Natural Resources and Environmental Sciences Capstone Project

Marion County Lake Research Synthesis

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Introduction

Marion County Lake and Park is located in south central Kansas (38.3152 -96.9916) about four miles southeast of the town of Marion, Kansas. The lake covers a total of 153 acres of water and provides an area with many recreational opportunities. For the past two years, NRES Capstone teams at Kansas State University have been working to collect data and information regarding the state of Marion County Lake, park and the surrounding watershed in order to assist lake managers in designing an effective and comprehensive lake management plan. While these reports contain quality data and useful information, they have yet to be combined or connected, making it difficult for lake managers to easily access key information. This report seeks to synthesize all the previously collected information and condense it into one overarching report that highlights the key findings Marion County Lake managers need. In doing so, this report outlines key in-lake information including water quality and sediment, out-of-lake information such as land use and soil, as well as information regarding the lake's community and various stakeholders.

Research Synthesis

In Lake

Water Quality

Recently, Marion County Lake has been struggling with various water quality issues, including excess nutrients causing eutrophic conditions which have led to recurring harmful algae blooms. In addition to harming wildlife, these water quality problems have also been severely reducing the opportunity for public recreation on the lake. As there are over 200 households around the lake alone, these water quality issues are limiting a large number of people from utilizing the lake. In order to assist lake managers in developing a strategy to combat these water quality issues, the following section provides information regarding past water quality studies including important benchmarks, key findings, recommendations for future work and potential solutions.

Background

Before previous datasets can be reviewed, it is important to first have a solid understanding of Marion County's water quality issues, and the threats they pose, starting with eutrophication. Eutrophication is the over-enrichment of water bodies with nutrients, often as a result of anthropogenic activities. Under eutrophic conditions, the rates of organic production exceed those of consumption, resulting in accumulation of organic matter which harms the ecosystem and promotes algae growth (Sun 2018). One of the most detrimental effects of eutrophication is the formation of Harmful Algae Blooms (HAB) or Cyanobacterial Harmful Algae Blooms (CHAB). These harmful algae blooms consist of cyanobacteria such as Microcystis, which can produce a slew of harmful cyanotoxins such as Microcystin-LR (MC-LR). Microcystis is the most prevalent genus of cyanobacteria worldwide and Microcystis are known to cause serious health risks to both aquatic animals and humans (Rajasekhar et al. 2012). In humans, exposure can cause liver and kidney damage, reproductive toxicity and promotion of tumorigenesis. It can also accumulate in the tissues of aquatic organisms causing biological amplification through the food web

(Ding Et al. 2018). Because of this, these large algal blooms tend to be harmful to aquatic ecosystems and may interfere with important ecosystem services and lake recreation (Lürling, et al. 2020). In order to prevent HAB, the water quality of the lake must be maintained, ensuring that there isn't an excess of nutrients.

Past Work Procedures

With an understanding of eutrophication and the associated risks, the next step is to reflect upon previous NRES Capstone reports. By understanding the procedures of previous work that was done, lake managers should have the opportunity and instructions given to them on how to either recreate or reproduce previous research in order to continue to research to further the data collected and understand how to help prevent HAB's. By doing so, lake managers will begin to start to compile data that will be able for use for future students that will allow them to accurately participate in research. Not only will future research benefit, but so will the lake managers since they will have more information and data at the ready about the lake as well as for the public that surrounds it.

Project 1: Influence of Waterfowl on Water Quality at Marion County Lake

Past work that was done by Jurczak et al. 2019 titled "Influence of Waterfowl on Water Quality at Marion County Lake" from Kansas State University and what they were looking at was how the native waterfowl of Marion County Park Lake influenced the water quality that resides within the park. How Jurczak and her team went about this was that they had to determine the concentrations of nutrients that were being leached into the water by the geese excretion. To do this Jurczak and her team did the process of feces collection mixed with the water containing active microbial populations. Jurczack and her team took water samples without feces as well to get a common variable to compare with. After doing so the waters that had the feces leached into the water.

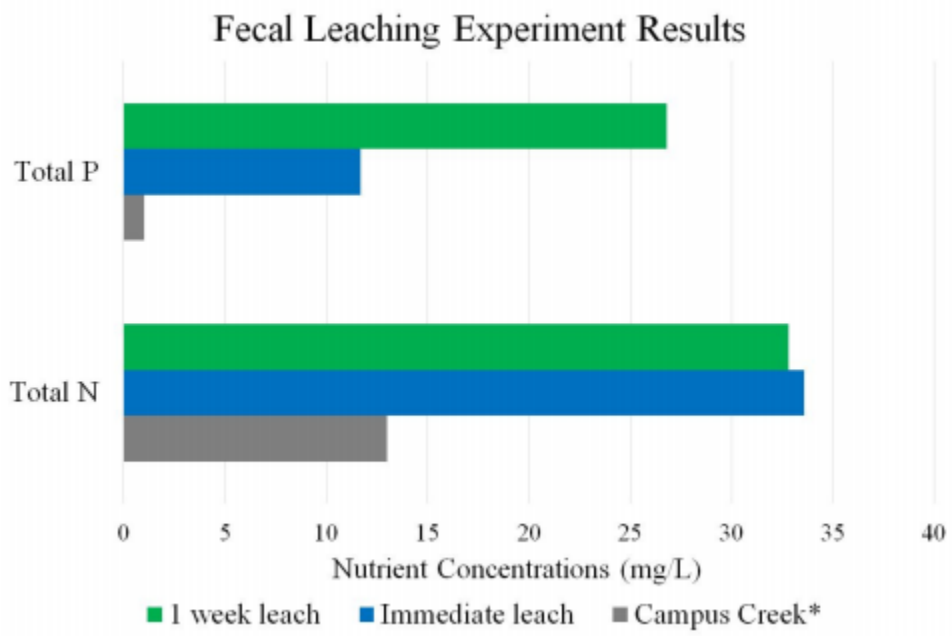


Fig 9: Results of the feces leaching experiment using water from the campus creek in Manhattan

In conclusion, Jurczack and her team were able to identify that the waterfowl population, more specifically geese, were an issue of being one of the producers of the excess levels of nutrients within the lake water as well as showing that Marion County Park Lake has high levels of Phosphorus and Nitrogen within the water. In order to further understand the impact waterfowl have on the water quality in Marion County Lake, the team suggests estimating goose counts annually. This will also help to see if the migration patterns are in fact changing over time.

