Lake Waynoka Protection and Enhancement: Study Results and Recommendations

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LIST OF ACRONYMS USED

ADP	Acoustic Doppler Profiler
ANOVA	Analysis of Variance
CAD	Computer Aided Design
CF	cubic feet
CFS, cfs	cubic feet per Second
EPA	Environmental Protection Agency
HydroCAD	Computer Aided Design program for hydrology calculations
LAC	Lake Advisory Committee
lf	linear foot
MAD	MAD Scientist & Associates LLC
NRCS	Natural Resources Conservation Service (formerly the SCS)
OM	organic matter
SCS	Soil Conservation Service
S&S	S&S Analytics (subcontracted laboratory)
SE	Standard Error
TOC	total organic carbon
TSS	total suspended solids
ųm	micron (micrometer)
U.S.	United States of America
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
WPOA	Waynoka Property Owners Association

EXECUTIVE SUMMARY

Lake Waynoka is a private, man-made lake located in northeast Brown County, Ohio. In 2003, concern was raised over the amount of sediment accumulating in the main tributary to the lake and the area was subsequently excavated. In 2010, sediment accumulation had again become problematic and a decision was made to seek a more sustainable solution than continual excavation. MAD Scientist & Associates (MAD) was contracted by the Lake Advisory Committee (LAC) of the Waynoka Property Owners Association (WPOA) in the winter of 2011 to conduct a bathymetric analysis of Lake Waynoka, to determine whether sediment accumulation had significantly altered lake depths from their original 1970 contours.

After completing bathymetric analysis, MAD concluded that sediment accumulation had not significantly altered contours within most areas of the lake, and that the 1961 topographic map remains a reasonably accurate reflection of the lake's bathymetry. However, sediment was noted to be accumulating in some of the coves, causing these coves to become too shallow for boat traffic. General observations and preliminary water sampling conducted during the bathymetric analysis phase pointed to seven coves as the primary sources of sediment input.

MAD was subsequently contracted to conduct a thorough sampling and analysis of the water and sediment in the seven select coves of Lake Waynoka and to provide recommendations for sediment and erosion control, as well as removal and prevention of incoming sediment. Water and sediment sampling and analysis were carried out over the summer of 2011 with assistance from the chairman of the LAC, George Kinney. Methods for stabilizing the severely-eroded south slope of Straight Creek cove were evaluated by the engineering firm Stone Environmental Engineering & Science (Stone), subcontracted by MAD to assist in the engineering analysis for this study.

The amount of organic matter present in the water column was found to be within the range, although on the high end, of U.S. lakes. Of the sampled coves, Cove 4 (Kiddie Corral) had the most organic matter present in the sediment, which corresponded with observations made during the winter drawdown. Straight Creek and Cove 8 were found to contribute the most stormwater (and consequently the most sediment) to the lake, with Straight Creek far exceeding Cove 8.

Based on the results of these studies, reducing the amount of sediment entering Lake Waynoka will be best done by targeting controls on Straight Creek and secondarily on Cove 8. Several high-priority action items have been discussed in the recommendations section of the report, which include excavation of sediment, stabilization of the south bank of Straight Creek cove and repair of the Waynoka Drive culvert. In addition, recommendations are provided for reducing erosion and sediment runoff throughout Lake Waynoka's watershed and for improving the lake habitat and fishery.

LAKE WAYNOKA PROTECTION AND ENHANCEMENT:
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1 INTRODUCTION

Lake Waynoka is a man-made lake of 300 surface acres, created in 1970 to provide lake front residential properties in Brown County, Ohio. In 1996, the Waynoka Property Owners Association (WPOA) chartered the Lake Advisory Committee (LAC) to oversee lake management, including water level manipulations, erosion control, shoreline protection, watercraft rules, and initiation of scientific studies of the lake. Straight Creek is the primary tributary to the lake, entering the lake at its uppermost reach after flowing under Waynoka Drive. Severe erosion has occurred along the southern bank of this creek for several years.

