marie Delarme.	1. Agricultural land use 2. Wetland degradation

Problem 2: Loads – Nutrient Loading	Due to the high amount of agricultural land, improper management or overapplication of fertilizer, manure, and livestock often occurs near waterways. Marie Delarme lacks sampling, so the amount of nutrient runoff cannot be reliably estimated.	1. Landcover and soil characteristics 2. Current agricultural management practices 3. Wetland degradation
Problem 3: Outflows – Sewer Infrastructure Issues	Failing septic systems and combined sewer overflows contaminate the watershed with fecal coliform, including E. coli, as well as increasing other problems such as turbidity, sediment, and nutrient loading.	1. Agricultural land use 2. Low-density residential land use

MISSION STATEMENT

In order to facilitate progress towards addressing the identified problems of this watershed, we put forth the BLOOM (**B**anks**, L**oads**,** and **O**utflow **O**bjectives for **M**arie Delarme) watershed management plan. Our mission statement is as follows:

"The mission of the BLOOM watershed management plan is to provide critical analysis and actionable solutions to the communities of Indiana and Ohio that encompass the Marie Delarme watershed. This plan addresses ongoing issues of nutrient loading, sedimentation, and failing sewage infrastructure that impact human and ecosystem livelihoods in the watershed and downstream. By 2045, we aim to secure a future where the watershed is fishable, swimmable, and provides a safe source of drinking water."

CURRENT GOVERNANCE STRUCTURE AND ECONOMICS

Due to Marie Delarme's position between 2 states and 4 counties, there are a lot of governance structures impacting the watershed. At the federal level, the Clean Water Act regulates discharges of pollutants and developed water quality thresholds that apply to the Marie Delarme

(US EPA, 2013). On a more regional level, the Great Lakes Commission and NOAA designated the Maumee River as an Area of Concern, which provides funding for habitat restoration through the EPA (Great Lakes Commission, n.d.). While this is helpful for the wider Maumee River Watershed, this program focuses mainly on urbanized areas, not the Marie Delarme, which is in a rural region. At the state level, Ohio's program H2Ohio administers Voluntary Nutrient Management Plans, which helps minimize nutrient usage in Ohio as well as implement other best management practices for watersheds, including conservation ditches and manure management (*Farming Practices: Smart Nutrient Management*, n.d.). H2Ohio has other projects as well, including grants for wetland restoration, dam removal, road salt management, and educational programs (*Preserving River Health*, n.d.). Furthermore, the Ohio EPA administers the Total Maximum Daily Load Program, created in the Clean Water Act (H2Ohio, n.d.). However, the last time that the Marie Delarme Creek was monitored for TMDLs was 2015 (EPA, 2021). The Ohio EPA's Maumee Watershed Nutrient TMDL 2024 Biennial Report includes wetland restoration in the Marie Delarme (Ohio EPA, 2026).

Across the state line in Indiana, the Indiana Department of Agriculture houses the Clean Water Indiana program, which has competitive grants for conservation and water quality projects (ISDA, n.d.). Additionally, the Indiana Department of Environmental Management has a Watershed Planning section, which offers information resources for stakeholder engagement and community watershed planning (Indiana Department of Environmental Management, 2026).

Furthermore, the Maumee River Basin Commission was established by Indiana State Law in 1986, with 6 member counties, including Allen and DeKalb Counties in Indiana. The Commission is funded with money from member counties based on their percentage of land area in the basin, as well as grants and interest from the Commission's investments (Maumee River

Basin Commission, n.d.). Notably, the commission only includes Indiana Counties. However, in 2014, Defiance County, OH, and Allen County, IN, collaborated to create the Upper Maumee River Watershed Management Plan with a grant from the EPA (Quandt et al., 2014). This plan has been a major information source for this project. Additionally, the Maumee River Basin Partnership of Local Governments is a coalition of local government officials that has been meeting since 2001 for watershed-based collaboration, but their website suggests this group is not very active with some outdated information (MRBPLG, n.d.).

In addition to these formal governance structures, there are also many non-governmental organizations involved with the Marie Delarme Watershed. For example, the Upper Maumee Watershed Partnership hosts educational speaker series about watershed conservation efforts (Land to Lake, 2026). Similarly, the Black Swamp Conservancy implements wetland restoration projects, including restoring 8 acres of previously farmed land back into wetlands in the Marie Delarme watershed in 2023 (Black Swamp Conservancy, 2023).