Project 2: Unsettling Sediment: How Sedimentation and Other Water Quality Issues can be Combated with Stakeholder Help

For this second project review this section will be covering the research that was done by Marsh et. al. 2020 titled Unsettling Sediment: How Sedimentation and Other Water Quality Issues can be Combated with Stakeholder Help from Kansas State University. What Marsh and her team ultimately were doing was that they wanted to evaluate the erosion rates and understand the landowner perception and knowledge of the conservation methods. How Marsh and her team went about doing this project was that they installed cross sections and measured those cross sections using laser level surveying equipment. That laser level surveying equipment was that of the Lecia Rugby 610 surveying model. How they went about this research process was that they used a CamLine measuring string to be placed perpendicular to the water channel to be assessed. This CamLine acts as a guide to keep the measurements straight across the stream cross section. The Lecia Rugby 610 was then used on a high landform so that the laser could see the land surrounding it to allow the machine to be ankle to hit the measuring rod that was hammered into the sediment on the opposite side of the water channel from the machine.

	Site 1	Site 2	Site 3
Station	L: 1' R: 94'	L: 1' R: 43'	L: 1' R: 43'
Elevation	L: 100' R: 100.14'	L: 100' R: 101.58'	L: 100' R: 94.5'
Latitude/Longitude Left pin	38.344214, -96.970300	38.342265, -96.971517	38.340933, -96.972402
Latitude/Longitude Right pin	38.344049, -96.970494	38.342383, -96.971499	38.340984, -96.972535

Fig 10: Sites and Elevations of the rebar pins that were installed at Marion County Lake

The first height measurement was taken from the top left bank rebar pin that was facing down stream. The final measurement was taken on the top of the right bank rebar pin that was facing up stream. Anytime that a change of slope was felt, the measurement was to be taken as well as additional measurements every 3 ft to produce a cross sectional profile of the water channel. By recording all of the 3ft variable measurements, Marsh and her team were to input the recorded data into Microsoft Excel. Marsh and her team were able to take that data and use a program called RiverMorph, to analyze the change between the 2018 erosion data from the 2020 erosion data to produce an estimated annual streambank erosion rate.

In conclusion, with Marsh and her team's research, it should allow for further research to be conducted at Marion County Park Lake to keep doing the same step by step research, to further the accuracy

of the erosion estimates. The lake managers could conduct this same research at the same sites that were listed above in figure 4, on a monthly basis to have accurate monthly data to continue comparing each year of the erosion that is taking place to understand where, within the lake, lake managers should provide a means to help mitigate the erosion and maintain their lake.

Project 3: Marion County Park and Lake Sediment and Water Quality Study

For this third project review this section will be covering the research that was done by Allen et al. 2018 titled Marion County Park and Lake Sediment and Water Quality Study from Kansas State University. What Allen and his team were ultimately doing was investigating the impact that sediments have on water quality in Marion County Park Lake. To start the investigation Allen and his team collected 12 different composite soil and water samples to test back at Kansas State University at the lab. Each of the 12 samples were all taken using a cross pattern. Each of the 12 different sites that Allen and his team took water and soil samples from are here, shown below in Figure 5.

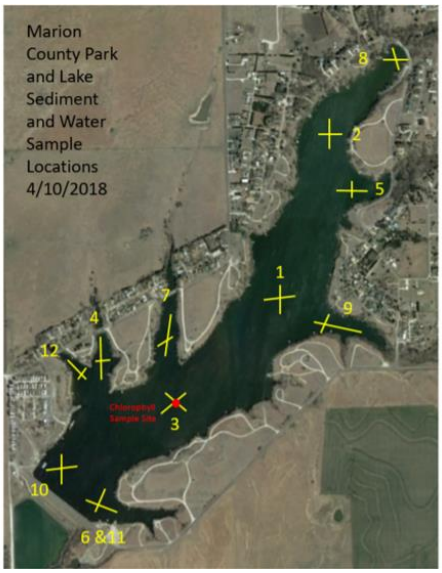
Fig 11: Marion County Sediment and Water Sample Locations

When taking the sediment samples, Allen and his team used a device called a gravimetric sediment sampler. Allen and his team would use the device to penetrate the surface sediment to collect a sediment core from the lake floor. By returning to this previous research project, the lake management team at Marion County should find that on the bottom of their paper is Appendices with detailed step by step instruction, to help recreate the experiments done by Allen and his team.

In conclusion, the lake management team at Marion County Park Lake should recreate the research procedures done by Allen and his team on a monthly basis to have a better understanding of soil and water quality of their lake. With the monthly process of this experiment, the lake management team should produce better and better data on a year round record. Once enough data has been collected, yearly records could be compared to see if soil and water quality are getting better or worse.

Key Findings

Having reviewed the procedures carried out by previous NRES Capstone teams, the next step is to understand and review key water quality indicators. Throughout the previous NRES reports, there have been several key water quality indicators that have been measured and recorded. These values include Total Nitrogen, Total Phosphorus, Total Suspended Solids, Total Dissolved Solids, Cyanobacterial Cell Count, Trophic State Index, Fecal Coliform and pH Balance. The two reports analyzed here collected water samples from 4 and 12 locations around the lake, respectively. The sample locations and findings can be seen below in figures 1 and 2 and tables 2, 3 and 4. Following those images is a brief overview describing each key indicator studied, including any relevant benchmarks and findings.



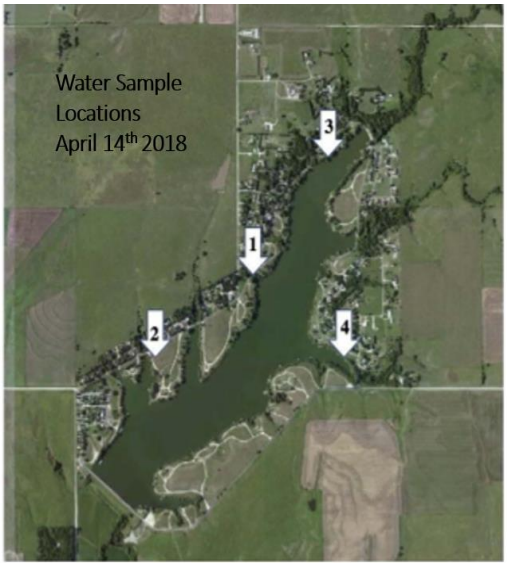


Fig 1: (Left) Locations of water quality data collected by Allen, J., Ddamulira, A., Maddox, C., Gerardy, H. for Marion County Park and Lake Sediment and Water Quality Study (2018).
Fig 2: (Right) Locations of water quality data collected by Wallace, H., Trigo, E., Keller, C. for Influences of Nutrient Accumulation, Sediment Loading, and Organic Matter on Water Quality in Marion County (2018).

