November 1, 2023

Waynoka Property Owners Association
Attn: Paul Cahall, General Manager
1 Waynoka Drive
Lake Waynoka, OH 45171

**Subject: White Paper regarding Algal Blooms at Lake Waynoka, Brown County, Ohio**

Dear Lake Waynoka Board,

At the request of the Waynoka Property Owners Association (WPOA) and its Board President, MAD Scientist Associates, LLC (MAD) has prepared this document summarizing and assessing main contributors to algal blooms and recommendations for reducing their frequency and severity in Lake Waynoka in Franklin Township, Brown County, Ohio. In compiling this white paper, we evaluated the recent issue of algal blooms, focusing on potential factors including nutrient loads, water condition, surrounding land use, effects of dredging, grass carp population levels, as well as climate change and weather patterns. A brief summary of recommendations to consider in order to address ongoing algae bloom issues is also included.

**General Factors Contributing to Algal Blooms in Lake Waynoka**

*Nutrients*

Oligotrophic lakes (*i.e.*, those with few nutrients) are generally clear, deep, and free of weeds and large algae blooms. Though beautiful, they are low in nutrients and do not support large fish populations. Comparatively, those with abundant submerged aquatic vegetation (SAV) and algae are generally considered eutrophic, having excessive richness of nutrients. Eutrophication is a natural process for lakes progressively becoming enriched with minerals and nutrients as they age; however, in urban settings, the process of nutrient accumulation can happen in decades instead of centuries (Peck and Deibel, 2023). These rapid changes can reduce the ability of natural systems to adapt, resulting in nuisance vegetation and algal blooms. The latter are typically caused by increased concentrations of nitrogen and phosphorus in the water column.

Phosphorus (P) and Nitrogen (N) are essential nutrients for algae and aquatic plants. Typically, P is the limiting factor for algae and plant growth, while N sources can be abundant and may vary. Even precipitation may introduce over 0.5 mg/L nitrogen compounds in rainfall. For N to facilitate a blue-green algae bloom, its concentrations must be above 0.5 mg/L. When the ratio of N and ammonia ($NH_3$) to P is less than 10:1, additional N inputs will stimulate algae growth. Alternatively, at a ratio of 15:1, if more P is added, it will stimulate algae growth. All values in between these ratios (*i.e.*, from 10 - 15:1) are considered transitional to causing algal blooms (UMassAmherst, 2016).



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Lake Waynoka likely has increasing N and/or P in the water column leading to the algal blooms. In recent years (*e.g.*, 2020-2023), Aqua Doc was contracted to treat algal issues using copper sulfate. Algal blooms in 2022 were particularly severe resulting in Aqua Doc applying weekly copper sulfate treatments. These treatments provided short-term relief; however, algal and vegetation issues quickly resumed indicating a continuous source of nutrients into the system.

*Water Conditions*

Warm water temperatures create conditions needed for algal blooms to thrive. Algal blooms occur most often in still bodies of water where temperatures are around 77 degrees Fahrenheit (Kohlhepp, 2015). Although water temperature data from sampling have not been recorded at Lake Waynoka, it is likely that water temperatures are increasing with warming summer air temperatures. Lake Waynoka is a shallow lake, with a maximum depth of 37 feet, and much of the lake is less than 20 feet deep. In the eastern portion of the lake, the average depth is just 10 feet. Algae has been observed in all coves but is reported to be much worse on the east end of the lake (*e.g.*, from Geronimo east and the cove just east of Tomahawk). Shallow water is more prone to greater temperatures preferred by algae and supports more prolific reproduction. In addition, Lake Waynoka also has long water residence time, which also supports high rates of growth and reproduction (Paerl et al., 2001).