PROPOSED GOVERNANCE STRUCTURE

With multiple jurisdictions involved (4 counties and 2 states), we have identified that a crucial part in solving the watershed's identified problems is championing collaboration across Marie DeLarme. Instead of a patchwork of county and state governments that lack coordination, we propose that a new watershed organization be formed using the hybrid combination management model. This model will take advantage of the current government leadership, but emphasize citizen knowledge with spots for citizens to participate in the organization, increasing total buy-in. There is no current watershed plan or group specifically for the Marie Delarme, so this is a very important step to facilitate change and partnership. This organization and the positions it creates will primarily be funded through the states and nonprofits, like the National Sustainable Agriculture Coalition's Regional Conservation Partnership Program, which provides funding for cross-state programs administered at the local level. Unfortunately, a drinking water fee is not applicable due to the region's dependence on wells, and many federal cooperative watershed management grants are currently paused, making state and non-profit funding the clear path forward.

PROBLEM 1: BANKS – SEDIMENT DEPOSITION AND EROSION

Problem Identification: Wind, water, ice, and gravity are often responsible for transporting eroded material. This process is called sedimentation (University of California Regents, 2025). Sediments are important, natural components of waterways that can determine the physical, chemical, and biological properties of their environment. (U.S. EPA, 2015). Anthropogenic influence can accelerate the process of sedimentation through processes like agriculture, construction, and mining (Lake James Environmental Association, 2018). Marie DeLarme suffers from this issue due to the intensive agriculture that takes place in the region. Agriculture often uses erosive practices like tilling, which can result in more sediments entering waterways.

While sediments can be beneficial in some cases, in high amounts, they can be detrimental to any aquatic ecosystem. As sediments enter waterways, they carry organic matter, waste, nutrients, chemicals, and pesticides (Lake James Environmental Association, 2018). High sediment amounts can also block sunlight, suffocate aquatic life, and cause infrastructure damage. Sedimentation is especially important to pay attention to in this region, as Lake Erie has a prevalence of harmful algal blooms that occur due to high phosphorus and nitrogen runoff (Ohio Sea Grant, 2018).

In the 2014 Upper Maumee River Watershed Plan, sediment levels exceeded normal values in half of the subwatersheds, and Marie Delarme was marked as one of the priority areas for sedimentation concerns (Maumee River Basin Commission, 2014). Unfortunately, total suspended solids were never measured for Marie Delarme, and the area still lacks sampling today. Thus, due to its unknown severity and critical nature, sedimentation is an essential problem for the watershed to address.

Problem Goal and Suggested Solution: Our goal for this watershed is to reduce sedimentation by 25% through our watershed organization. However, this goal and solutions must utilize adaptive management. Because little is known about the sediment level in the watershed, after initial sampling, the goal may need to be adjusted to more accurately reflect the current condition of the watershed. Thus, the first suggested solution is setting up continuous water quality gauges and monitoring for the watershed. Ideally, in the first year, sediment sampling needs to be conducted to set a baseline. Then, through the watershed organization, a frequent pattern of sampling should be established to assess progress. Preferably, this will be done by setting up stream gauges, as the watershed currently lacks them, but if needed, manual field sampling can be conducted by the organization or associated parties.

The second solution for this region will focus on buffer areas. As previously mentioned in the introduction, draining the wetlands of the Great Black Swamp deprived the watershed of its natural buffer for filtration. Thus, creating new wetlands and buffers needs to be a priority for the region. Thankfully, they have already started this process. In the 2024 Maumee Biennial Report, the Marie DeLarme Wetland Restoration project was highlighted, which restored eight acres of land that was previously used for high-intensity crop production, followed by 10 years of hay production. Two of the eight acres were restored to seasonal wetlands, and the other six were restored to riparian woodland areas (Ohio EPA, 2024). Through the watershed organization, more projects like this can continue to be facilitated across state and county boundaries. Initially, the lands that surround farms or are no longer being used for agricultural production should be explored as options. Additionally, the organization should connect farmers with programs offering conservation easements or funding to convert some of their farmland to wetlands and buffers.

This brings us to our third proposed solution, which is to use the watershed organization to connect farmers across state and county boundaries with buffer and conservation programs. This may be done through community liaisons or by offering a new online database targeted at opportunities that are applicable to the residents of the watershed. Marie DeLarme already has access to a lot of beneficial programs, but the key is making sure people know about them. For example, the Ohio Working Buffer Program offers 2-year contracts for \$200-\$250 per acre for conversion to less intensive agriculture like pasture and hay (Paulding Soil & Water Conservation District, 2026). Similarly, there is the Indiana Conservation Reserve Program (CRP), which offers 10-year contracts to plant and protect forest buffers (USDA, 2025). Providing ease of access to these resources is crucial for increasing adoption rates. Furthermore, the organization can potentially facilitate collaboration between programs and encourage new initiatives as well.