Lab # (s)	Sample Name	TSS mg/L	TDS mg/L	EC mS/cm	pH	Total N ppm	Total P ppm	NH4-N ppm	NO3-N ppm	Ortho P ppb
502794	1	19	244	0.35	8.00	0.95	0.02	0.04	0.15	144
502795	2	25	246	0.35	8.20	1.04	0.03	0.06	0.13	41
502796	3	35	258	0.37	8.12	0.96	0.03	0.09	0.10	10
502797	4	184	247	0.35	8.18	2.28	0.17	0.04	0.14	<5

Table 1: Water Analysis Results collected by Wallace, H., Trigo, E., Keller, C. for Influences of Nutrient Accumulation, Sediment Loading, and Organic Matter on Water Quality in Marion County (2018).

Sample Site	Total N (ppm)	Total P (ppm)
1	0.69	0.03
2	0.73	0.02
3	0.69	0.01
4	0.67	0.02
5	0.81	0.02
6	0.73	0.01
7	1.03	0.02
8	1.54	0.17
9	0.81	0.03
10	0.76	0.01
11	0.98	0.01
12	0.73	0.01

Sample Name	Volume (mL)	W1 (g)	W2 (g)	W3 (g)	TSS (mg/L)	VSS (mg/L)	FSS (mg/L)
1	500	1.3595	1.3649	1.3628	10.8	4.2	6.6
2	500	1.3742	1.3832	1.3808	18	4.8	13.2
3	500	1.362	1.3667	1.3646	9.4	4.2	5.2
4	500	1.388	1.3924	1.3905	8.8	3.8	5
5	500	1.389	1.3957	1.3994	13.4	-7.4	20.8
6	500	1.3631	1.3679	1.366	9.6	3.8	5.8
7	500	1.3595	1.3639	1.3621	8.8	3.6	5.2
8	100	1.3766	1.3921	1.3907	155	14	141
9	500	1.3716	1.3769	1.3752	10.6	3.4	7.2
10	500	1.3502	1.3544	1.3528	8.4	3.2	5.2
11	500	1.3602	1.3642	1.3625	8	3.4	4.6
12	500	1.3559	1.3602	1.3583	8.6	3.8	4.8

(Left) **Table 2**: Total Nitrogen and Phosphorous and (Right) **Table 3:** Additional Water Quality Data both data sets collected by Allen, J., Ddamulira, A., Maddox, C., Gerardy, H. for Marion County Park and Lake Sediment and Water Quality Study (2018).

Nitrogen & Phosphorus

High nitrogen or phosphorus concentrations within a lake can help to identify areas within the watershed that have high concentrations of nutrients (Allen, Ddamulira, Maddox & Gerardy, 2018). According to KDHE in 2002, the Kansas benchmarks are 625 ug/L for Total Nitrogen and 23 ug/L for total phosphorus. Additionally, according to research conducted by Wallace, H., Trigo, E., and Keller, C., nitrate-nitrogen concentrations of above 3 mg/L and total phosphorus above 0.025 mg/L may be an indication of pollution (2018). The study conducted by that team in 2018 found that the total nitrogen content of the ranged from 0.95-2.28ppm and the total phosphorus ranged from 0.02-0.17ppm (table 1). A similar water quality study conducted by Allen, J., Ddamulira, A., Maddox, C., and Gerardy, H. also in 2018 found the total nitrogen content to range from 0.67-1.54ppm and the total phosphorus content to range from 0.01-0.17ppm (table 2). Despite slight differences in measured values, both studies found the total nitrogen and phosphorous levels to be higher than expected, suggesting a high concentration of nutrients in the lake. Additional research conducted by Marsh, M., Owens, M., Parker, E., and Vinduska, K in early 2020 found that a total of 1,043 pounds of phosphorus per year is entering the lake from the surrounding area (KDHE, 2002). They also estimated that 0.309 kg phosphorus is lost annually through soil erosion near Marion County Lake, which could help to explain the high nutrient concentration.

Total Suspended Solids (TSS)

Total suspended solids are solids which are known to be able to block sunlight from reaching submerged vegetation. A high concentration of total suspended solids can prevent submerged vegetation from accessing sunlight, reducing the rate of photosynthesis. Decreased rates of photosynthesis also reduce the rate of oxygen respiration into the water by the vegetation, therefore lowering the oxygen content. Additionally, a high TTS concentration could also indicate a large presence of nutrients, pesticides, bacteria or metals in the water. (Wallace, Trigo, & Keller, 2018). According to the KDHE in 2009, the benchmark for TSS is 100 mg/L. Results from Wallace, H., Trigo, E., and Keller, C., water quality samples from 2018 found the average TSS to be 65.75 mg/L when taking sample 4 into account and 26.3 mg/L when excluding that value (table 1). The second water quality study conducted by Allen, J., Ddamulira, A., Maddox, C.,

and Gerardy, H. in 2018 found the average TSS to be 10.4 mg/L (Table 3). According to these studies, the TTS values were generally lower than the benchmark, with the exception of sample #4 from the first study.

Total Dissolved Solids (TDS)

Total dissolved solids is the measurement of the dissolved content of all inorganic and organic substances in a liquid. A TDS concentration that is too low or high could negatively impact the aquatic organisms in the lake. According to Wallace, H., Trigo, E., and Keller, C., a TDS above 1,000 mg/L indicates poor water quality. The studies conducted by that same team found that all 4 water samples collected in Spring 2018 were well below that limit.

pH Balance

The pH balance of the lake represents the concentration of hydrogen ions in the water. According to the US Environmental Protection Agency, the standard pH balance for lakes should be within 6.5 to 8.5. Water samples collected from Wallace, H., Trigo, E., and Keller, C. in 2018 had an average pH of 8.124, which is slightly high but still within an acceptable range. That same team suggested that one cause for the higher pH could be due to calcite which is known to be present in Kansas soils, and can release carbonates resulting in more alkaline waters.

Chlorophyll-a

Chlorophyll-a is a measurement of the response of algal communities to the conditions within a water body, and is commonly used as an indicator of the eutrophic conditions within a body of water. According to the KDHE in 2002, the Kansas benchmark for chlorophyll-a is 8 ug/L. Additionally, lakes with a chlorophyll-a concentration between 7.21 and 30.0 ug/L are considered eutrophic. KDHE has been studying the chlorophyll-a concentration of Marion County Lake from 1988 to 2009 and has found that the concentration has been rapidly increasing. In 2009 KDHE found the chlorophyll-a concentration to be 56.7 ug/L, classifying the lake as hypereutrophic. When Wallace, H., Trigo, E., and Keller, C., conducted their water quality survey in spring 2018, they found the chlorophyll-a value of Marion Lake to be 15 ug/L, which is above the Kansas benchmark. The team noted that while Marion County Lake and Marion Lake are separate bodies of water, the fact that they share the same watershed and several similar characteristics suggests that Marion County Lake is also likely to have a high chlorophyll-a concentration, and is therefore at risk of water quality issues.

