Identification of Sediment Sources in the Tributaries of Marion County Park & Lake to Develop Future Erosion Management Plan

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Abstract

The purpose of this report is to identify sources of sedimentation within the tributaries of Marion County Park & Lake in order to assess the sediment's erosion potential in the streams as well as their downstream impact on lake bed fill and overall water quality. To accomplish this, soil samples, water samples, stream cross section measurements, and documentation of erosion-prone areas were collected. The water samples were analyzed and Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and Total Nitrogen and Phosphorous (TNP) were measured. Particle size data was collected from ten different soil samples from the two largest tributaries of Marion County Lake. There are differences between these samples, but do not appear to be correlated strongly with any variable measured. In conclusion, the methodology of this project could be replicated in future semesters in order to collect and develop a baseline of measurements that observe long-term bank retreat and erosion hotspots in the tributaries of Marion County Park & Lake.

Introduction

Water is one of the most valuable resources on earth. Continuous efforts to protect this resource have been growing as population around the world increases and sources of water are threatened by natural and anthropogenic factors. Overtime, erosion mainly from both stream banks and surface soil threaten reservoirs as sediment makes its way downstream and reduces water holding capacity. Reducing the water holding capacity of these reservoirs is a problem because it limits their ability to provide flood control, drinking and irrigation water, and recreation such as boating and fishing. In Kansas alone, a third of its reservoirs are expected to be half filled up with sediment by 2105. It would cost $13.8 billion to dredge the sediment out of these Kansas reservoirs by the end of the century (Denoyelles and Kastens, 2016). Therefore, it is essential to design an effective sediment management plan to reduce sedimentation. Attempts to decrease sediment loads in streams continue even though the fundamental question as to whether these sediment loads come from either stream banks or surface soils remains relatively unanswered (Collins and Walling, 2004; Walling,2005). Most natural lakes are thousands of years old and have developed a long lasting ecohydrological relationship with their surroundings. These relationships are changing due to several factors such as removal of grasslands to agricultural and urbanized land after the Euro-American settlement. Before then, riparian vegetation stabilized soil while slowing and filtering runoff. Anthropogenic drainage modifications such as straightened stream channels and constructed stream levees have resulted in "sediment starved" high water flows causing reduced overbank dispersion, reduced residence time, and increased discharge rates. These characteristics have increased fluvial energy producing greater in-channel erosion and sediment carrying potential. In order to improve stability, regular monitoring, maintenance, repair, and replacement of issues in these watersheds are required (Denoyelles and Kastens, 2016). Our research focuses on these problems surrounding the tributaries running into Marion County Lake and how it may be impacting water capacity in that specific watershed. This research highlights important characteristics in this watershed that could be contributing to sedimentation in the lake with a goal of building a sustainable watershed management plan for the area in coming years.

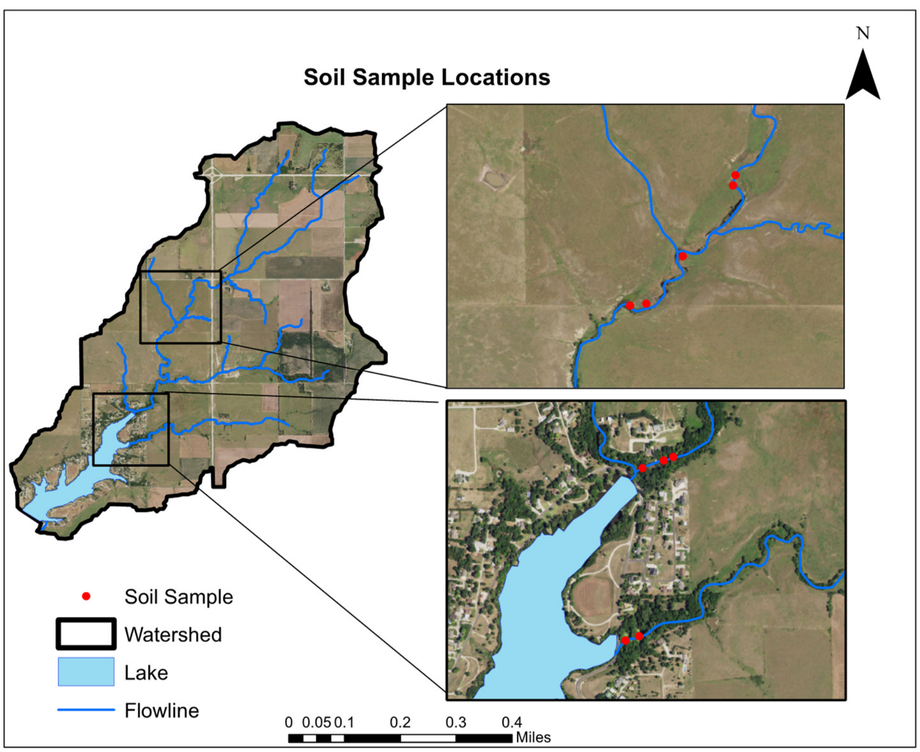

Figure 1: Map of site and soil sample locations along the two tributaries of Marion County Lake. The top right figure is Northern Stream Site A. The bottom right figure shows Northern Stream Site B north of the lake and the Northeast Stream Site towards the bottom of the figure.

