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River Sediment Sampling Methods- Causeway Building and Removal

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Disclaimer: The following thesis was produced in the Environmental Studies Program as a student senior capstone project.

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Abstract

The Environmental Protection Agency (EPA) and U.S. Fish and Wildlife Service (USFWS) suspect that causeways have a negative impact on river ecology both when installed and when removed. The Nebraska Department of Roads routinely uses causeways as a tool in the construction and repair of bridges. Although research has not been conducted on the impact of causeway building and removal data has been collected about the impact of dams, causeways, etc. on estuaries. This data is considered subjective and authors often cite sampling methods as a source of error. Currently there are no widely used handheld sampling methods that are used to take soil profiles of both sandbar and riverbeds. The goal of this study was to test the utility of 5 sampling methods to determine which would be best suited to study the impact of causeway building and removal. A 2 inch diameter, tapered end probe was determined to perform best of all methods studied with a percentage of recovered sediment of 92.3% for sandbar and 97% in stream. If the opportunity to continue this study presented itself the 2 inch tapered end probe could be improved by obtaining a “butterfly”, or one-way valve that would allow sediment to pass when the probe is pushed into the ground but would close upon retrieval.

Introduction

Intricate roadways and bridges mark the landscape of developed countries, and their presence impacts the surrounding ecology (Forman & Alexander, 1998). According to the U.S. Department of Transportation (2010), an estimated 8,483,969 miles of roadway and 603,259 bridges occur in the United States. Of these bridges, 15,436 are located in Nebraska (U.S. Department of Transportation, 2010). The nation's bridges range in size from those that cross a meandering creek to those that cross multi-channeled streams for miles. The task of building a bridge is an intricate feat of engineering that requires thoughtful planning.

The Nebraska Department of Roads (NDOR) routinely uses causeways as a tool in the construction and repair of bridges. Causeways are temporary earthen crossings, built into a river so serve as a work platform for construction equipment. The Environmental Protection Agency (EPA) and U.S. Fish and Wildlife Service (USFWS) suspect that causeways have a negative impact on river ecology, both when installed and when removed. Concerns are based on that when the sediment used to build or remove a causeway is disturbed within the river system, fine sediments are deposited downstream. These fine sediments are believed to have an impact on pallid sturgeon eggs and river micro-ecology. This belief lacks research data to support the speculation; however, research has been conducted on temporary structure construction and removal practices in coastal river systems, which are influenced by the ebb and flow of ocean waters, the temperature of ocean waters, and the salinity of ocean waters.

Temporary structures that have been researched include dikes, causeways, dams, and wharves that are often intended to control the impacts of tidal waters to inshore lands. According to Wells (1999) the unintended impacts of building and/or removal of a temporary structure are often negative. These negative impacts include reduced lengths of tidal rivers, reduced movement of saltwater, change in hydrodynamics of the river, severe sedimentation, reduced nutrient transfer, and interference with movement of fish. On the other hand, removal of temporary structures can have beneficial results. Wells did not cover the impacts caused by removal of temporary structures (i.e. causeways), focusing on the benefits of removal of the structures. A causeway was removed from the main channel of the Sheepscot River of Coastal Maine to enhance the dilution of heated effluent from an electrical generation plant (McAlice & Jaeger Jr., 1983). McAlice and Jaeger (1983) found that the salinity levels returned to a more natural level and the river was allowed to return to historical flow. Due to the current lack of information on the affects of temporary structures on riverine ecology, Wells (1999) suggests that state and federal agencies work to strengthen current data on the impacts on temporary barriers, and to determine the effects of building and removal of these structures.

Although the use of temporary structures in estuaries is not identical to the use of these structures in bridge building and repair inland (i.e. NDOR's usage of a causeway), similarities exist that allow for extrapolation of these data. The goal of this study is to compare sampling methods that could be used to extract a sediment core that can be studied to determine the impacts of causeway installation and/or removal on inland rivers. Faulty sampling collection methods are often the cause of the largest amounts of error in riverine sampling, including sediment and water sampling (Martin, Smoot, & White, 1992).