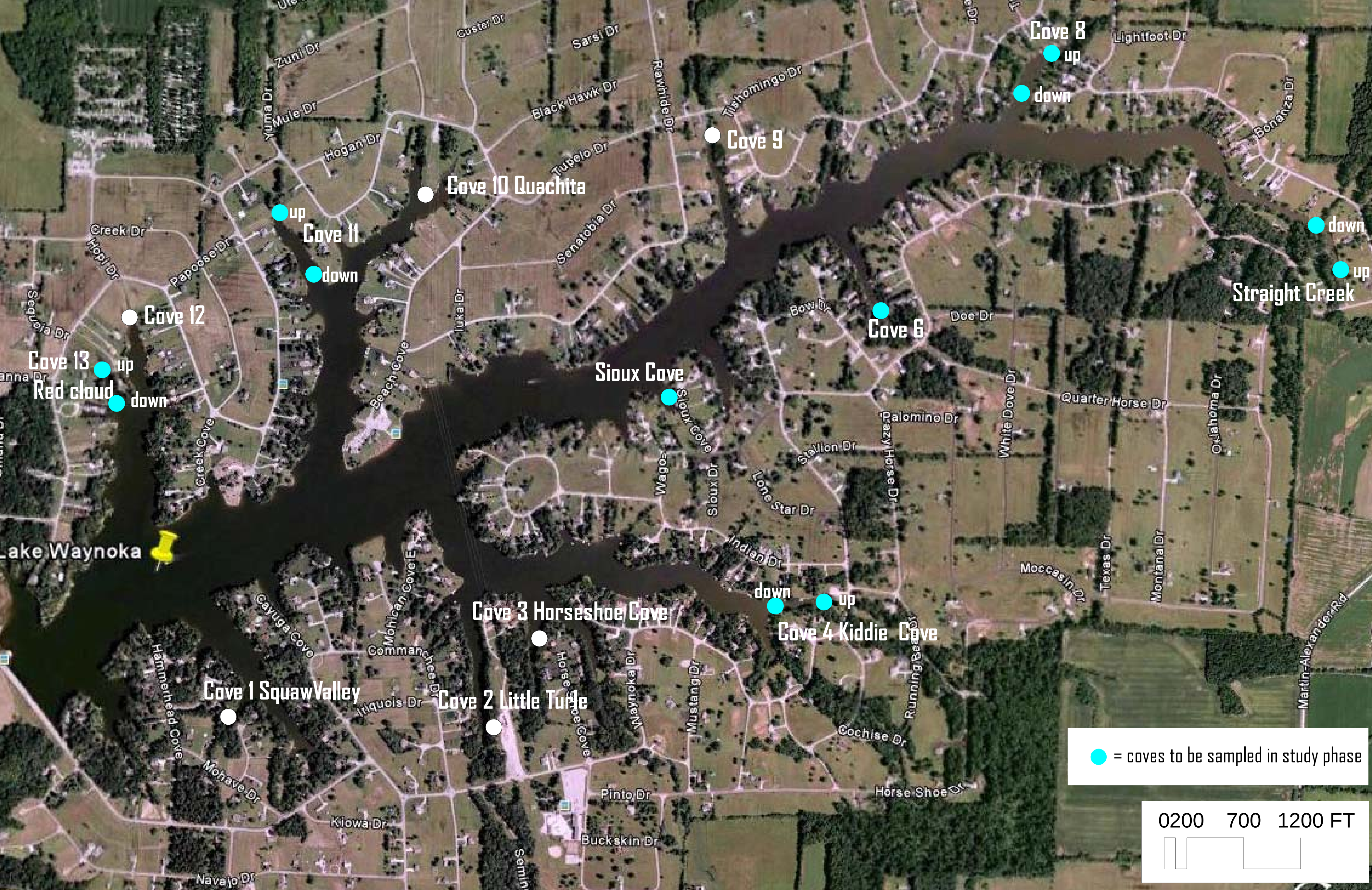
In November of 2010, the LAC observed that the cove into which Straight Creek flows was filling with sediment and, as a result, becoming too shallow for boat traffic. Seven years prior, this cove had been excavated from the entrance of Straight Creek downstream through the lake for a distance of 500 feet. When the committee was faced with a recurrence of the issue in 2010, it again obtained quotes for excavation and dredging, but decided that a more sustainable approach to regular excavation or dredging of the lake was needed.

The chairman of the committee, George Kinney, suggested that a Request for Proposal be written to facilitate the hiring of a team of environmental professionals to help the LAC assess current lake conditions and develop a long-term, sustainable strategy for lake improvement and maintenance. MAD Scientist & Associates (MAD), a firm that specializes in wetland and ecological consulting and strives to provide sustainable solutions for its clients, was retained in the winter of 2011 to complete this study. MAD's initial contract with the WPOA was to conduct bathymetric mapping of the lake and to develop a study plan that would identify sources and types of sediment within Lake Waynoka.