*Surrounding Land Use*

Surrounding land use is an important factor impacting algal blooms in water bodies. For example, agricultural lands can generate up to 40 times more N and P than that of forested landscapes (Brattebo et al., 2016). Suburban and urban land use will generate 10 to 20 times the nutrients over background levels. Because predominant land uses within the Lake Waynoka watershed include intensive agriculture and residential homes, surrounding land use is a significant contributor to N and P loading in the lake and its coves.

Based on aerial imagery (Attachment A), it does not appear that there has been an increase in agricultural land use within the past few years, but it is possible that the types or amounts of fertilizers applied or practices on agricultural lands have changed. The lake itself is about 300 acres with approximately 1,600 residential properties and increasing by about 40 residences per year. The rate of residential development increased from about 10-20 residences per year to 30-40 per year within the last few years. Runoff from residential and agricultural fertilizers likely add nutrients, especially P, into Lake Waynoka, which contributes to algal bloom frequency and intensity, even leading to harmful algal blooms. Inadequate nutrient reduction or mitigation farming and community land use practices result in increased nutrient loading, in particular phosphorus concentration, in heavily agricultural and residential watersheds (St. Johns River Water Management District, 2023). Overusing fertilizers, maintaining livestock near water supplies, sewage discharges, and run-off are all common contributors to high nutrient loading.

*Dredging*

Dredging can be used to reduce internal loading and cycling of nutrients. Specifically long term, dredging helps reduce algal blooms, but in the short term they may exacerbate them. Dredging efforts at Lake Waynoka are currently very intensive and frequent. The whole lake requires a 12-year cycle fully dredge. During dredging efforts at Lake Waynoka, three dredge boats that work with an excavator, removing 12-14 loads per day working six months out of the year. This includes removal of between 3,000 to 5,000 cubic yards of dredged material each year just from the east end of the lake, at a cost of approximately $100,000 per year. Boats are also noted to stir up sediment during this process. Hydro-dredging is used to suck



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sediment in some locations. Every time dredging occurs, it releases nutrients from the sediment back into the water column, which can support algal blooms. Some shallow areas of Lake Waynoka, such as in the coves, are not dredged. The aquatic vegetation is very dense in these areas based on a Site visit MAD conducted in August 2021.

*Fish and Plant Populations*

Certain fish species can be used to mitigate algal blooms. Common carp were introduced to Lake Waynoka as a response to nuisance vegetation. In the early 2000s, due to extremely dense vegetation prohibiting motorized watercrafts from recreating the lake, 1,100- 1,500 grass carp were introduced over a three-year period. By 2010, the lake had no vegetation. Accounts indicate carp removing all cattails by eating their roots and following lawnmowers along the shore to eat grass that ended up in the water. From 2011 to 2014, many dead carp were removed from the lake and shorelines. Because of their large size, dead carp became boating hazards. In 2016, small amounts of aquatic vegetation and cattails returned. In 2019, approximately 25 carp were stocked. During the following year, large amounts of aquatic vegetation and algae were observed. In response another 100 carp were added and Aqua Doc was contracted to treat the lake. In 2021, the situation worsened, and an additional 150 carp were added with more frequent visits from Aqua Doc. Little change was observed in 2022, so an additional 500 carp were introduced, and Aqua Doc made weekly visits for treatment. In 2023, 50 carp were added and aquatic vegetation have been largely reduced. Aqua Doc still treats some areas for aquatic vegetation, but algae growth remains a problem but less so relative to 2022. Attempts to promote a balance between fish and vegetation have been sought through this recent process. Cattails remain along the shoreline, likely indicating that carp populations are currently not too dense.

Cattail roots are not thought to be a preferred food source, but it appears that carp will eat them and potentially even algae when other food sources are low. Typically, grass carp (*Ctenopharyngodon idella*) prefer to eat fully submerged vegetation. If there is a lack of submerged vegetation, they may occasionally eat filamentous algae (Swistok, 2022). Grass carp are not recommended as a control for algae because their waste is high in the same nutrients which lead to toxic cyanobacterial growth and algae blooms (Solitude Lake Management, 2022). In addition to this, removing too many of the aquatic plants within the lake by dredging or an overpopulation of grass carp can lead to excess free nutrients within the lake, resulting in an algae bloom (Solitude Lake Management, 2022).