I hypothesize that the vacuum type probes (Swanson, 1978), described further within *Methods*, will extract the best consolidated sample from both sandbar and river bed within the Little Blue River when compared to the other methods. It is likely that using a split spoon and tapered end sampling probes will not suffice in extracting a sediment core, as sampled sediment will likely wash away while pulling the probe through the water column.

Methods

Due to a lack of current bridge work on local rivers and the level of the Platte River at the time this study is conducted, this study will focus sampling methods on the Little Blue River. The Little Blue River is located in the Big Blue River Basin (Basin), which is mainly an agricultural watershed. Of the four rivers (Big Blue, Little Blue, West Fork of the Big Blue, and the Black Vermillion River) within the Basin, the Little Blue carries roughly 36 percent of the mean annual flow of the Big Blue (Franti, Devlin, Rice, & Roeth, 2000). An ideal study would be conducted on a causeway that was built and then removed on the Platte River within the last five years.

To develop a protocol that will provide reliable riverine sediment sampling, five sampling methods were evaluated, vacuum type probes and non-vacuum type probes (Photo 1). Non-vacuum type probes include the following: open faced probe, 2 inch tapered end push-type probe, and split spoon, (Photos 2, 3, and 6). Vacuum type probes include two sampling tools that are composed of a fixed tube, which is pushed roughly five inches into the sediment then filled with water from the top, and then the handle that also acts as the cap is attached forming a vacuum (Swanson, 1978). One is composed of one and one-half (1 ½) inch Polyvinyl chloride (PVC) with a removable three-quarter (¾) inch inner sleeve to allow for easy viewing of extracted sediment (Photo 4). The second vacuum type probe is composed of one inch threaded steel piping with a removable inner sleeve that is split half way up the sleeve to allow for easy viewing of extracted sediment (Photo 8). Finding the most effective riverine soil sampling method will assist in expanding the knowledge base on the impacts of construction and removal of causeways on river ecology. These data can then be used by NDOR, EPA, and USFWS to study the impacts of future built causeways.

Ideal sampling locations were selected according to the most recent construction and removal of a causeway within the Platter River system. This location (mile marker 427+20 to 427+50) is the Interstate 80 (I-80) crossing of the Platte River, roughly half way, between Lincoln and Omaha (Attachment(s) 1,2 & 3). Due to unseasonally high water and lack of open sandbar, sampling within the Platte River was determined unsafe.The sampling sites were moved to the Little Blue River because it carries similarly sized sediments as the Platte of coarse sand to gravel (Attachment 5). To assess the chosen sampling methods under different conditions, five samples were taken with each sampling method from two locations within the river system: within moving water and within an open sand bar. Samples were compared against each other to view which sampling method provides the best representation of intact soil profile from each area sampled. Each sample was handled and stored to allow later viewing of the dried sample. Photographs were taken throughout the process to illustrate the usage of each sampling method. Samples were measured by length and an average was calculated to represent each sampling method's capacity.

The sampling tools were acquired from the University of Nebraska – Lincoln and/or the Nebraska Department of Roads, as well as two fabricated Swanson-like tools. Swanson's sampling tool was fabricated to quantify the amount of waterfowl food within a wetland by using a steel pipe attatched to a plactic graduated cylinder with a hole drilled into the end to allow for a rubber stopper to be insterted once wetland sediment was penetrated (Swanson, 1978). Swanson's concept of using a tube and a created vacuum is proven to work within soft organic and inorganic wetlands.

Swanson mentions that this method is inoperable in coarse sand and gravel, likely due to the size of the graduated cycinder, so each Swanson-like tool for this project was fabricated with steel and Polyvinyl chloride (PVC) piping from a local hardware store. One was made using one inch threaded-end steel piping and the other from one and one-half inch PVC. Each tool will have their ends beveled down to allow for easier sediment penetration. Each will allow water to be poured into the top of the sampling tool once the tool (Photo 20) has been pushed into the soil. Each of these apparatus were sealed with a handle that acts as a stopper to create a vacuum when being pulled from the soil.