Background

Sediment Sources

Both suspended sediment from surface soils and stream banks pose a threat to Marion County Park and Lake. Overtime, suspended sediment reduce water holding capacity of lakes and can lead to it filling in with sediment. To build an effective lake management plan it is important to study the causes of sedimentation and ways it can be reduced. A past study fingerprinted sources of suspended sediment through soil samples taken from various land cover types: stream banks, forests, pastures, construction sites, roads and road cuts (Voli et la., 2013). Suspended soil samples were then taken from the water to be compared. Results indicated that stream bank erosion had the greatest contribution of sedimentation. Particularly areas with eroding stream banks (Nagle et al. 2007). Based on these conclusions our research focused mostly on stream banks. The amount of the sediment from each source also depends on sampling location within the stream. Research shows that in the upper reaches of the streams suspended sediment was dominated by topsoil (64%-85%), but declined as samples were taken further downstream. In the lower areas of the stream, sedimentation from the stream bank (32%-51%) and shale bedrock (29-40%) were found to be more prevalent. The cause of the change was related to the transition in the dominant erosion processes from the topsoil to stream bank erosion and the incision of the stream through the shale bedrock (Koiter et la. 2013). Because of dry conditions in the watershed and limited access to all areas of the stream our data does not included upstream water samples. Though in future research under ideal conditions, data from upstream should be collected.

Stream Characteristics

Although stream banks were the main focus of our research, the changing land cover types in the watershed are a significant concern. The area around the lake has seen a steady increase in urbanization as more home are being built (M. Meyerhoff, personal communication) A sediment budget study found that areas with higher rates of urbanization experienced the lowest amounts of gross and net floodplain trapping, leading to higher amounts of sediment ending up in streams (Arp et al., 2006). Natural grassland does a much better job of capturing sediment flows. Water infiltration rates also increase because of vegetative cover when compared to urbanization. This is a key factor in limiting the channelization of streams that further pose a threat to the lake. As streams become more channelized it creates more flow power, which is damaging to stream banks and increases stream bank height.

Areas with eroding stream banks have been found to contribute the highest amounts of sediment in watersheds (Nagle et la., 2007). These were areas defined as banks with exposed roots and sediment depositions at the base. Protecting stream banks with riparian vegetation is beneficial. Riparian vegetation can reduce erosion by up to three times compared to unvegetated areas. Types of vegetation can also make a difference, grass banks are four times more likely to erode compared to tree vegetated banks (Purvis & Fox, 2016). Additionally, stream bank height is mentioned as concern because of floodplain connectivity. When floodplain connectivity is reduced, water is less likely to disperse over the stream banks and spread across the floodplain. Results indicate the important relationship between channelization and the floodplain, stating that as the floodplain width increases relative to the channel width, less erosion occurs (Arp et al., 2006). The last characteristic brought to attention in our study is sinuosity. Stream banks on the outside of meander bends experience higher shear stress as opposed to the inside of the bend, leading to higher erosion rates on that side (Purvis & Fox, 2016). Image 1 shows an example of meander bends along Northern Stream Site A.

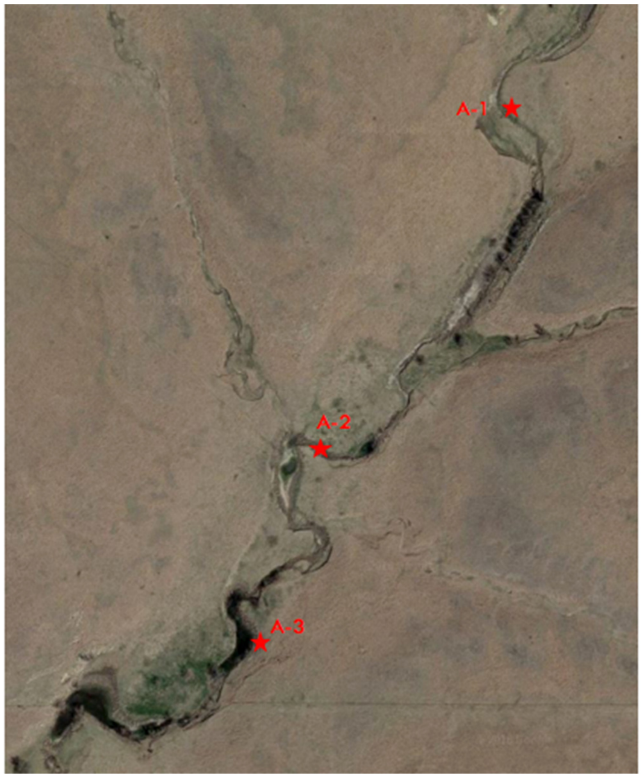

Image 1: Aerial photo of stream profile measurements A-1, A-2, and A-3 (labeled with red stars) at Northern Stream Site A. Example of how areas of sinuosity should continually be monitored in the stream.

Lithology

Identifying the ways in which the lithology of a stream bank and surrounding area affects the rate and intensity of erosion. Incision in streams is also important to gain a better understanding of how data can be collected at Marion County Park and Lake. Consequently, this information could be used to make conclusions as to which type of bedrock is most likely to erode and likely cause flooding in those areas. Identifying a precise model for direct methods for measuring parameters like tensile strength, slope, and using erosion pins to record bedrock lowering, help successfully determine incision rates and therefore aid in hypothesizing patterns of incision for different lithologies. This information provides good context to this project because it shows a lot of examples of how different lithologies affect erosion with the most apparent deduction being that weaker lithologies like shale experience greater bedrock lowering during a shorter period. Similarly, stronger lithologies like limestone are less likely to erode overtime (Stock, 2005). The bedrock underneath the area of Marion County Lake is limestone and shale. The mix of these two weak and strong lithologies means that bedrock lowering would have to be monitored over time to get an idea about how it effects stream profile heights. Observations like these could be conducted periodically in the tributaries of Marion County Lake to monitor changes.