In April, 2011, MAD evaluated the bathymetry of the lake bottom using a combination of a highly-accurate Acoustic Doppler Profiler (ADP) system known as the RiverSurveyor and a hand-held depth sonde. Details of the mapping and reconnaissance activity are included in the report addressed to George Kinney dated May 17, 2011 (Appendix A). Based on a comparison of the 1961 topographic elevations and the current lake bottom elevations, Lake Waynoka appears to be reasonably stable.

Direct observations made by the team during field data collection also support this conclusion. Almost all measured locations have current elevations that are within 10 feet of the original 1961 topography, and only one quarter of the transects were found to have elevations that differ by more than five feet from 1961. Because overt changes in water depths were not observed, the 1961 map is deemed to remain the most accurate map available for interpretation of water depths across the lake. It is important to note that, although the water depths measured in some of the coves did not significantly differ from the original water depths, they are very shallow and are likely to become shallower if subjected to high sediment loading from upstream. In addition, particular problem areas for sediment accumulation have already been observed by the LAC.

During the mapping period, a significant storm occurred which delayed mapping, but allowed MAD to collect water samples during a high flow event. Thirteen lake samples were collected on April 12, 2011, which were analyzed for Total Suspended Solids (TSS) concentrations, to provide an indication of where sediment accumulation may present the greatest potential problems for Lake Waynoka property owners. Of the 13 coves sampled, four had very high concentrations of TSS, 87-450 mg/L, (Kiddie Corral, Cove 6, Straight Creek, and Cove 8), and an additional three coves (Sioux Cove, Cove 11 and Cove 13) had somewhat high concentrations of TSS, 29-38 mg/L. These seven coves were targeted for additional study and are the focus of this report. The coves have been assigned numbers for ease of identification as shown on Figure 1.



MAD Scientist & Associates LLC	N	**Figure 1.** Water and Sediment Sample Locations	Source of Aerial: Google Earth Pro
		Lake Waynoka, Brown County, OH	Created By: JM / Revised: 7-7-2011

Following completion of the first phase of work, MAD was contracted in June of 2011 to carry out the proposed study plan. This study plan included collecting water samples to be analyzed for TSS to determine how much sediment is entering the lake from each targeted tributary (based on concentration and estimated discharge in cubic feet per second, cfs, for each respective storm event), and for total organic carbon (TOC) to determine what percentage of the suspended solids are organic particles.

TSS refers to the amount of sediment floating in the water column, and is what makes the water appear cloudy. Suspended sediment primarily consists of silt, but contains some very fine sand. Clay particles are too small to be measured with the TSS method. TOC is the amount of organic carbon molecules larger than 0.45 microns (ųm), which gives an idea of how much organic material is present in the water column. In this study, MAD also collected sediment samples which were analyzed for the percent of organic matter present in them, which will provide an indication of whether sediment accretion is primarily from the accumulation of detritus (mostly leaves and other plant debris) or eroded soil. At Lake Waynoka, primary sources of organic material include lakeside vegetation, such as fallen leaves and algae, and debris and livestock waste that washes in from agricultural areas. Sediment cores were also collected to obtain information on the amount of accumulated sediment present in the selected coves.

2 OBJECTIVES

Based on the initial water sampling, bathymetric mapping, and discussions with the LAC, the following objectives were established for this study:

- Determine the amount of sediment entering the lake from the seven coves of concern, and assess whether the source is primarily erosion of exposed soils, or an accumulation of plant debris on the lake bottom that is re-suspended in storm events;
- Evaluate potential erosion control measures for the severely eroded south bank of Straight Creek;
- Analyze the potential for a created wetland and/or sedimentation forebay located near Waynoka Drive to reduce inflowing sediment from Straight Creek;

- Create a list of recommended native submerged vegetation appropriate for providing fish habitat; and
- Determine the best method(s) for re-establishing vegetation within the lake.

In addition, MAD was asked to provide general recommendations regarding fish species for restocking.

3 METHODS

3.1 Watershed Investigation

Aerial photographs and topographic maps were used as preliminary investigation tools to determine possible sediment source areas for Lake Waynoka. After likely sediment source areas were determined, an on-the-ground watershed investigation was conducted on July 7, 2011, to verify current land conditions. During this investigation, the MAD team also noted the number of active construction sites located along each cove and the presence or absence of erosion control measures.