Results

Samples were taken within the Little Blue River (Attachments 4 and 5), SW ¼, SW ¼ SEC. 26 T06N R10W, on July 4, 2010 at 3:15 p.m. Weather was overcast, 0 – 5 mph wind speed, with a temperature of 78° Fahrenheit. River data was collected from the USGS Real-Time Water Data for Nebraska gauging station located roughly 20 miles downstream from the sample site (USGS, 2010). A 24 hour rain accumulation within the studied area was measured at 1 ½ inches (Table 6) that raised the river 1 ½ inches (Table 7). River current was estimated at 5 – 7 mph. River depth at deepest location was roughly 2 feet and samples were taken at 1 ½ feet. River turbidity was measured at 1 ½ inches. River is roughly 20 feet wide with 10 – 15 feet high banks. River is meandering with open sandbars visible on inside of River turns. River sediment consisted of saturated coarse gravel to coarse sand. Vegetation near the stream consisted mostly of forested wetlands, the canopy of which was dominated by green ash (*Fraxinus pennsylvanica*). Adjacent land consists of irrigated row crops. Open sandbar was the first and stream bed was second to be sampled for each sampling tool.

Two Inch Tapered End Probe

The 2 inch tapered end push-type sampler (Photo 3) proved to be the best method tested. A clay base was reached at a depth of 13.0 inches on the sandbar location and at a depth of 16.5 inches within the river. This depth was determined to be the maximum depth the probe could reach. Total length (inches) was recorded within Table 1 for Sample 1 through Sample 5. A percentage of sediment recovered was figured and recorded in Table 1 for each Sample 1-5. An average depth reach was recorded in Table 1 for both sandbar and river sampling locations, which equated to 12.00 inches on sandbar and 16.00 inches in stream. An average percent sample recovered was recorded in Table 1 for both sandbar and river sampling locations, which equaled 92.3% for sandbar and 97% recovered in stream.

	2" Tapered End Probe - Sandbar (Percent Recovered in Inches)	**2" Tapered End Probe - Stream Bed (Percent Recovered in Inches)**
Sample #1	**90.4%** (11.75/ 13.00)	**(100%)** 16.50/ 16.50
Sample #2	**100%** (13.00/ 13.00)	**(97%)** 16.00/ 16.50
Sample #3	**96.2%** (12.50/ 13.00)	**(95.5%)** 15.75/ 16.50
Sample #4	**84.6%** (11.00/ 13.00)	**(95.5%)** 15.75/ 16.50
Sample #5	**90.4%** (11.75/ 13.00)	**(97%)** 16.0/ 16.50
Percent Recovered/ Average Depth Reached	**92.3%** (12.00/ 13.00)	**(97%)** 16.0

Table 1: 2" Tapered End Probe. Clay base was reached at 13.0 inches on sandbar and 16.5 inches in stream

One and One-Half Inch Vacuum Type PVC Probe

The one and one-half inch Capped PVC with water vacuum method is similar to the method used by Swanson to sample within wetlands (Swanson, 1978). A clay base was not reached at either sandbar or stream locations. The total depth reached was determined unknown. Total length (inches) was recorded within Table 2 for Sample 1 through Sample 5. An average percent sample recovered could not be figured due to the unknown depth of clay base at both sampling locations, however, an average depth reach was figured for Samples 1-5 and recorded in Table 2. This average equated to 12.50 inches on sandbar and 8.50 inches in stream.

	Vacuum Type PVC Probe - Sandbar (Percent Recovered in Inches)	**Vacuum Type PVC Probe - Stream Bed (Percent Recovered in Inches)**
Sample #1	(12.50/unknown)	(8.50/uknown)
Sample #2	(12.00/unknown	(8.00/unknown)
Sample #3	(13.50/unknown)	(9.75/uknown)
Sample #4	(12.75/u unknown)	(9.00/uknown)
Sample #5	(13.50/ unknown)	(9.75/uknown)
Percent Recovered/ Average Depth Reached	**Unknown %** (12.50/unknown)	**Unknown %** (8.50/unknown)

Table 2: Vacuum Type PVC Probe. Clay base was not reached.