The colluvial units analyzed and discussed in the paper "An assessment of the erodibility of Holocene lithounits comprising stream banks in northeastern Kansas, USA" by Layzell & Mandel is mostly limestone and shale. This is the type of lithology that is present in the streams at Marion County Park & Lake. To assess erodibility, soil tests were conducted to determine soil units and parent material. Erodibility tests were performed using a mini jet-test device. The take away from analyzing changes in lithology is that basins with diverse lithologies and variable/random erosion and abrasion rates will produce sediment transport rates that are very dependent on a certain type of lithology (Layzell & Mandel, 2014). In other words, if that lithologic variable were to change, sediment transport downstream would become variable and unpredictable without further investigation to prove otherwise. This information is useful as a long-term parameter to measure in Marion County. If bedrock were to change significantly due to erosion, it is likely that sediment transport would change and that would need to be studied.

Stream Hydrology

Stream hydrology governs the magnitude and timing of sediment transport through a system. Many factors influence the characteristics of these events and vegetation is one of those in how it changes the erosional potential on stream banks. Geyer et al. (2000) used aerial photography to examine what controlled the erosion on a stream in Kansas during the flood in 1993. The researchers found that woodier areas limit erosion and served as areas of deposition of sediment rather than a source of sediment. Cropland and grassland showed the greatest amount of lateral erosion. Geyer et al. (2000) also found that radius of curvature and width did not have a significant impact on the erosion of the stream bank. This is in contrast to the normal thinking of erosion along curves in streams and is probably due to how high the flows were during this flood – high enough to flow over a curve and not erode it as a smaller flow would. Also, sandy areas eroded more than silty areas (Geyer et al. 2000).

The sediment loading of a system can be governed by a number of different factors. The impacts of grazing related to sediment transport are that higher grazing leads to an enhancement of water delivery to the system meaning there is more energy to transport sediment downstream (Baker et al. 2004). This study was done in the U.K. with animals other than cattle, so its direct applicability to this study on Marion Co Lake needs more research. Other factors that control the sediment loading of a system are duration of a stream flow event, peak discharge during the event, antecedent base flow, and the availability of sediment to a river (Squires et al. 2017). In their study of the Paradise Creek Watershed in Northern Idaho, Squires et al. (2017) examined the processes that controlled the sediment loading and transport in the system. Results showed that in this particular watershed, the largest event in a year contributed one third of the sediment transported in a given year. Sediment loading on this watershed during an event was primarily within the first 20% of an event (Squires et al. 2017).

These aspects of stream hydrology such as vegetation, amount of grazing, duration, peak discharge and availability of sediment are important to note for this study because this area has sections that are heavily wooded, sections that are grazed and areas that are prone to flooding, as reported by local landowners during field work, which could greatly impact the amount of sediment flux into the lake.

Materials and Methods

Study Area

The focus of this research, Marion County Park and Lake, is a 300-acre park owned by Marion County located two miles southeast of Marion, Kansas. Within the park is a 153-acre lake that is a drainage point for the surrounding watershed of approximately 4000+ acres. Open since May of 1940, this lake has become a popular destination for camping and fishing and more recently has seen a steady increase in urban development. National Landcover Data (NLCD) from 2001 to 2006 shows a 5% increase in urbanization across the watershed. This increase occurred mostly around the lake as the major roads and highways in the watershed were built before 2001. Today, approximately 200 houses are located near the lake. Besides urban development, land cover in the watershed consists mainly of cropland and pastureland with some riparian forests. Users of the lake: residents, stakeholders, and county officials, are concerned over water quality issues because of the increased frequency of algae bloom. The scope of this research, however, focuses on the sources and amounts of sedimentation running into the lake which is another major concern. At this time, there is no comprehensive management plan in place to improve or monitor these conditions.

Water Sampling and Data Analysis

Water samples were collected from four separate locations along the two largest tributaries of Marion County Lake to assess nutrient and sediment loads flowing into the lake. To take water samples from the stream around the Marion County Park and Lake, a depth integrated method was used. This ensured a representative sample was collected. A single discharge weighted composite sample from the stream is collected by raising and lowering the sampling device throughout the depth of the water column, with the mouth of the device pointed upstream. Samples were then taken back to the K-State Research and Extension Soil Testing Lab for tests on Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and Total Nitrogen and Phosphorous (TNP). These samples were taken on the 29th of May, 2018, with another set of samples from the same locations taken on the 10th of April, 2018. Both sets of samples had the same tests ran on them. Funding for the tests was given and appropriated by the KSU Research and Extension.

Soil Sampling

Soil samples from the stream banks were taken using a grab sampling method to understand the soil physical properties and characteristics related to grain size and erodibility. A sampling depth of 45 cm below the soil surface was determined as sufficient to reflect the portion of the soil profile that would make it into solution of the streams. Soil samples were collected from ten different locations along two tributaries leading into Marion County Park and Lake. The lithology of the area is limestone and shale. The two soil types are Labette-Sogn silty clay loam 0 to 8 percent slopes at the Northern Stream Sites and Sogn silty clay loam, 0 to 10 percent slopes. The parent material of these soils is residuum weathered from limestone and shale. According to Web Soil Survey descriptions for Labette-Sogn silty clay loam and Sogn silty clay loam. The weighted average clay and silt percentages of these two soils types are 37 and 52 percent, respectively. The organic matter of these soils in the sampling area (first 45 cm) is 1.5-3.5 percent. These parameters are affected by erosion and weathering.

Image 2: Sampling soil sample N7-S at Northern Stream Site B.