PROBLEM 2: LOADS – NUTRIENT LOADING

Problem Identification: In the Upper Maumee River Watershed Management Plan of 2014, a windshield survey was described to be conducted from May to September of 2012. This survey involved many vehicles, two personnel per vehicle, driving along every road in the watershed and making note of areas of significant soil loss, lack of riparian buffer zones, livestock access to open water, or other sources of pollution. This is important to observe as the lack of protection from nutrient runoff will lead to harmful algal blooms developing in water, creating dead zones where harmful toxins impact human and animal health. These blooms are a documented problem within Lake Erie, which is connected to this watershed via the Maumee River, thus making it a problem for the Marie DeLarme sub-watershed (National Centers for Coastal Ocean Science, 2026). Then, to verify the notes taken on each site, aerial photography from 2011 was used. Based on this windshield survey, there were 26 locations identified as potential problems. The sites within the Marie DeLarme sub-watershed were almost entirely located on the 87% of land cover classified as agricultural land, and the problems identified at these locations form the basis of this watershed management plan.

The watershed comprises mostly farmland; however, the soil composition is described as a hydric soil, which forms under conditions of saturation, flooding, or ponding. Hydric soils are a good indicator for areas of wetlands, and while they can have a high nutrient and organic matter content, they require management in the form of drainage of water so that plants do not drown (Trettin et al., 2020). This drainage is done through subsurface (tile) drainage, which often includes pipelines that intercept water below ground and direct it to an outlet like a ditch, stream, or a wetland (North Dakota State University, n.d.). Fertilizer and manure runoff are exacerbated by drainage tiles, pumping nutrients from fertilizer into rivers or wetlands. At several locations of the windshield survey, it was observed that livestock from pastured lands had open access to nearby water sources. Fertilizer and manure from improper management of livestock and application of fertilizers near waterways. Marie Delarme has not been measured regularly for water quality samples, so the amount of nutrient runoff cannot be reliably estimated. Only one potential point source of pollution is present, which is the Underground Storage Tank located in

Allen County. They have been reported to have never leaked and are not expected to cause a problem.

As shown in the map from the Upper Maumee River Watershed Management Plan (Quandt et. al., 2014) and mentioned earlier, there is a very limited amount of water quality sampling conducted in this area. There was only one site that was sampled by the Indiana Department of Environmental Management (IDEM). One other site was proposed to be sampled toward the start of the Marie DeLarme Creek, but that would not yield any information on how the nutrient runoff from agriculture impacts the water quality throughout the watershed due to its location upstream.

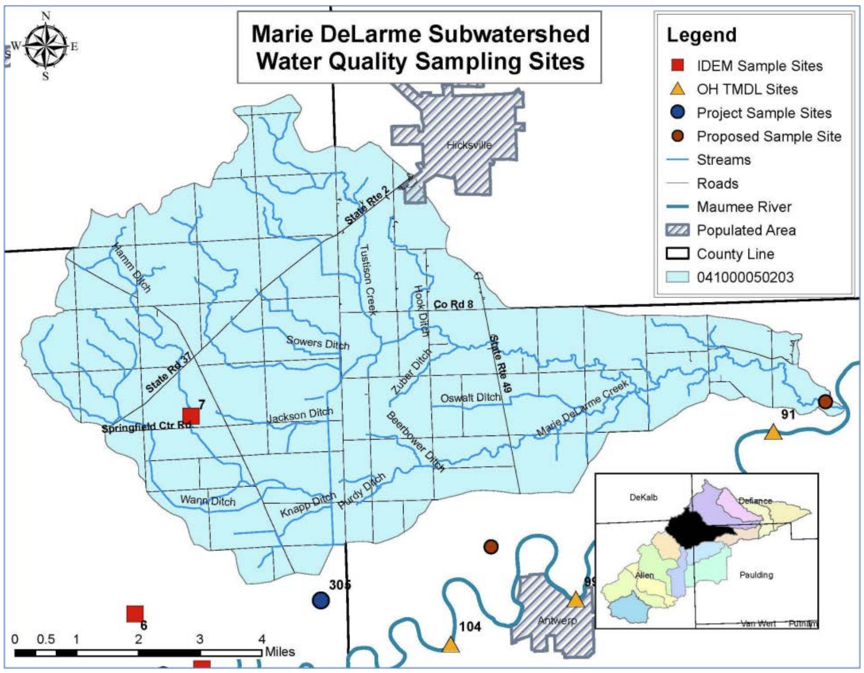

Figure 3. Marie DeLarme Sampling Locations (Source: Quandt et. al., 2014)