3.2 Water and Sediment Sampling

Water quality samples were collected from each of the seven targeted coves on three different dates in July, when a 48-hour dry period was followed by a rain event of approximately one inch (as estimated by George Kinney and verified with the weather.com website for Hillsboro, Ohio; Table 1). With the exception of Cove 6 and Sioux Cove, all coves had samples collected at a point as close to the head of the cove as could be reached via boat, as well as at a location midway between the head and mouth of the cove (Figure 1). Because Cove 6 and Sioux Cove are relatively small, samples were only collected at the midpoint for these coves.

Water temperatures on the sample dates ranged from 83ºF on July 12 to 90ºF on July 19, 2011. During the July 12 sampling, the lake water was turbid (brown in color due to suspended material). On July 19, 14 hours after the storm event, ditches surrounding Lake Waynoka still contained standing water.

Table 1. Dates and Sizes of Storms and Subsequent Sampling Dates

Storm Date	Storm Size	Sample Date
July 11, 2011- evening	45 minute intense rain	July 12, 2011 by 4pm
July 16, 2011- midnight	~One inch in one hour	July 17, 2011 by 3pm
July 18, 2011- 8:30-9:30am	2.75 inches in one hour	July 19, 2011 by 3pm

At each sampling location, three grab samples were collected to provide replication of the sampling procedure. TSS sample bottles were rinsed three times with lake water, submerged under the lake surface, filled with water, capped, and stored in a cooler with ice until they were delivered to the analytical laboratory. TOC bottles were filled in the same manner and capped and stored in a box until they were delivered to the lab. Water samples were analyzed by Advanced Analytics in Columbus, Ohio. Copies of the raw lab results are provided in Appendix B.

Lake sediment samples were collected from each of the seven targeted coves on August 3, 2011. Scoops of sediment were collected from three locations within each cove using a combination of sampling devices including a petite ponar dredge (sediment sampling device) and manual scooping of the sediment with a bucket in shallow areas with loose, unconsolidated substrates. The three grab samples were mixed in a five-gallon bucket to reduce variation due to sample location within the cove. Following mixing, three sample bottles were filled with the homogenized mix and sent to S&S Analytics in Findlay, OH for analysis. S&S analyzed the samples for organic matter content and sieved them to determine the proportions of gravel and sand particles present. Copies of the raw lab results are provided in Appendix C.

Core samples were also collected from the top one foot (1’) of the lake bottom, to provide insight into the depositional history of the lake. Cores were collected in areas where the water depth was five feet or less, using a device called a Sludge Judge. The Sludge Judge is traditionally used to sample sludge accumulation in wastewater treatment systems. It consists of a long, three-inch-diameter plastic tube that is pushed into the sediments to the desired, or achievable depth, at which point the end of the pipe above water is capped, creating suction that enables the tube to be pulled out of the water with the core intact. Cores were measured and photographed, and color and texture observations were recorded.

3.3 Statistical Analyses

Following field collection and lab analysis of the samples, the data was statistically analyzed to determine where significant differences existed amongst the sampled coves. One-way Analysis of Variance (ANOVA) was used to assess differences among the coves at a significance level of $p = 0.05$. Prior to running the ANOVA, sample distributions were assessed for normality and equal variance. Non-normal distributions were transformed, and if normality could not be achieved through transformation, the non-parametric Kruskal-Wallis test was used. Two-sample comparisons were done with t-tests for normal data and Mann-Whitney tests for non-normal data.

3.4 Stormwater Runoff Calculations

The volume of runoff that flows into each cove during a storm event was calculated using HydroCAD, which is a Computer Aided Design system for modeling the hydrology and hydraulics of stormwater runoff. It is based largely on the hydrology techniques developed by the Soil Conservation Service (SCS, now named the Natural Resources Conservation Service, NRCS), combined with other hydrology and hydraulics calculations. For a given rainfall event, these techniques are used to generate hydrographs throughout a watershed. Typically, this allows the engineer to verify that a given drainage system is adequate for the area under consideration, or to predict where flooding or erosion is likely to occur. Stormwater runoff rates were calculated for three storm sizes: 0.75-inch, 1.5-inch and 2.5-inch storm events. These storm event sizes were chosen because the Environmental Protection Agency (EPA) uses a 0.75-inch event for water quality analysis, and a 2.5-inch storm event is considered a one-year event, or an event that has a 99% chance of occurring every year.