Aquatic plants assimilate nutrients, including phosphorus, and store them. When these plants are removed, there is less storage for nutrients, making these nutrients bio-available to algae. If these plants are killed and then left to decompose in the lake, then their nutrients are then released back into the lake (Pekarek, 2017). Lake Waynoka stocked grass carp to reduce the abundant submerged vegetation. Adding carp which excrete N and P while removing aquatic vegetation that would typically uptake these nutrients may have led to the additional free nutrients for the algal communities and/or exacerbated the issue of excess nutrients in the lake.

*Climate Change and Precipitation*

Climate change is another driving factor in recent algal blooms worldwide. An increase in the intensity of rain leads to more nutrient run-off from farming. Increased carbon dioxide in the atmosphere is dissolved into bodies of water which leads to more rapid algae growth. Increasing temperatures lead to a more favorable environment for algae growth as well (Environmental Protection Agency, 2022). Severity of heavy precipitation increases levels of contaminated runoff and nutrient loading in lakes and major



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waterways. Current vulnerabilities to extreme and sustained precipitation that encourage algal blooms, such as agricultural runoff and combined sewage overflows, will be amplified with increased total and extreme precipitation. Models project that the observed increases in the frequency and intensity of heavy downpours in the region will continue in the future.

In recent decades, many areas of Ohio have seen increased precipitation and frequency of severe storm events. These trends are expected to increase due to climate change. Due to increased precipitation and frequent storm events and the steep topography surrounding the lake, erosion and sediment deposition may be increasing. Increased sediment deposition often coincides with increased nutrient concentrations. In Lake Waynoka, increased annual nutrient deposition rates may have reached the concentration threshold required to support a thriving population of algae bodies, thus resulting in contemporary algal blooms. This is likely compounded by the fact that sedimentation deposition is causing the lake basin to become shallower and warmer.

**Summary of Historical Water Testing at Lake Waynoka**

In 2012, MAD Scientist Associates conducted a study and recommended management techniques to improve the water quality within Lake Waynoka. At the time of this study, the major concern for the long-term health of the lake was the amount of sediment deposition. An increased amount of total suspended sediments (TSS) was observed, which often include dissolved particles such as phosphorus that can result in algal blooms. In 2012, 4 of the 13 samples had very high concentrations of TSS (MAD Scientist Associates, 2012). If the recommended management techniques were not implemented or not effective, it is likely that the TSS has continued to be an issue and may be a factor leading to algal blooms.

In 2016, Ohio Environmental Protection Agency (OEPA) collected water samples from Lake Waynoka, the water supply reservoir, and the up-ground water supply reservoir. In the two reservoirs, there were several species of phytoplankton that can produce cyanotoxins that can lead to harmful algal blooms. The phytoplankton community within Lake Waynoka contained far fewer of these species. Lake Waynoka was considered hypereutrophic in 1992 and decreased to eutrophic in 2015 and 2016. In 2016, these reservoirs had been experiencing algae blooms and OEPA stated that these algae blooms were most likely driven by phosphorus because the nitrogen concentrations within these bodies were within the normal limit (OEPA, 2018). Since water from these reservoirs drains to Sugar Run and into Straight Creek west of Lake Waynoka, it is not likely that the water from these reservoirs would likely be entering Lake Waynoka. Alternatively, it is possible that whatever was affecting these reservoirs, be it runoff from agriculture, climatic changes, or environmental changes, is now also affecting the lake.