Problem Goal and Suggested Solutions: Our first goal is to limit the number of potential sources of nutrient pollution into the creeks and rivers of the watershed. With a lack of monitoring, it is difficult to say just how much of a reduction in nutrient pollution is necessary; however, establishing a total maximum daily load (TMDL) will place limits on the number of nutrient inputs. Once monitoring is completed, an exact TMDL number can be determined. With the majority of problems coming from agriculture, implementing the solutions below should diminish the amount of nutrient pollution into waterways by at least 50%.

Wetlands are good at filtering water by slowing down water flow and by trapping sediments, pollutants, and excess nutrients (Wetlands International, 2025). While some wetland restoration, approximately 8 acres of land, has occurred due to the Black Swamp Conservatory's efforts, strategic monitoring of where the most runoff happens needs to be done to identify locations of future wetland restoration. We recommend that, after more water quality monitoring in Marie DeLarme, wetland restoration efforts be concentrated in areas where nutrient loading and runoff occur.

An additional way to reduce the amount of runoff is to properly manage livestock and the waste they produce. It was mentioned in the windshield survey that at many sites, livestock had open access to an open body of water, most of the time a stream or a creek. The EPA does not specifically mandate livestock to be fenced off from a body of water; however, Concentrated Animal Feeding Operations (CAFOs), which determine how farmers manage their livestock and feed them, fall under the regulation of the state. The EPA does, however, require a farmer to limit the amount of discharge as close to zero as possible, meaning they must limit as much nutrient runoff as possible (US EPA, 2015). As for fertilizers for cultivating crops, applying the fertilizer at the right time, in the right amount, and in the right places would reduce the amount of nutrients that are carried away and leached into nearby rivers (EcoServants, 2024). Oftentimes, though, the information, software, and hardware required to conduct such precise fertilization have high upfront costs. We recommend that the states of Ohio and Indiana work with the farmers in the watershed to provide adequate help through funding precision fertilizer technologies and providing monetary incentives to keep livestock away from open bodies of water.

Our second goal as a solution to nutrient loading is to foster a connection between the states and the residents who live in the watershed. Both Indiana and Ohio have state departments involved with the Environmental Protection Agency, which each have their own goals for their own respective states. Indiana also has their department of Environmental Management that is separate from the EPA but works closely with them in Total Mean Daily Load reporting for nutrients and fertilizers. We recommend that these agencies work together to release joint reports and monitor the water quality of watersheds whose boundaries do not fall solely in one political boundary (i.e., the Marie DeLarme watershed, whose boundaries fall in both Indiana and Ohio). Additional recommendations involve educating members of the public and residents. Mandates by the federal, state, or local governments are one thing, but forcing property owners to invest in strategies on their own is logistically more difficult. Fostering individual engagement and interest through education should be a priority to increase stakeholder investment in the solutions listed above.

PROBLEM 3: OUTFLOWS – SEWER INFRASTRUCTURE ISSUES

Problem Identification: The Marie Delarme Creek is identified as the highest priority area for septic failure in the 2014 Upper Maumee River Watershed plan, meaning more than 300 households were estimated to have failing septic systems at the time (Quandt et. al., 2014). Failing septic systems contaminate the watershed with fecal coliform, including E. coli, as well as increasing other problems such as turbidity, sediment, and nutrient loading. Likewise, in the 2014 plan, the Marie Delarme ditch had a geometric mean of 616 CFU/100ml of E. coli, well over the state standard of 125 CFU/100ml (Quandt et. al., 2014). Clearly, septic systems and their failure are a key issue for water quality in the Marie Delarme watershed and its downstream neighbors. Importantly, because of the rural nature of the watershed, most residents rely on well water, which can be contaminated by fecal coliform.