Sample Denotation

The samples were labeled by dividing them into groups. The first division is done by divvying up the two tributaries. The one that runs into the north of the reservoir was named the Northern Stream, while the other stream investigated was the tributary that runs into the northeast of the reservoir south of where the Northern Stream comes in. This stream was labeled as the Northeast Stream. Both can be seen in Figure 1. The Northern Stream is then divided up by the two sampling areas. Northern Stream Site-A is the area shown in the top right picture in Figure 1. This section of stream is located on the plot of land just to the southwest of the intersection of KS-256 and US-77. Northern Stream Site-B is the site that is located right off the reservoir where the stream runs into it and goes upstream past the culvert all the way up to the Kraus Property, a family that did not allow access to their land. The Northeast Stream was not divided up so there is only one site which is denoted as the Northeast Stream. The samples taken are labeled as follows, if the sample was taken along the Northern Stream, the names are first labeled with an N, along the Northeast Stream an NE. This is followed by a number which indicates the location of the samples (1 is the furthest away from the reservoir, as the numbers increase the distance to the reservoir decreases). The sample locations are also shown in Figure 1. After the number indicating location it is then followed by a dash and then either an S or W indicating the type of sample. S is for a soil sample while W indicates a water sample. Cross-sectional measurements and stream profiles were only taken at Northern Stream Site A. Therefore, samples are indicated with an A, indicating the site, followed by a number. Site A-1 is the furthest away from the reservoir, while A-2 is closer and so on.

Site Name	Sample/Measurement ID	Latitude	Longitude
Northern Stream Site A	N1-S, A-1	-96.970385	38.344355
	N2-S, A-1	-96.970444	38.344088
	N3-S, A-2	-96.971750	38.342250
	N4-S, A-3	-96.972701	38.341013
	N5-S, A-3	-96.973122	38.340962
Northern Stream Site B	N6-S, N6-W	-96.976361	38.330098
	N7-S, N7-W	-96.976679	38.330015
	N8-S, N8-W	-96.977386	38.329822
Northeast Stream Site	NE1-S	-96.977619	38.325467
	NE2-S	-96.978075	38.325361
	NE3-W	-96.978168	38.325368

Figure 2: Site name, sample and measurement ID, and location in latitude and longitude of each point where data was collected.

Stream Profile Measurements
Stream cross section measurements were taken from three locations on the Northern Stream Site A where soil samples N1-S, N2-S, N3-S, N4-S, and N5-S were taken. These measurements were used to gather baseline data for comparison with future measurements. Also, these measurements are an indication of how the stream cuts through the landscape as it gets closer to the lake. Measurements were taken using a leveled sight on a tripod and a levelling staff. Once the sight is set up, a tape measure is laid across the stream profile in question. The leveling staff is placed at zero on the tape measure, and a height measurement is obtained by using the sight. The levelling staff is then placed along the measuring tapes at points where there is an elevation change and a measurement is taken through the sight.

Image 3: Taking stream profile measurements using a level sight and leveling staff.

Soil Particle Size Measurements

Particle size measurements of soil samples were done using the Malvern Mastersizer 3000. Samples were bathed in 25% hydrogen peroxide solution, added 3 mL at a time, for several days to remove organic particles. It was determined that enough of the H_2O_2 was added once a physical reaction of the sample stopped. Samples were then bathed in DI water twice, then given ample time between decanting to increase settling time. This process ensured no clay particles were lost. Finally, samples were run using the Malvern Mastersizer 3000 according to procedure.

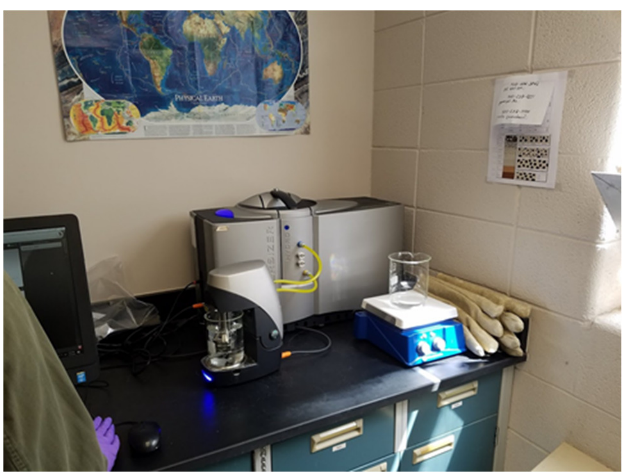

Image 4 & 5: Mastersizer 3000 (left) and samples settling before decanting (right).

Results and Discussion

Water Samples

The amount of nitrogen and phosphorus in these streams is most likely the lowest concentration compared to other times of the year. In other words, the last agricultural applications of nitrogen and phosphorus were during the beginning of the last growing season. It is important to consider the time of year when analyzing contaminant concentrations. The levels of N and P will likely be higher in summer and early fall. There is a high chance of sampling error for the sediment in these water samples. This is most likely due to not giving enough time to allow the sediment to settle after walking to the sampling site, as well as the sampling instrument hitting the bottom and disturbing more sediment. That being said, there was not a lot of rain that occurred between sampling dates, so it is assumed that the results would be relatively similar for each parameter. Values don't change much between sampling times, despite a small amount of rain, 0.13 inches between 3/29 and 4/10 according to local reported rain gauge data. This rain did not cause significant flow in the streams (M. Meyerhoff, personal communication). The TDS and EC were very similar throughout each sampling site (Table 1).