Furthermore, in its 2018 study of Lake Waynoka and its tributaries, OEPA determined that Lake Waynoka itself did not have excessive concentrations of N and P at that time, but high concentrations of these nutrients were present at levels needing to be addressed in the Sycamore Run, which is within the Lake Waynoka watershed. Sycamore Run connects to Straight Creek west and downstream of Lake Waynoka, and therefore this area, similar to the water supply reservoirs, would not be a source of the issue for Lake Waynoka. However, due to the finding that nitrogen and phosphorus are elevated in the surrounding watershed and the concentrations of these nutrients vary seasonally, an increase of nitrogen and/or phosphorus concentrations causing recent algal blooms would not be unlikely. It may be worthwhile to request OEPA to conduct this sampling again, or to contract another entity like MAD to assist with water quality sampling to determine current N and P concentrations since the algae blooms have been occurring.



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**Recommendations**

There are many approaches to improving water quality in lakes, and only a brief overview is provided in this summary. First, recognizing that all the components within a system are interconnected is integral when developing remedies. A holistic approach with involvement and collaboration with relevant partners, such as state, county and local water experts, limnologists, and soil and watershed partners, is needed to evaluate how changes will interact. This builds stewardship, understanding and beneficial involvement to address challenging situations such as nutrient loads and algal blooms. It is also imperative to collect baseline data to aid in understanding existing conditions and identifying goals. Issues such as nutrient and algal issues at Lake Waynoka are often best addressed through adaptive management. Typically, the adaptive management process involves assessing and identifying issues, developing a management strategy, and monitoring the results of management. Based on monitoring results, new management strategies are implemented and the cycle repeats to continue finding a balance in the system to meet prioritized goals.

Remedies to treat the ecosystem should evaluate effects and conditions upstream, downstream, as well as internal and external sources. A Lake Management Plan focused on evaluating the watershed should be developed to assess current conditions including further investigation determining current nutrient concentrations and sources as the first step. Although determining the source of phosphorus is important, it is the quantity and timing of phosphorus availability within the lake that needs to be determined (Brattebo et al., 2016). Preventing excess inputs from internal loading (*i.e.*, nutrient recycling within the lake) as well as minimizing external loading (e.g., sources from the watershed and shoreline) are required. While watershed management of phosphorus loading is the key to slowing accelerated eutrophication (Brattebo et al., 2016), both internal and external sources need to be addressed. Addressing only one has shown failure in multiple case studies (Peck and Deibel, 2023

Watershed best management practices (BMPs) are an important component in reducing overall loading to lakes and reservoir for long-term management success (Brattebo et al., 2016). To reduce external loading, BMPs such as keeping leaf piles away from the lake can be beneficial for improving water quality and reducing aquatic vegetation. In addition, ensuring septic systems are functioning properly is also imperative, as these can be sources of phosphorus. It is estimated that a faulty septic system can introduce four pounds of phosphorus per household per year, while it only takes one pound of phosphorus to allow the production of 500 pounds of vegetation (Peck and Deibel, 2023). Other BMP tools include erosion control, fencing, volunteer efforts and planting native plants, trees, and shrubs. Laws and setbacks established by the WPOA, such as a no-mow buffer zone that extends 25-50 feet from shore (preferable), or 10-15 feet (still beneficial) would be potentially effective, especially if implemented around the large shoreline habitat surrounding Lake Waynoka.

Planting native vegetation is one of the best BMPs to reduce algae blooms. A recent approach for naturalized shoreline using native plants is termed “lakescaping” (Minnesota Department of Natural Resources, 2012). The native vegetation along the shore acts as a buffer zone, intercepting nutrients, reducing runoff, erosion, and sedimentation, while providing habitat and resources for wildlife. For example, native vegetation has many benefits compared to turfgrass in that it can uptake many more nutrients. Roots of native vegetation reach down to the water table several feet down whereas Kentucky bluegrass roots only extend a few inches (Peck and Deibel, 2023). The extra biomass below ground increases the filtration of water and absorption of nutrients to aid in the growing of the plant. Lakescaping can have a wild or manicured appearance depending on the approach. There are guidance documents available as well as an online program through local Soil and Water Conservation Districts (Minnesota Department of Natural Resources, 2012).