It's not surprising that septic systems are a challenge in the Marie Delarme. In fact, while most of the population in the Upper Maumee River Watershed is rural and depends on septic systems to process wastewater, only 3% of the land is suitable for septic systems (Quandt et. al., 2014). Since the watershed used to be wetlands (the Great Black Swamp), the soil is mostly hydric, which means it is too wet to effectively filter septic system discharge. Figure 4 is a map showing the different soil types in the Marie Delarme watershed, with only the lightest blue and lightest green soil types suitable for traditional septic systems.

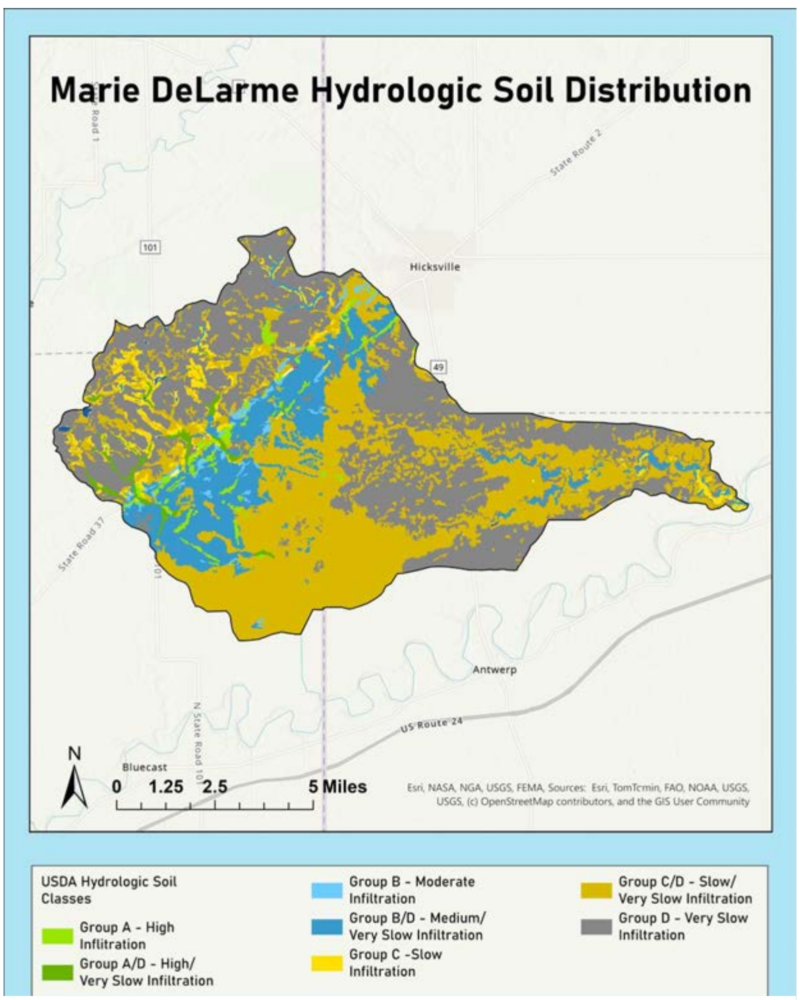

Figure 4. Marie DeLarme Hydrologic Soils Map (Created in ArcGIS Pro)

Despite the fact that most of the soil in the watershed does not support septic systems, people built homes and farms in rural areas without public sewer service. The 2014 plan reported that only 5% of the watershed is developed, and only 1% is developed with any intensity. This extremely low-density means that most residents depend on septic systems prone to failure, and public sewer systems are not a realistic alternative. Adding to the problem of fecal coliform contamination, plan writers in 2014 observed 2 areas where livestock had unrestricted access to waterways.

Problem Goal and Suggested Solution: Since the residents of the Marie Delarme watershed live in dispersed, rural communities, a public sewer system is not a realistic alternative to the failing septic systems. Instead, there are alternative septic system technologies that can function in hydric soils. For example, Solano et al (2004) found that constructed wetlands can be an effective solution for wastewater treatment. The US EPA notes that they require an impermeable barrier between the wetland system and wastewater, which may flow into a secondary drain field after flowing through the constructed wetland. Figure 5 is a diagram of the potential process. The East Texas Plant Materials Center has developed a guide of wetland plant species suitable for wastewater filtration (East Texas Plant Materials Center et al., n.d.).

Other alternatives to traditional septic systems include aerobic treatment systems, which rely on microbes instead of soil to treat wastewater. They use a process similar to municipal water treatment plants, but on a smaller scale (US EPA). Other options include other above-ground septic systems, including recirculating sand filter systems (US EPA).