Trophic State Index (TSI)

The trophic state index is derived from the chlorophyll-a concentration in lake water, and is a good indicator of nutrients and potential algal growth (Allen, Ddamulira, Maddox & Gerardy, 2018). Data collected by Wallace, H., Trigo, E., and Keller, C., in spring 2018 found the trophic state index of the lake to be 56.39, indicating that the lake was fully eutrophic at that time. This data supports that discussed in the chlorophyll-a section as well.

Fecal Coliform

The presence of fecal coliform in a water sample indicates that the water has been contaminated with fecal material. The USEPA has established a specific maximum contaminant level (MCL) and has set a standard of 5% MCL for drinking water. The results of Wallace, H., Trigo, E., and Keller, C.'s water quality analysis conducted in the spring of 2018 found that the maximum total fecal coliform found in the lake was 10

cfu/100mL with 7.14% of samples testing positive. While the standards for fecal coliform are intended for drinking water specifically, these results exceeded the 5% MCL standard, indicating that there may be harmful bacteria which could pose health risk for those who use the lake recreationally.

Cyanobacterial Cell Count

Cyanobacterial cell counts can help identify and predict HABs. According to the World Health Organization (WHO), a level of 100,000 cyanobacterial cells/ml serves as the guideline value for a moderate health alert in recreational waters. Studies conducted by the KDHE found the maximum cyanobacteria cell count on August 9th, 2017 to be 520,380 cell/mL, which exceeded the MCL allowed by USEPA and WHO.

Sediment

Sedimentation can be one of the root causes for issues with lake water quality that can lead to harmful algal blooms. The occurrence of sedimentation loading in lakes can be affected by a variety of driving factors of the surrounding area of the lake. Some of these are out of our control, such as climate, temperature, and precipitation amounts. Others can be much more easily influenced with management of agricultural practices. Sedimentation can cause numerous problems in water bodies including loss of storage capacity and can affect the design life of water basins (Motter, Whitten, Johnson, & Wickey, 2020). Sedimentation's largest impact on water quality is easily the effect it has on nutrient loading.

Sediment can come from a variety of places watershed wide; erosion of the bank of the Marion County Lake itself, erosion of the banks and beds of the rivers and streams that feed into the lake, and in runoff from the watershed land. Streambed cross sections were measured both in the spring of 2018 and 2020 by the groups Balkenbusch, Zee, and Linder and Marsh, Owens, Parker, and Vinduska, respectively. The latter cross section measurements were based on a rough estimate of the location of the initial measurements in 2018. If the cross-section measurement locations are accurate, the soil erosion rate could be as high as the estimated 0.61 feet per year.

Sediment that washes into the lake can contribute to the nutrient loading compounding the problem. Eroded soil carries both phosphorus and nitrogen from the surrounding land. An ArcGIS study shows that approximately a quarter of the land in the watershed is used for crop production (Allen, Ddamulira, Maddox, & Gerardy, 2018). This means that the sediment and soil surrounding the lake are especially nutrient rich. Tillage of these croplands bares the soil making it more susceptible to runoff. It also breaks the soil up into smaller particles that travel much further downstream in water suspension.

The team of Balkenbusch, Zee, Linder (2018) collected water and soil samples that were taken at both of the main tributaries of the lake to the North and Northeast of the lake. The samples were determined to be silty clay loams of 1.5 to 3.5 percent organic matter content. These samples were tested for particle size distributions using a Malvern Mastersizer 3000. No significant correlations were found regarding particle size and distance from the lake or sample depth. This could possibly be due to inadequate allowance of settling time. Water samples were taken at the same sites as the soil samples to test suspended sediments. They tested for Total Suspended Solids, Total Dissolved Solids, Electrical Conductivity, Total Nitrogen, and Total Phosphorus.

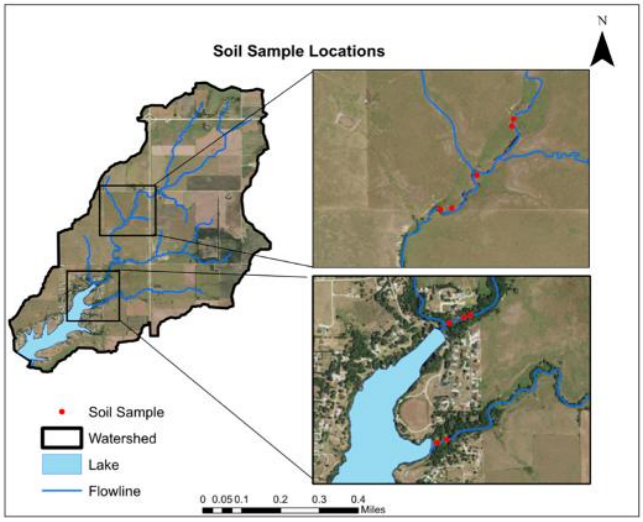


Fig 3: Map of watershed and sampling locations. Top right shows Northern Stream Site A. Bottom right shows Northern Stream Site B and north of the lake and Northeast Stream Site (towards the bottom of the figure).

Site Name	Sample/Measurement ID
Northern Stream Site A	N1-S, A-1
	N2-S, A-1
	N3-S, A-2
	N4-S, A-3
	N5-S, A-3
Northern Stream Site B	N6-S, N6-W
	N7-S, N7-W
	N8-S, N8-W
Northeast Stream Site	NE1-S
	NE2-S
	NE3-W

Fig 4: Denotes sample IDs. (N is for Northern Stream Site A, NE is for Northeast Stream Site, S is for soil samples, and W is for water samples.)

Table 4: Water Sample Data

Sample Name	Sample Date	TSS mg/L	TDS mg/L	EC mS/ cm	Total N ppm	Total P ppm
N6-W	3/29/18	84	451	0.64	1.93	0.14
	4/10/18	38	433	0.62	1.37	0.08
N7-W	3/29/18	50	449	0.64	2.08	0.13
	4/10/18	288	438	0.63	3.90	0.40
N8-W	3/29/18	12	441	0.63	1.63	0.10
	4/10/18	517	414	0.59	3.62	0.49
NE3-W	3/29/18	167	332	0.48	2.02	0.41
	4/10/18	95	280	0.40	1.57	0.16

Figures and table by Balkenbusch, C., Zee, T., Linder, L. for Identification of Sediment Sources in the Tributaries of Marion County Park & Lake to Develop Future Erosion Management Plan (2018).