Split Spoon Probe

The Split Spoon Probe was next to be studied was heaviest compared to the group and did not allow for hand pushing, so a 6 lb. sledge hammer (Photo 25) was needed. A clay base was reached at a depth of 13.5 inches on the sandbar location and at a depth of 13.75 inches within the river. This depth was determined to be the maximum depth the probe could reach. Total length (inches) was recorded within Table 3 for Sample 1 through Sample 5. A percentage of sediment recovered was figured and recorded in Table 3 for each Sample 1-5. An average depth reach was recorded in Table 3 for both sandbar and river sampling locations, which equated to 12.00 inches on sandbar and 12.70 inches in stream. An average percent sample recovered was recorded in Table 3 for both sandbar and river sampling locations, which equaled 92.3% for sandbar and 97% recovered in stream.

	Split Spoon Probe - Sandbar (Percent Recovered in Inches)	Split Spoon Probe - Stream Bed (Percent Recovered in Inches)
Sample #1	**92.3%** (12.00/13.50)	**94.5%** (13.00/13.25)
Sample #2	**100%** (13.50/13.50)	**85.5%** (11.75/13.75)
Sample #3	**75.9%** (10.25/13.50)	**100%** (13.75/ 13/75)
Sample #4	**90.7%** (12.25/13.50)	**90.9%** (12.50/ 13.75)
Sample #5	**88.9%** (12.00/13.50)	**90.9%** (12.50/13.75)
Percent Recovered/ Average Depth Reached	**89.6%** (12.00/13.50)	**92.3%** (12.70/13.75)

Table 3: Split Spoon Probe. Clay base was reached at a depth of 13.5 inches on sandbar and 13.75 inches in stream

Open Faced Probe

The open faced probe (Photos 2, 9 &10) was the easiest of all sampling tools to be pushed into both sandbar and stream bed, requiring very little force. A clay base was reached at a depth of 13.00 inches on the sandbar location and at a depth of 15.00 inches within the river. This depth was determined to be the maximum depth the probe could reach. Total length (inches) was recorded within Table 4 for Sample 1 through Sample 5. A percentage of sediment recovered was figured and recorded in Table 4 for each Sample 1-5. An average depth reach was recorded in Table 4 for both sandbar and river sampling locations, which equated to 7.65 inches on sandbar and 0.00 inches in stream. An average percent sample recovered was recorded in Table 4 for both sandbar and river sampling locations, which equaled 58.9% for sandbar and 0.00% recovered in stream.

	Open Faced Probe - Sandbar (Percent Recovered in Inches)	Open Faced Probe - Stream Bed (Percent Recovered in Inches)
Sample #1	**69.2%** (9.00/13.00)	**0.0%** (0.00/15.00)
Sample #2	**51.9%** (6.75/13.00)	**0.0%** (0.00/15.00)

Sample #3	**53.8%** (7.00/13.00)	**0.0%** (0.00/15.00)
Sample #4	**57.7%** (7.50/13.00)	**0.0%** (0.00/15.00)
Sample #5	**61.5%** (8.00/13.00)	**0.0%** (0.00/15.00)
Percent Recovered/ Average Depth Reached	**58.9%** (7.65/13.00)	**0.0%** (0.00/15.00)

Table 4: Open Faced Probe. Clay base was reached at a depth of 13 inches on sandbar and 15 inches in stream

One Inch Vacuum Type Steel Probe

The one inch Capped Steel performed the poorest of all sampling methods studied. A clay base was not reached at either sandbar or stream locations. The total depth reached was determined unknown. Total length (inches) was recorded within Table 5 for Sample 1 through Sample 5. A percentage of sediment recovered was figured and recorded in Table 5 for each Sample 1-5 to be 0.00% for both sandbar and river locations due to 0.00 inches being recovered at each location. An average depth reach was figured for Samples 1-5 and recorded in Table 5. This average equated to 0.00 inches on sandbar and 0.00 inches in stream.