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There are a few options for addressing internal loading. Dredging can remove phosphorus laden substrates and temporarily reduce phosphorus in the lake. Alum treatments and aeration of the lake can also break up the compounds so that they are not readily available for algae and aquatic vegetation production. Aquatic vegetation that is already growing can be harvested and removed for composting (placed away from the lake). ProcellaCOR is an effective treatment for milfoil used by Aqua Doc and can be used to manage nuisance of vegetation while protecting the benefits of vegetation. If needed, it should be used selectively to treat invasives and dense weeds where necessary, in conjunction with long term and recommended lasting remedies. Phosphorus inactivation (e.g., Aluminum sulfate) has been proven effective in shallow lakes, regardless of the level of watershed management, in reducing internal phosphorus loading and harmful algal blooms (HABs) Brattebo et al., 2016), however, it is often not a long-term solution, especially in waters with boat traffic that disturbs the substrates, because phosphorus will be resuspended into the water column.

Another remedy is floating islands or floating treatment wetlands (FTWs). Because of the benefits of native plants taking up nutrients from the water, adding FTWs can maximize the absorption of excess nutrients in the lake. Without chemicals and modeled after nature, FTWs were designed to mimic nature's own floating wetlands. These FTWs have been installed around the world and are effective at removing contaminants such as nitrogen, phosphorus, total suspended solids (TSS), and Propylene Glycol and reducing biochemical oxygen demand (BOD) (Floating Islands West, 2003). In addition, multiple case studies of FTWs indicate that they outperform constructed wetlands in removing BOD, total nitrogen, ammonia, TSS. For example, FTWs were installed in Illinois in two stormwater ponds that were inundated with algae during the growing season, and afterward the dissolved oxygen (DO) levels greatly increased while algae levels and turbidity decreased. Furthermore, having wetlands in the lake can also reduce the amount of sunlight that is entering the water to reduce algae growth further. There are variable sizes from 25 to 100 square feet and could be held stationary with anchors and placed in problematic areas to improve the water quality.

**Conclusion**

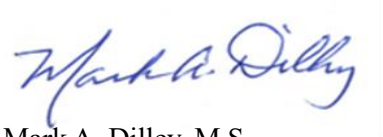
This white paper summarizes main contributors of algal blooms and recommendations for reducing them at Lake Waynoka. Algal blooms and water quality issues in lakes involve many factors and need to be addressed holistically. There are many remedies suggested that can be implemented in conjunction with each other to improve the issue at Lake Waynoka.

If you have questions or would like to discuss the evaluation of algae blooms and recommendations to reduce them at Lake Waynoka, please feel free to contact us at 614-818-9156 or via email at Jenna@madscientistassociates.net and Mark@madscientistassociates.net. Thank you for the opportunity to provide this white paper to your board at Lake Waynoka.

Best Regards,

Jenna Roller-Knapp, M.S.

Aquatic Ecologist



Mark A. Dilley, M.S.