It should be noted that these water sediment samples were collected outside of the regular crop growing season and at a time of little precipitation. Sedimentation rates increase with precipitation rates, and Nitrogen and Phosphorus concentrations from sediment runoff in the water are likely much lower than that of samples taken during the beginning of the growing season during the spring and summer when nutrients are applied to cropland (Allen, Ddamulira, Maddox, & Gerardy, 2018).

In Lake Recommendations

The following is a culmination of all of the recommendations for in lake water quality and sediment management, as provided by previous capstone teams.

- Surface water and lake sediment should be sampled frequently and according to a regulated procedure and sent to a lab to be processed to test for excess nutrients and toxins (Wallace, Trigo, & Keller, 2018).
- Further water quality sampling should be conducted at the northern end of the lake, with ten composite samples obtained throughout multiple time frames from the northern cove to build a higher resolution of nutrient deposition and patterning (Allen, Ddamulira, Maddox & Gerardy, 2018).
- Further testing also needs to be performed during different seasons to build a chronological pattern of nutrient loading. Subsequent sampling should be conducted later in the summer months or early fall to determine what effect the rainy season and algal blooming had upon the lake's characteristics (Allen, Ddamulira, Maddox & Gerardy, 2018).
- As the lake was experiencing drought conditions during their sample collections, the team consisting of Allen, Ddamulira, Maddox & Gerardy recommend subsequent water quality sampling during normal operational elevation to determine the effects droughts have on the lake's water quality (2018).

In Lake Potential Solutions

Water Quality- Install Floating Waterbeds

In response to concerns regarding waterfowl pollution in the lake, the previous NRES team Jurczak, J., Kimbrell, K., Prindle, K., and Ryan N. authors of the report entitled Influence of Waterfowl on Water Quality at Marion County Lake (2019) found that utilizing floating waterbeds would be an effective way to remove excess nutrients from the lake. According to their research, floating waterbeds are foam matts which are designed to hold submerged vegetation. They found that these structures have been proven to have high nutrient removal efficiencies using native vegetation. They also noted that floating waterbeds are cost effective, require minimal maintenance for cleaning, and can be easily self-assembled. They recommend that 300 acres of the lake be covered with these floating waterbeds, but starting with a smaller amount would still help improve water quality. An example of a "Beemat" floating waterbed, which has a nitrogen removal rate of 0.01 g/m2 of matt/day is shown in the figure below (McAndrew et al., 2016). We would strongly encourage the adoption of this pollution prevention measure, if it hasn't been adopted already.

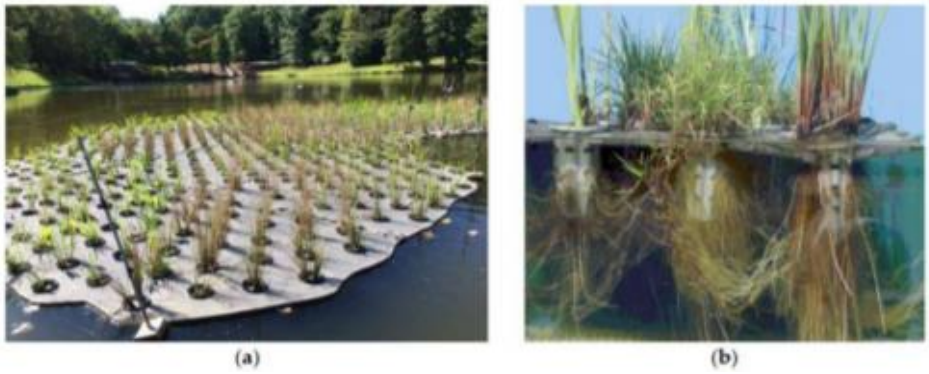


Fig 5: Surface (a) and cross-sectional (b) views of a "Beemat" floating waterbed system McAndrew et al., 2016).

In-Lake Treatment options for HABs

As the formation of HABs across lakes, ponds and reservoirs continues to be an important water quality issue across the globe, there has been considerable efforts to identify effective, affordable and environmentally benign in-lake treatment methods. We would recommend reviewing the literature review entitled "In-Lake Treatment Methods to Control Harmful Algae Blooms" in which peer-reviewed scholarly articles were collected, analyzed and organized into the three distinct methods of treatment. Those methods include the Physical, Chemical and Biological methods of treating HABs. The literature review in question provides both summaries describing the various techniques of each of the three types of HAB methods, and a brief feasibility evaluation for the application of each method in a U.S. lake.

Out of Lake

Land Use

Throughout the years, the land use surrounding the Marion County Lake has been changing. From urbanization to land being put into agricultural production and then transitioned to native grasses, you see acreage changes across the board. Below, I have outlined the top 3 (over 10%) uses of the surrounding land for the years 1990, 2005, and 2015. I have also shown the acreage of available water.

The decrease of warm-season grassland acres from 1990 to 2005 is due to the introduction of irrigated cropland, which didn't seem to last long because there is then an increase in acres by 2015. This is due to the benefits that native grasslands have on the land. The transition from agricultural cropland back to native grasses is something that the property owners surrounding the lake feel is beneficial to not only the lake and land, but also for some personal gain. Individuals who transition back to grasses are given multiple options for use of the grass. One option is grazing livestock on the land. This provides an immediately available food supply for their operation. Another option is cutting and bailing the grass. This option can go one of two ways: for personal use (feeding livestock) or for sale (additional income). Both options either save or make the producer money, making the practice an easy sell! If a producer is choosing to continue to keep his land in agricultural production, suggesting some best management practices would be ideal to help mitigate any unwanted issues.