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

Table 1: TSS, TDS, EC, Total N, and Total P results from water analysis

Grain Size

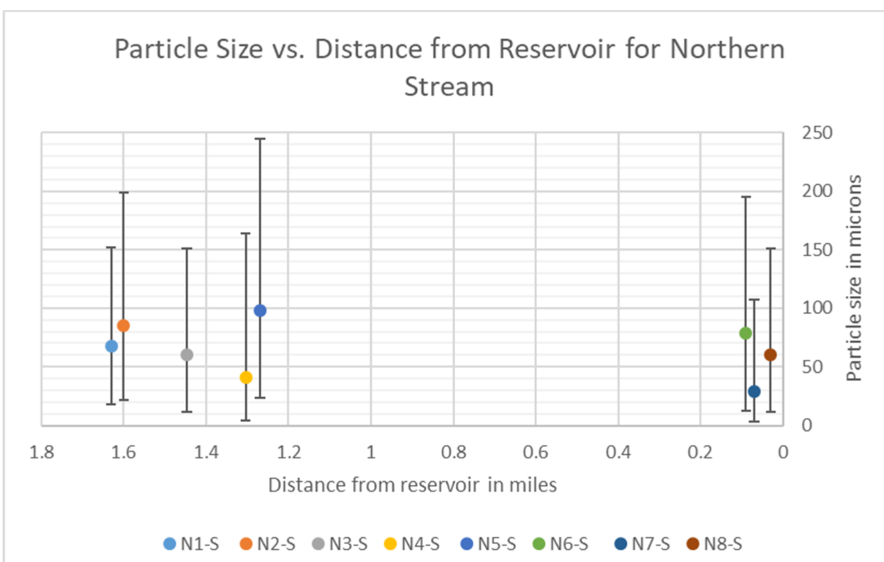

Figure 3: Particle Size Data for all Northern Stream samples in relation to distance from reservoir. The bottom tick mark in each box represents the Dx10 size, the dot in the middle represents the Dx50 size and the top tick mark represents the Dx90 size.

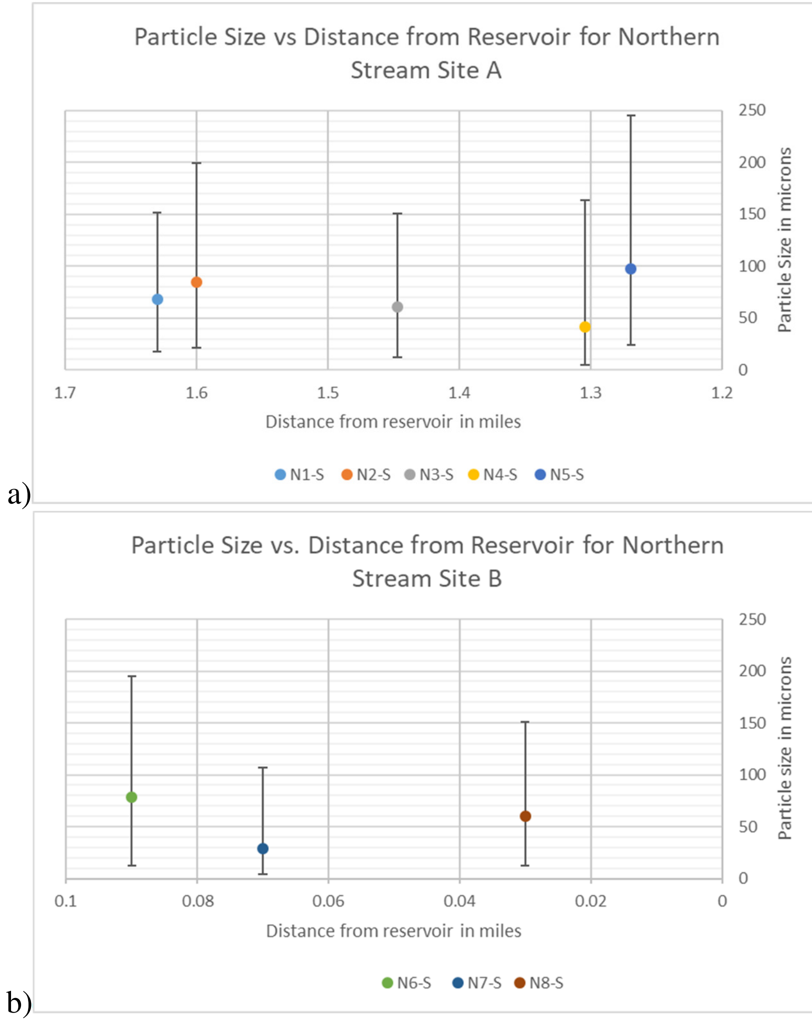

Figure 4: Particle Size Data from the Northern Stream Site A (a) and from Northern Stream Site B (b). Both show distance from the reservoir in miles. The bottom tick mark in each box represents the Dx10 size, the dot in the middle represents the Dx50 size and the top tick mark represents the Dx90 size.

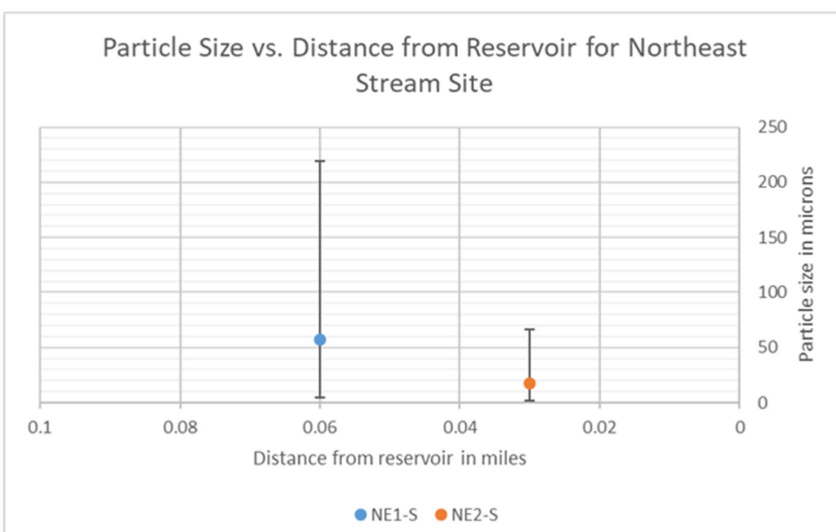

Figure 5: Particle Size Data from the Northeast Stream in relation to distance from the reservoir. The bottom tick mark in each box represents the Dx10 size, the dot in the middle represents the Dx50 size and the top tick mark represents the Dx90 size.