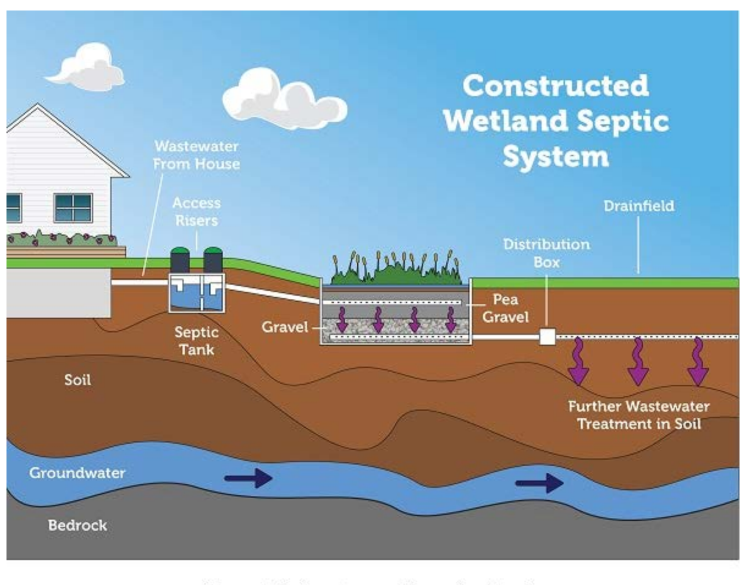

Figure 5. Diagram of Constructed Wetland Processes (Source: US EPA)

Importantly, these changes to septic systems cannot happen without assistance and education. We recommend that local governments provide funding for septic system updates, replacement, and regular maintenance. Since local governments do not provide municipal water, the conventional approach of increasing drinking water fees does not apply here, so creative methods of fee raising are necessary. For example, this financial assistance could come from grants aimed at drinking water quality as well as watershed management.

Additionally, as discussed previously, we are recommending that a watershed management organization be formed for the Marie Delarme, and we recommend that septic systems be one of the first issues they consider. For example, one option is to require that owners and operators of septic systems have maintenance and inspection contracts with approved vendors to ensure that septic systems are less likely to fail. This is level 2 of the 5 levels of septic system protection recommended by the Association of New Jersey Environmental Commissions' 2017 report on municipal options for managing failing septic systems. Since this change would have a big impact on residents of the Marie Delarme, we recommend that the new watershed commission implement community engagement and facilitate a public process of deciding which level of protection would be most appropriate and effective in the region. Other levels of protection include requiring permits to own septic systems and having local governments, not residents, responsible for septic system ownership and operation. The watershed commission should also lead education efforts about the issues with failing septic systems, the importance of septic system maintenance, and alternatives to traditional septic systems. Our goal is for this new regulation to be deliberated with the community and then to be in effect by 2028.

Additionally, inspired by the Delmarva Conservation Network’s recommendations, we recommend that the 4 local governments and/or two state governments implement real estate disclosure requirements for properties with septic systems in soil not suited for them, as well as properties in flood-prone areas. This would allow prospective homebuyers to be informed about their options for wastewater management. Furthermore, we recommend that zoning ordinances and building codes require new developments in hydric soil types to include appropriate wastewater management systems. While the area is mostly agricultural and rural currently, this measure would protect against further harm if some of the hydric farmland is converted into more residential land uses. Our goal is for these updates to be in effect by 2028.

Additionally, we recommend that the local governments implement a requirement to test drinking water quality in residents' wells, to ensure it is of high quality and not contaminated with fecal coliform. While residents may be resistant to more regulations of their septic systems, if their wells are contaminated with fecal coliform, they may be more on board with finding solutions to groundwater contamination from failing septic systems. Our goal is for all drinking water wells to be tested for fecal coliform by 2028, including public engagement about why testing is important and guidance on how residents can interpret the results.

CONCLUSION

The Marie Delarme watershed is a critically under-monitored component of the larger Maumee River basin, where agriculture, altered soil and hydrology, and failing infrastructure impact both the local ecosystem and water quality. Sedimentation, nutrient loading, and septic system failure are all connected and influenced by the loss of wetlands and the dominant use of agriculture and pasteurization on hydric soil. Addressing these problems requires targeted solutions and a coordinated governance structure that can transcend the political boundaries of both Ohio and Indiana, as well as engaging local stakeholders. The proposed BLOOM watershed management framework provides a foundation for efforts of collaboration, adaptive management, and increased monitoring to fill gaps in understanding and available data on water quality.

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