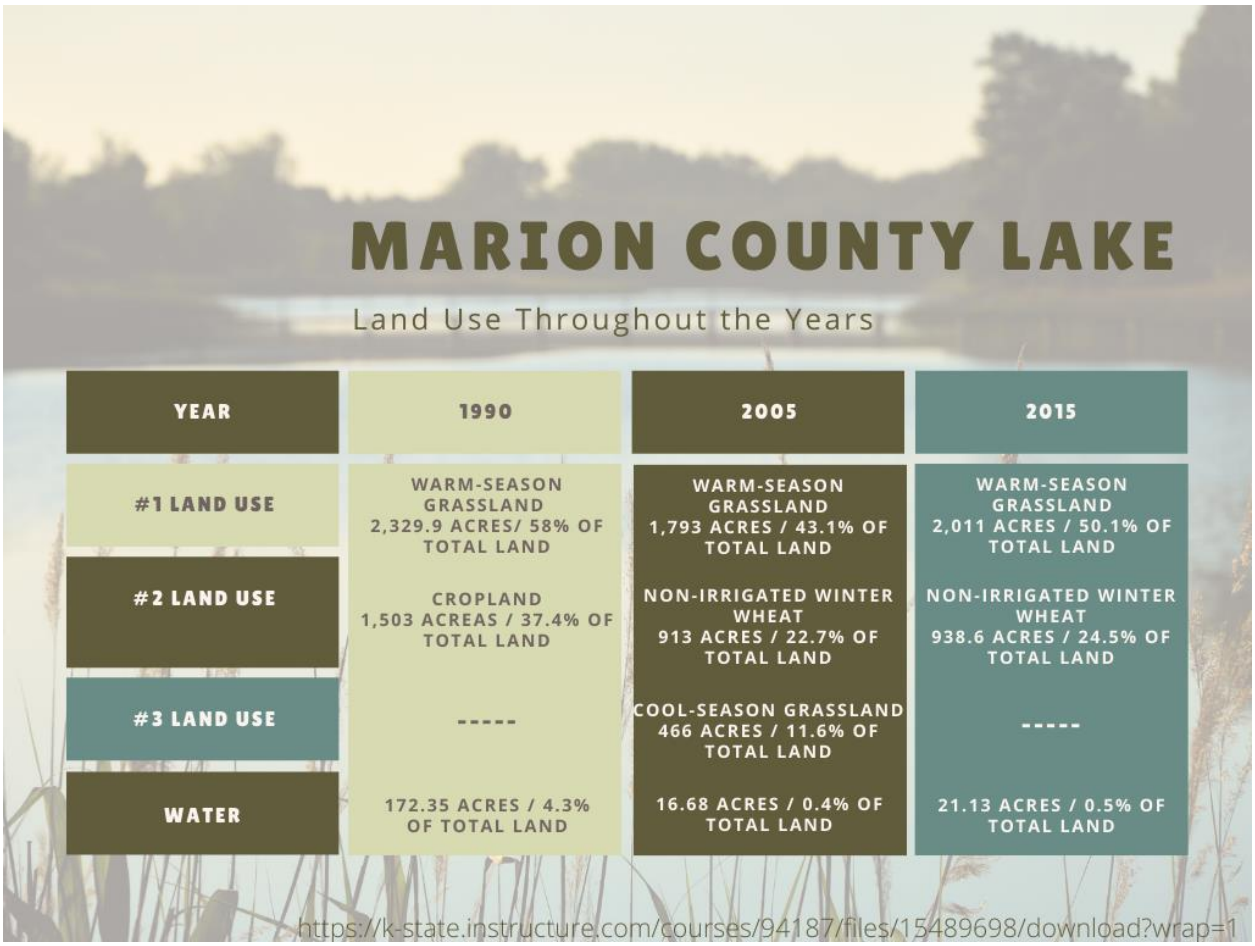


Fig 6: Image developed by Alexandra Clark. Information provided by Trisha Moore from an Unknown Source.

Best Management Practices (BMPs)

Agricultural

Some examples of agricultural BMPs include safe management of animal waste, controlling pests and nutrients, contour farming, crop rotation, and vegetative buffers near streams. There are essentially eight types of agricultural BMPs.

Conservation Tillage- the practice of leaving harvest plant materials on the soil surface to reduce runoff and soil erosion

Crop Nutrient Management- managing all nutrient inputs helps ensure that nutrients are available to meet crop needs while reducing nutrient runoff.

Pest Management- using various methods for managing pests while protecting soil, water, and air quality.

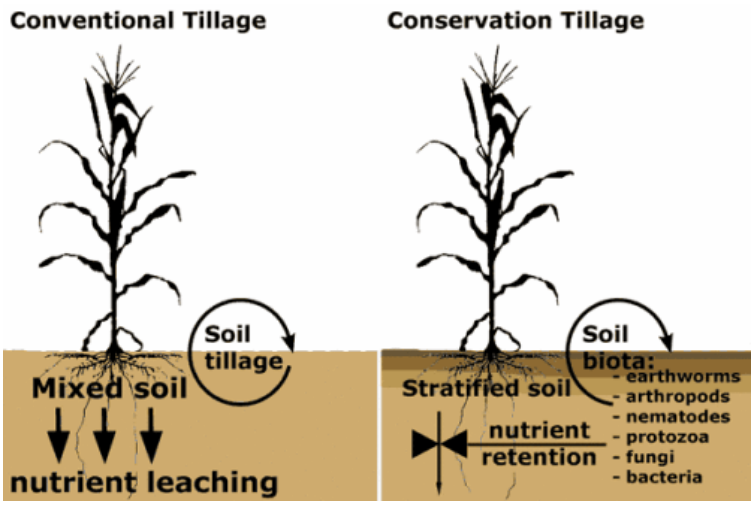


Fig 7: The difference between conventional tillage and conservation tillage. (Pinterest)

Conservation Buffers- using vegetation strips to provide additional barriers of protection which prevent potential pollutants from running off into surface waters.

Irrigation Management- increasing irrigation efficiency can reduce nonpoint source pollution of ground and surface waters.

Grazing Management- managing livestock grazing to lessen the water quality impacts (e.g. reduce erosion potential).

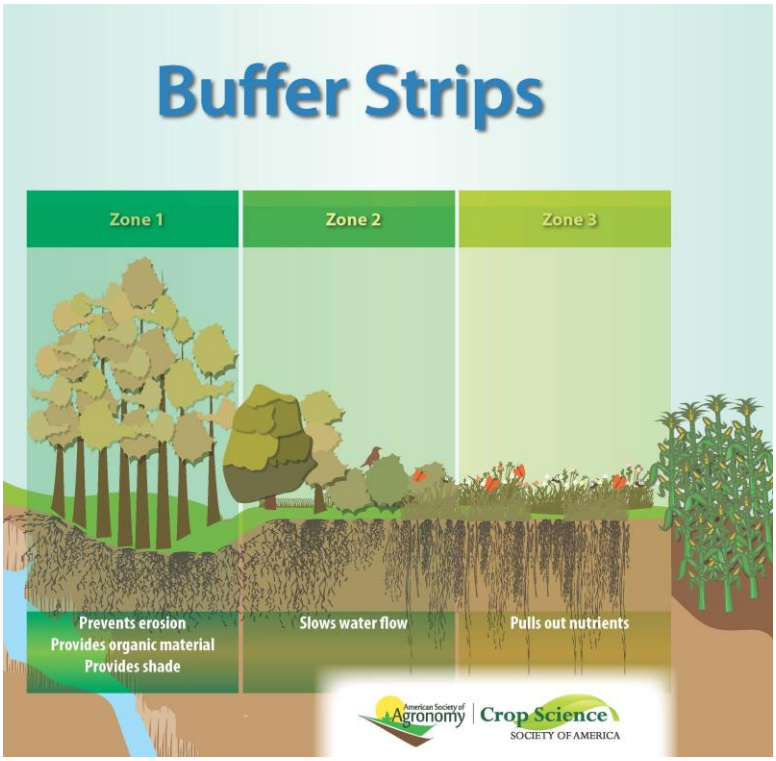


Fig 8: How various buffer strip zones work. (Crop Science Society of America)

Animal Feeding Operations Management- using runoff control, proper waste storage, and nutrient management to minimize the impacts of animal feeding operations.