Figure 3 above shows the particle size of the samples from the Northern Stream along with their distance from the reservoir. The considerable gap between data sets represents a large portion of the stream where permission was not granted to take samples and measurements. Sampling from this area will be crucial to further research and analysis of the tributary system of Marion County Lake. Particle sizes are plotted with the Dx50, or the size at which 50% of the sample is either larger or smaller, as the colored dot. Dx10 and the Dx90, the points at which there is 10% particles of a smaller size or 10% larger in the sample respectively, are plotted as the bottom and top tick marks. Figures 4 and 5 are plotted using the same method. Using the classification of clay particles being smaller than 2 microns, none of the samples have a clay concentration of over 10% of the sample. The fraction of clay and silt particles affects the erosive potential based on the horizonation of a given soil. A and Bt horizons that have a greater proportion of clay particles (where the majority of our soil sampling occurred) are generally more erodible than C horizons that have less clay (Layzell, 2014). During testing, it is possible that not enough time was given for all the particles to settle before decanting leaving the possibility that some of the clay particles were lost in that process. That aside, the results indicate that all, except for N7-S and NE2-S, have concentrations of silt at lower than 50%. The definition of silt is particles in between 2 microns and 50 microns. Samples N7-S and NE2-S are majority silt and the rest of the samples have sand concentrations of over 50%. Correlating the testing location and distance from the soil surface does not shed much light on the differences between samples. Height beneath the soil surface is shown in Figure 6. There seems to be little change in the composition of the soil as you move downstream.

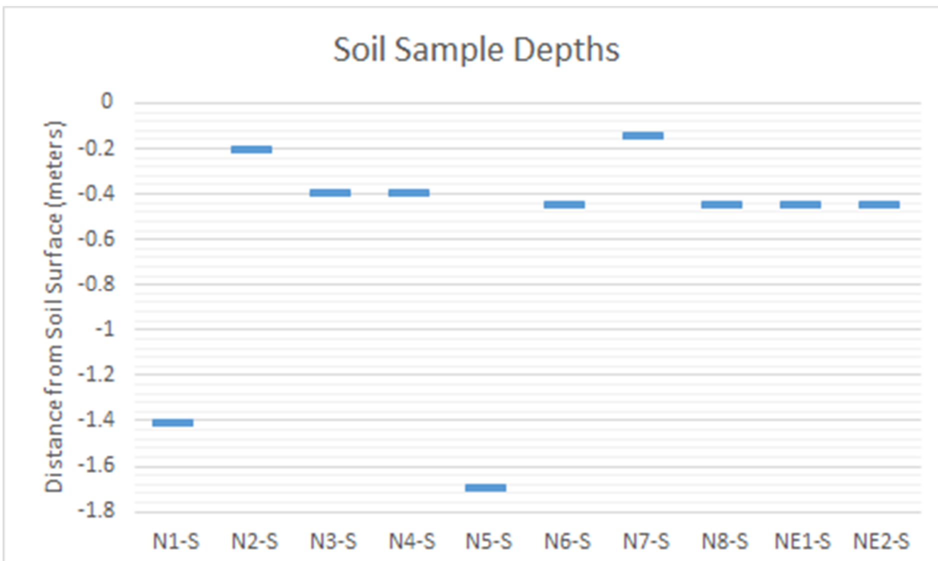

Figure 6: Depth of all soil samples measured down from the soil surface. Measurements are in meters.

There are differences between these samples, but these samples do not appear to be strongly correlated with any variable measured. Some samples, such as N7-S and NE2-S have a lower average particle size than the rest and are closer to the reservoir than all samples besides N8-S. This is in part because the soils at the Northeast site and closest to the lake were darker, had more organic matter, and therefore more clay. Clay accumulation would lead to smaller particle size in this area. More research would need to be done to see if this is correlated across the reservoir. Another explanation is that N7-S is the sample that is taken closest to the surface, which could mean it was most likely taken in the A horizon where clay content is relatively low compared to the rest of the profile.

Stream Profile Measurements and Physical Erosion Observations

For A-1, the profile is taken looking downstream with a floodplain extending to the left of the profile. The stream was not flowing at the time of measurement. Site A-1 was right after a large bend and had a large area for water to pool up with a very steep cut bank on the right side. The brunt of the energy during a flooding event would erode the steep cut bank as shown in Image 6. This profile was taken looking downstream (Figure 7). The small indention on the left is where normal stream flow would flow through. The rocks before this bend appeared to be part of the bedrock. These rocks were very tabular and appeared to be exposed and cracked bedrock. Characteristics of stream sediment like grain-size and flux affect the erosion of the channel as sediment moved downstream and said lithology also controls downstream evolution of the channel (Mueller et al., 2016). The size of sediments affects how much stream power is needed for the sediment to play a role in stream erosion. The soil samples taken here were N1-S and N2-S which had Dx50s of 67.7 and 84.8 microns respectively. Both had less than 10% clay.