Chief Scientist



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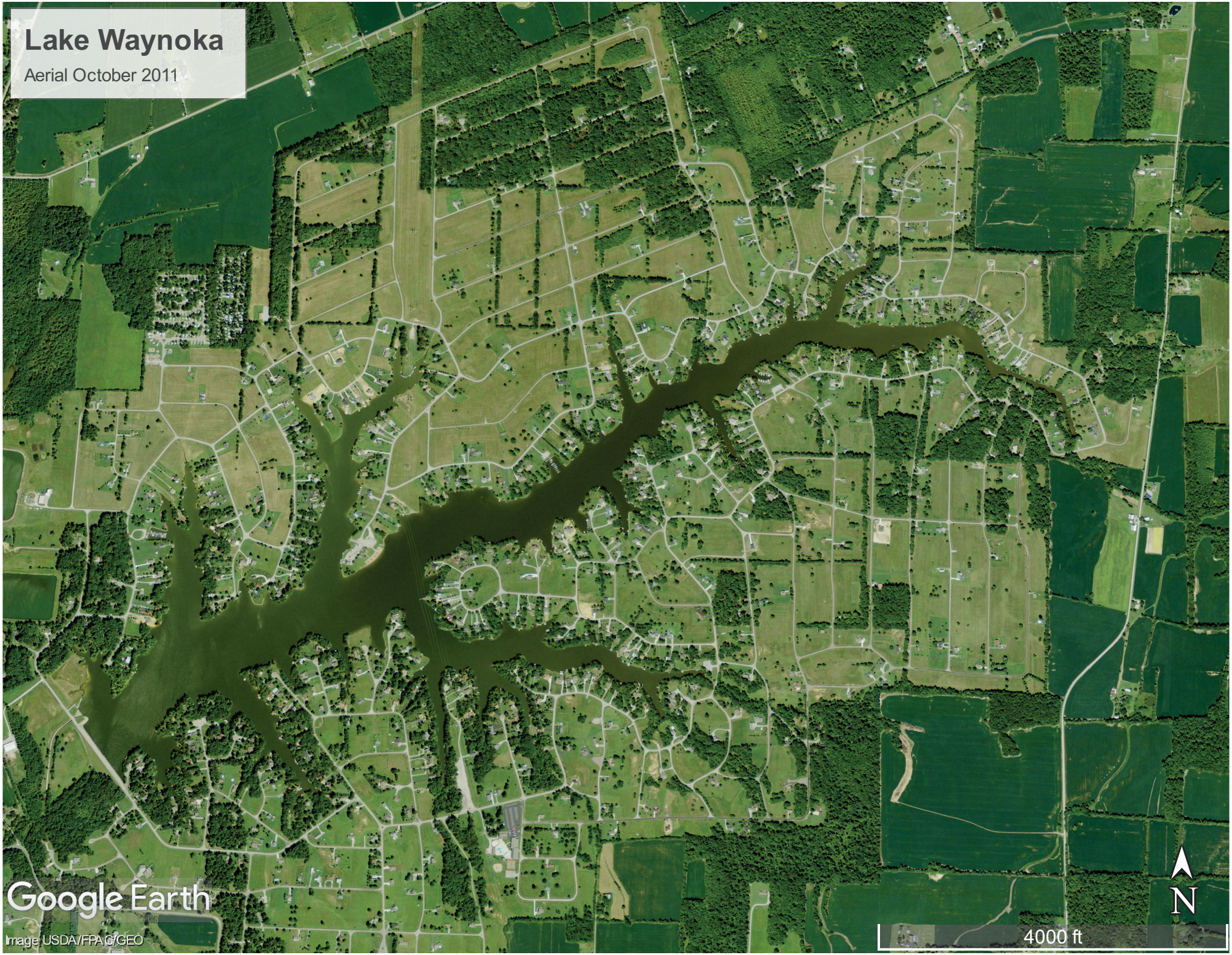
# Attachment A