Erosion and Sediment Control- using practices to conserve and reduce the amount of sediment reaching water bodies, overall protecting agricultural land and water quality.

Urban

Fertilizer Use- apply at the right time, rate and amounts. If more fertilizer is applied than the grass can utilize, it can wash into nearby streams and lakes. Get a soil test to see what your soil needs.

Pesticide Application- identify the pest, disease or cause of the problem, learn when and where pesticides may be needed, then select chemicals that are the least toxic or that break down quickly. Always read the label before mixing and applying.

Preventative Landscaping Practices- protect your soil by planting ground cover vegetation or by using mulch. Soil washed away by rain can pollute water bodies. Gardens and construction sites with areas of bare soil are prone to erosion.

Wash Your Vehicle Wisely- use a commercial car wash. Wastewater from these businesses does not enter the storm drains and is sent to a water treatment facility. If washing your car at home, pull your vehicle into the grass before you start washing. This will help water the yard as well as keep the soapy water from running straight into the storm drain.

Dispose of Pet Waste- pet waste washed into streams, rivers, or lakes contributes to nutrient pollution. Pet waste can carry disease carrying organisms. Dispose of pet waste properly by either collecting the waste and flushing it down the toilet, burying it in the yard five inches deep, or putting it in the trash.

Use and Disposal of Household Chemicals- never pour chemicals onto the yard or directly into storm drains, or the next rain will take the chemicals directly to a nearby waterbody. See if there is a household chemical collection center near you and drop them off there. Also, using alternative cleaning products that are less hazardous to the environment is beneficial.

Current Implementation

Marion County Lake is within a watershed with a multitude of resources to help with the maintenance and upkeep of the waterbody. Currently, they don't see much kickback from the surrounding landowners about implementing new practices to help with the lake's health. They began a few years back by educating on the impact that no till would have on not only helping with groundwater pollution but also on soil health. The WRAPs team saw some adoption of the practice but also saw some producers see tillage as a "social mindset" and often refer to them as "recreational tillers". These are essential individuals that don't see an issue with tillage even though they have experienced loss due to their tilling.

The next BMP that was advertised was the planting and use of cover crops. Cover crops provide a multitude of benefits to your land. They not only hold your soil in place, they can provide nutrients to your soil as well as allow an additional location to graze livestock. Livestock love the taste of the new feed source and happily graze while also supplying fertilizer to the field.

Additionally, the idea of permanent cover was introduced and for some acreage even adopted. The idea that you can convert your land from crop ground to native grasses or brome allowed farmers to see the benefits of haying the land to sell or grazing their personal livestock on the land.

Other practices that have been discussed include but are not limited to alternative water sources for livestock, field borders that filter runoff, precision application of nutrients by testing your soil, and grid sampling of the field to determine what spots are underperforming and over performing.

Out of Lake Recommendations

The following is a culmination of all of the recommendations for in-lake water quality and sediment management, as provided by previous capstone teams.

- As the primary source of the eutrophication in the lake is nutrient contamination from agricultural operations, farm managers should implement the government suggested BMP's regarding fertilizer application, tillage, and animal waste removal (Wallace, Trigo, & Keller, 2018).
- Animal operations should be located a safe distance from the lake shore to avoid solid waste contamination (Wallace, Trigo, & Keller, 2018).
- Nearby farmers should implement no-till cultivation to prevent erosion and runoff of soluble nutrients such as phosphorus and nitrogen (Wallace, Trigo, & Keller, 2018).
- Both farmers and governmental policy are responsible for solving environmental issues and supporting public health of communities. Therefore, regulation of wastewater and proper removal of solid waste is equally as important as individual contributions (Wallace, Trigo, & Keller, 2018).

To successfully combat the issues which the lake is experiencing, we need to begin by educating the individuals who have a direct hand in the pollution of the lake whether they know it or not. By educating both the agricultural and "urban" individuals, we can avoid pointing fingers and blaming a specific party. We should see a decrease in excessive lawn fertilization, an increase in BMP implementation and an overall decrease in blue-green algae presence. Thus, bringing back the beauty and fun behind the lake. To do this, farmers must be willing to reach out to local resources, such as the NRCS, who allocate nearly $250,000 a year in cost-share funds to allow farmers to be proactive and prevent pollution by implementing new practices into their operation.

People

Surveys

Desired conditions in national and state parks are highly determined by one's background in natural resources and/or social norms. To achieve an understanding of visitor use at Marion County Lake and Park, surveys from past NRES Reports included a variety of questions revolving around attitudes, values, beliefs, desires, perceptions, and cultural importance about different aspects found on public lands. These surveys also included basic questions regarding the outdoor activities recreationalist took part in during their time at the lake/park. When forming the survey methods, several question formalities are crucial in order to keep those surveyed engaged for a high survey return rate. Surveys also introduce the topic questions first for full transparency and input the demographic questions last due to them taking less time/critical thinking.

Main Topics Addressed in Surveys

- The anthropogenic induced climate change on Earth's natural resources and the effects on soil, vegetation, water, wildlife, air, soundscapes, night skies, and historical/cultural resources.
- Factors Influencing Desired Condition vs. Conservation/Preservation Missions

The feedback from the survey(s) will potentially bring forth information about high-use areas giving the managerial focus on trails, campgrounds, roadways, parking lots, popular sites, or other facilities. It will also provide information regarding recreationalist visit times with months and days.

Key Findings of Past NRES Surveys

1. Marion County Park and Lake User Survey
    a. 97.5% of visitors are from Kansas; 24% of the 97.5% being Marion, Kansas
    b. The most popular outdoor recreation activity being camping and boating (Boat Model/Registration was taken into account).
    c. Visitors to the areas spend an average of 1-3 nights with the high visitation rates falling in September and October.
2. Marion County and Park Survey (Not conducted due to the COVID-19 Global Pandemic)
    a. Survey will highlight the difference between visitors from non-visitors to the lake/ park.
    b. Collect information on the outdoor recreation activities people are participating in.
    c. Survey will collect visitor/resident demographics, trip itinerary, and opinions on what the park/lake offers/overall experience.