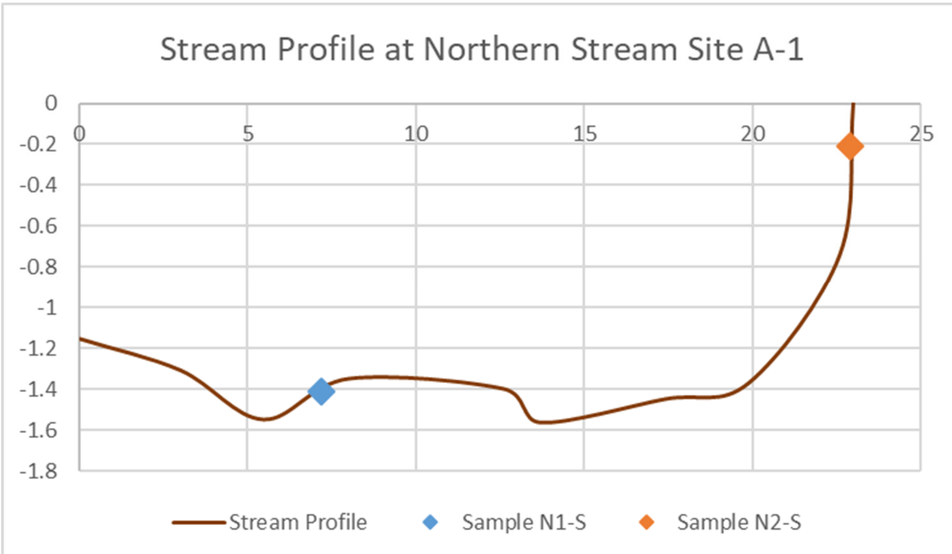

Figure 7: Stream profile with soil sample locations for the Northern Stream Site A-1. Profile done looking downstream. Both axes in meters, Y axis origin is from the height of the sight.

Image 6: Site A-1. Downstream look at steep cut bank exposed at the horizon of the picture. Tabular blocks at stream bottom.

Site A-2 was on a bend as well, the deeper cut channel suggests a stronger erosive potential here compared to A-1 (Image 7). This profile was taken looking downstream (Figure 8). On the inside of the curve, which would be on the right of the profile, woody vegetation was rooted and behind that extended a floodplain. Evidence of slumping can be seen in grass clumps detaching and moving down the slope. Sample N3-S was taken here with a Dx50 of 60.8 microns, also with less than 10% clay.

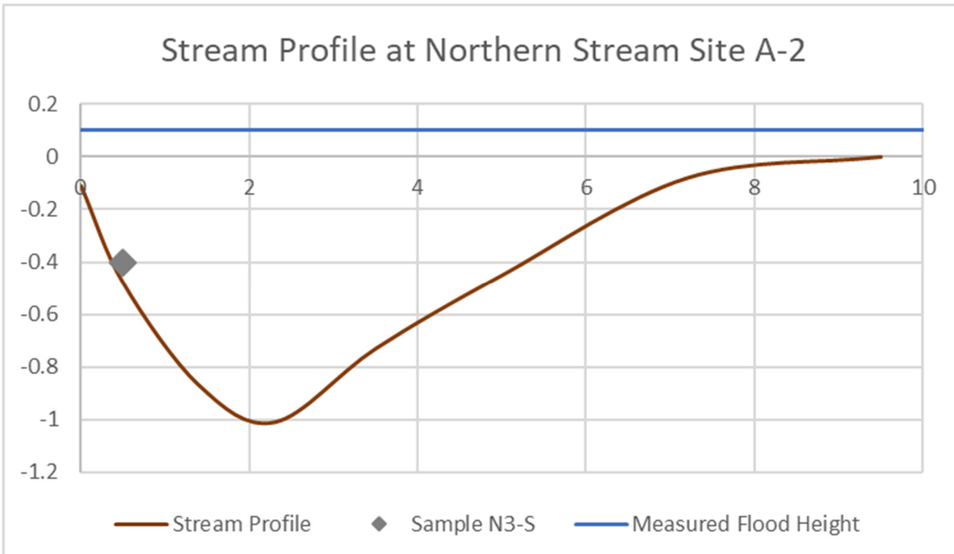

Figure 8: Stream profile with soil sample locations for the Northern Stream Site A-2. Profile done looking downstream. Both axes in meters, Y axis origin is from the height of the sight.

Image 7: Site A-2. Evidence of bank slumping and detachment in the grass clumps moving downward on the left bank. Flood debris can be seen caught in the tree on the right. Picture taken looking downstream.

For site A-3, this area was probably the most prone to erosion. The landowners placed two large concrete slabs, one 2.85 meters long to slow the erosion that was occurring. The erosion and the slabs are in the picture below (Image 8 & 9). The profile was taken looking downstream (Figure 9). The erosion on the right of the picture was slowed and stopped to that extent by a tree, whose exposed roots are seen on the right of the photo. This area also shows bank slumping as shown by the grass clumps that are moving down the stream bank. Samples

N4-S and N5-S where taken as shown in the profile. The Dx50s were 41.3 and 97.8 microns respectively. Both had less than 10% clay. Sample N5-S had the highest Dx50 of all the samples as well as the highest Dx90, which was 245 microns.