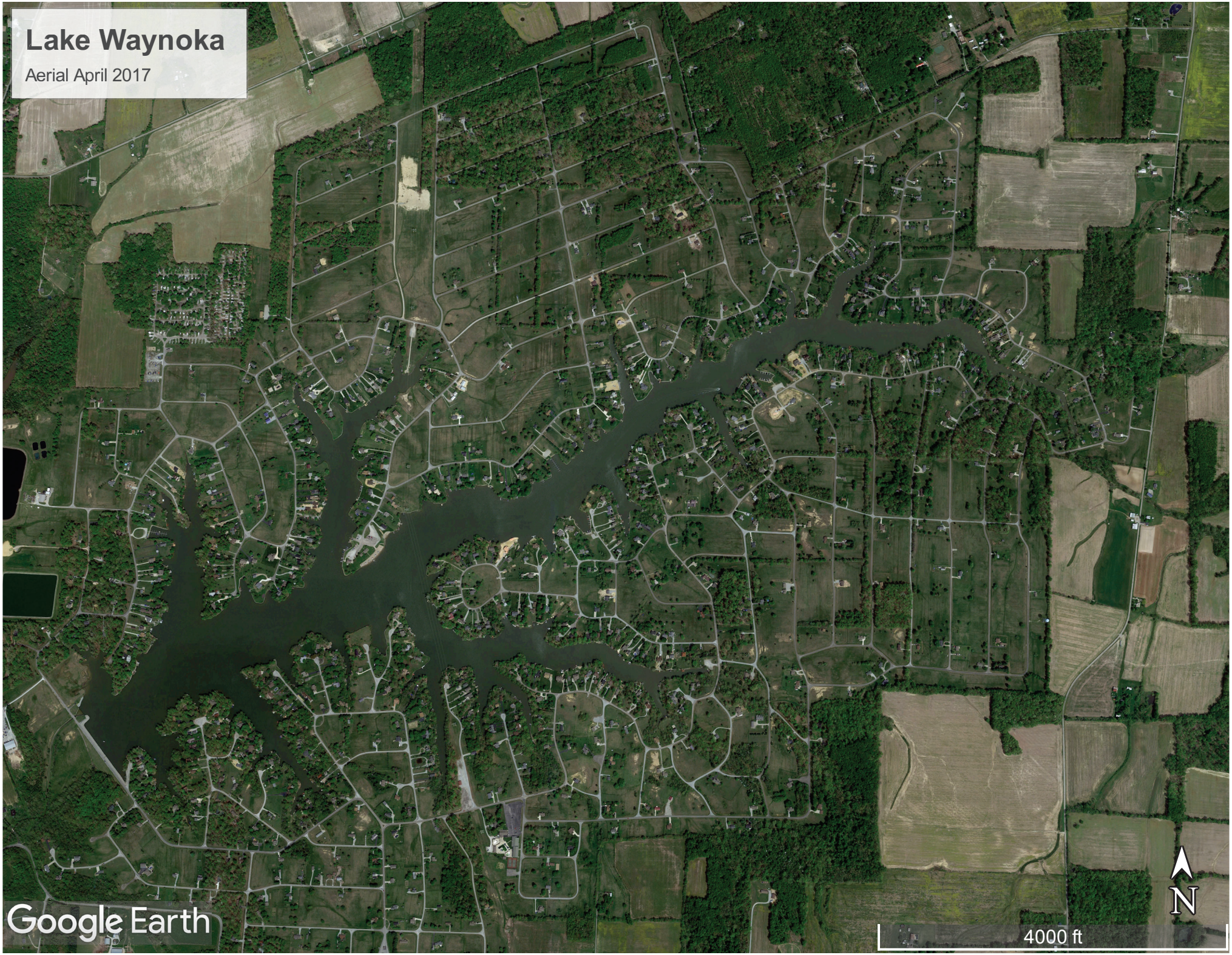
253 North State Street, Suite 101 Westerville, Ohio 43081 (614) 818-9156 Fax (614) 818-9157 www.madscientistassociates.net


Lake Waynoka
Aerial June 2004
Google Earth
Image USDA/FPAC/GEO
N
4000 ft


Lake Waynoka
Aerial June 2009
Google Earth
Image USDA/FPAC/GEO
N
4000 ft


Lake Waynoka
Aerial October 2011
Google Earth
Image USDA/FPAC/GEO
N
4000 ft


Lake Waynoka
Aerial July 2015
Google Earth
N
4000 ft


Lake Waynoka
Aerial April 2017
Google Earth
N
4000 ft


Lake Waynoka
Aerial March 2021
Google Earth
N
4000 ft