Stakeholders

Stakeholders of Marion Lake and Park fall to the 275+ residents who are in to a close proximity of the area (the majority of visitors being the residents). This is due to the positive/negative effects on the lake directly and indirectly affecting their personal livelihoods. To gain a better understanding, the surveys above show what residents/recreationalist are participating in and their overall duration of time at the lake. With this information, park and lake managers should have all the information they need to allocate time and resources needed to accommodate for desired conditions as well as upholding their mission of conservation/preservation. Residents and further stakeholders hold the key with the shared information to alleviate the issues arising at Marion Lake and Park. By working with their natural resources, they can also benefit from personal inputs on further management practices/preferences.

EPA CyAN Application

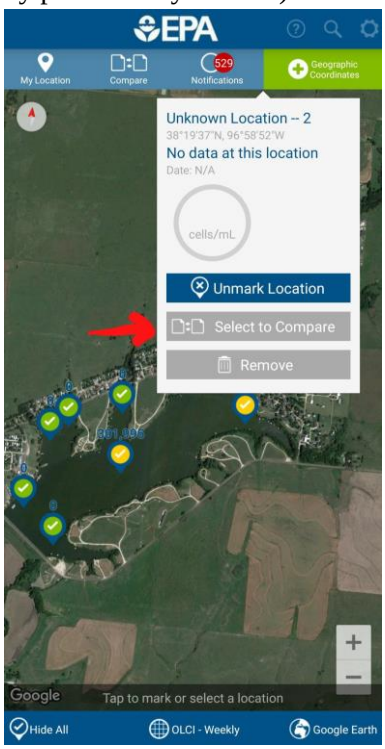
The Environmental Protection Agency (EPA) produced and released a free to download application that is named the Cyanobacteria Assessment Network (CyAN). The CyAN app is a tool free to the public that uses satellite data to alert its users of when HAB's could be forming based off of the changes in the color of the water in the images that the satellites took. The EPA, NASA, NOAA, and the U.S Geological Survey all came together to produce this app to help lake managers and water quality managers understand when there may be a HAB forming and hopefully avoid potential health impacts to people, livestocks, pets, and the environment.

This section will cover the app in a detailed and explained step by step way, so that the lake managers at Marion County Park Lake will be able to accurately use and maintain the app so that they should know if any HAB's are forming within their waters.

Steps for using app:

1. Opening: When opening the app, the user will have to find their watery location that they would like to monitor. The easiest way to find the location is to click the button on the bottom right (Google Earth) and change that to Google Maps. This will have the locations and parcels labeled.
2. After the location has been found, it is time to pick and choose locations around the water that the user would like to have monitored. It is as simple as clicking on the lake.
3. Once the locations have been placed like the image below, CyAN will remember these points and update regularly to alarm the user if one of the points in the lake is too high.

4. If you want to compare, for example, two points that you have marked in the lake, you will simply click the point that you made and a window will pop up like in the image below. Then you will want to select the first point to compare. Do this same step to another point that you want to compare with. (You can compare however many points that you want).

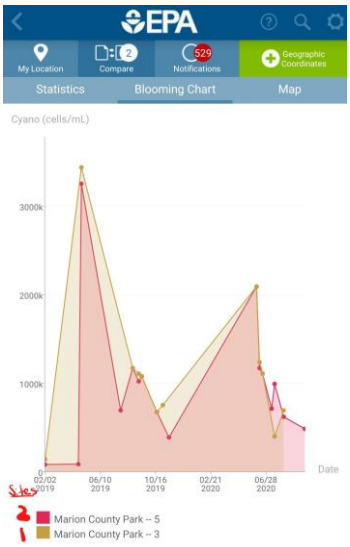


5. For this demonstration this project will be comparing these two locations in the image below. Sites 1 and 2.

6. Now that you have your sites selected and ready to compare, you will click the button on the top that says ‘Compare’. After clicking that tab you should see a screen like in the image below.

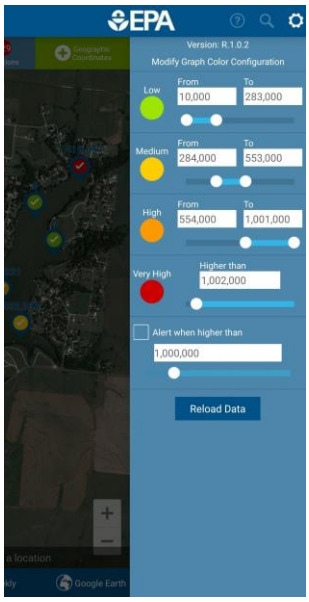
7. From here you can click the compare locations button beneath the sites that you are wanting to compare. The first tab that you will be able to see is the ‘Statistics’ tab. This shows the differing stats between all locations selected. It should look as follows.

8. The next tab to the right of the statistics tab is called ‘Blooming Chart’ and when you click it, it should take you to a graph of your selected sites throughout given dates of recorded CyanoBacteria (HAB). It should look like the image below.



9. The next tab is the ‘Map’ tab and all this does is take you to show you where your locations that you selected to compare are.
10. Tap the left pointing arrow in the top left corner to go back to where you put your selected sites at.
11. In the top right section of the app there is a settings cogwheel that allows the users to change the variables of how low, medium, and high the concentrations are. The cogwheel is shown in the image below.

12. Inside the settings cogwheel you should see different sliders to adjust to your discretion of what is considered low in your lake, average in your lake, and high in your lake. The sliders look like the image below.



13. Play around with the many different stats, graphs, points, and levels to get a better understanding and feel for the app.

One key aspect of this application is the alarm feature, which can be set up to notify Marion County Park and Lake managers whenever satellite images detect potential harmful algae blooms on the lake. Additionally, this application can also record this data at previously determined sites on a monthly basis to help lake managers know where the highest concentrations of Cyanobacteria are in the lake for any given time of year. Again, it is a free app that is not limited to the lake managers but is also free that should be informed about to the surrounding areas citizens that utilize the lake for whatever they so desire.

Limitations

The following factors limited the team's ability to fully synthesize and collect information to the extent they would have liked.

- COVID-19 - No further data collection
- GIS License Restrictions

Conclusion

The purpose of this report was to collect, analyze and summarize key findings from NRES Capstone reports collected over the past two years, in order to help lake managers create an effective lake management plan. To do this, the team read through all of the previous reports gathering the data collected by past teams to be assembled here. In doing so, the team was able to identify key water quality, sediment, land use and stakeholder information that the Marion County Lake managers can use to create a comprehensive lake management plan. In the process of synthesizing previous NRES Capstone projects, this report has also identified several recommendations for further studies, best management practices and potential solutions which can be used to help improve the water quality in the lake. Finally, the team also provided a brief overview explaining how the EPA application can be used to track cyanobacteria cell concentrations, therefore helping lake managers understand HAB trends in the lake.

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