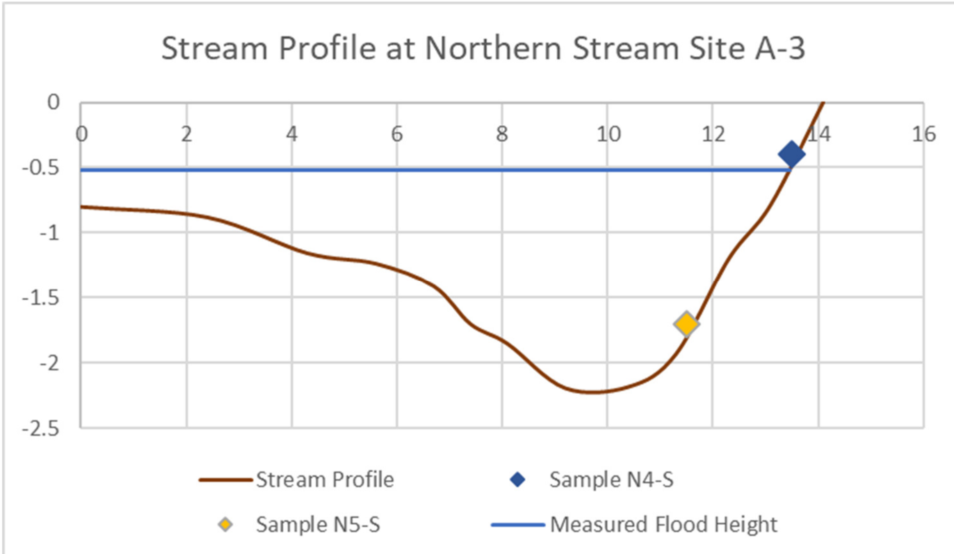

Figure 9: Stream profile with soil sample location for the Northern Stream Site A-3. Profile done looking upstream. Both axes in meters, Y axis origin is from the height of the sight.

Image 8 & 9: Slump and undercut erosion with two concrete slabs placed by landowner to slow flow at site A-3. Left slab is 1.2 m and right slab is 2.85 m.

Precipitation Data

Though rainfall data in Marion County Lake was not collected, Figure 10 shows rain gauge data collected at Marion County Reservoir, which is close to Marion County Lake. This information could be used in future semesters of NRES or by county officials when developing an erosion management plan. The depth, duration, and frequency of rainfall events can help predict how often a certain storm were to occur. There is a strong correlation between rainfall intensity and speed of flow in a stream. This would affect how much sediment is being picked up and transported into the lake. Overall, we found this information important to include in this report as it could be useful for this project as it continues.

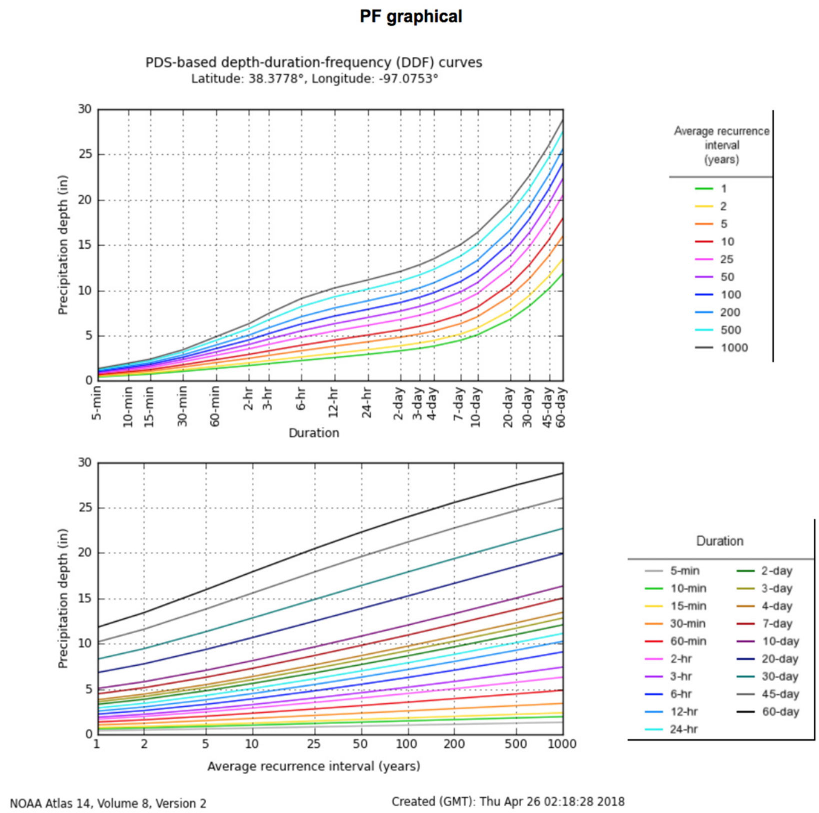

Figure 10: Atlas 14 data showing depth-duration-frequency curves for rainfall events taken from a rain gauge at neighboring Marion Reservoir (Station ID: 14-5039)

Conclusions

This project consisted of collecting a series of parameters relating to stream erosion. In future semesters, our methodology could be continued in order to develop a baseline of measurements for years to come in order to observe long-term bank retreat and erosion hotspots in the tributaries of Marion County Park & Lake. Parameters such as channel width, documentation of established terraces and incision areas, grain size, and suspended sediment can be replicated and compared over time to help establish a long-term erosion management plan. The field work aspect of this project was extremely beneficial and helped us develop skills using new scientific implements such as the depth-integrated water sampler and level and sight staff. It was a great experience working and learning with people from different disciplines of natural resources because each person brought different areas of expertise to the research. We encountered some issues with land access along the way. A family named the Kraus' owned a significant amount of the land around Northern Site A and did not want us on their land. We had to work around property boundaries in order to samples from this location. Ideally, we would have wanted access to more of the tributary in Northern Site A. This is an access issue that could hopefully be resolved during future semesters of this project. Despite this problem, we would encourage future students to continue to collect data at this site to provide a more complete dataset for Marion county officials. Overall, we feel the data we have collected this semester has achieved our goal of identifying sources of sedimentation in the tributaries of Marion County Lake. We hope this information will be used to create a future erosion management plan for Marion County Lake and the surrounding area upstream.

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