	Vacuum Type Steel - Sandbar (Percent Recovered in Inches)	**Vacuum Type Steel – Stream Bed (Percent Recovered in Inches)**
Sample #1	**0.0%** (0.00/unknown)	**0.0%** (0.00/unknown)
Sample #2	**0.0%** (0.00/unknown)	**0.0%** (0.00/unknown)
Sample #3	**0.0%** (0.00/unknown)	**0.0%** (0.00/unknown)
Sample #4	**0.0%** (0.00/unknown)	**0.0%** (0.00/unknown)
Sample #5	**0.0%** (0.00/unknown)	**0.0%** (0.00/unknown)
Percent Recovered/ Average Depth Reached	**0.0%** (0.00/unknown)	**0.0%** (0.00/unknown)

Table 5: Vacuum Type Steel Probe. Clay base was not reached. Probe did not extract any sample.

<u>Discussion</u>

Two Inch Tapered End Probe

The 2 inch tapered end push-type sampler (Photo 3) proved to be the best method tested. The large circumference of the tool and thin wall of the pipe allowed for a large core to be extracted easily from the ground. The core taken was also easy to be extracted from the probe – simply tapping the end of the probe on the work platform allowed the sample to slide out. This tool also allowed the operator to place a hand at the end of the tool and "cap" the end while pulling up sample (Photo 16). Tool was easiest to push within river bed (Photo 15) and reached clay bed at both sandbar (Photos 13 and 14) and river bed locations. Due to the ease of use, weight of probe, and results this probe was determined satisfactory for sampling both sandbar and river locations.

One and One-Half Inch Vacuum Type PVC Probe

The one and one-half inch vacuum type PVC probe is similar to the method used by Swanson to sample within wetlands (Swanson, 1978). The 1 ½ inch Capped PVC on open sandbar (Photo 19) required considerable force to push, but could not reach a depth of more than 13.5 inches on sandbar and 9.75 inches in river (Table 2). When sampling within the river (Photo 22) this method pushed considerably easier than on the sandbar, but the resulting average of sediment extracted did not support this. Extracting the probe from the ground proved to require little force, but extracting the core from the probe was cumbersome. The sample had to be pushed out from the opposite end with a stick. Water was poured into the end of the sampling tool to create a vacuum on both sandbar and riverbed (Photos 20 and 21), however since the sediment being sampled was coarse and saturated the vacuum likely failed. The probe did not allow for easy extraction of the sediment for study, so it was determined that this probe is inadequate for the uses of sampling within a riverine system.

Split Spoon Probe

The Split Spoon Probe was next to be studied was heaviest compared to the group and did not allow for hand pushing, so a 6 lb. sledge hammer (Photo 25) was needed. This method reached the clay base just as the better performing 2 inch tapered probe, but was cumbersome while doing so. Considerable force was required to drive the probe on both sandbar and riverbed (Photos 25 and 27), but pulling the probe up required little force. Extracting the sediment core from the probe proved difficult as well. Splitting the split spoon designed required the use of the sledge hammer again along with a long screwdriver. Due to the weight and need for a sledge hammer to drive the probe in it was determined inadequate for the uses of sampling within a riverine system.

Open Faced Probe

The open faced probe (Photos 2, 9 &10) was the easiest of all sampling tools to be pushed into both sandbar and stream bed, requiring very little force. Riverbed testing (Photo 11) proved that this probe is inadequate to pull sample from through the water column location. Past 15 inches, a clay base was reached with this sampling tool, but the clay cap recovered from the sediment did not hold the coarse sand and gravel in the probe. It was determined that this probe is inadequate for the uses of sampling within a riverine system.

One Inch Vacuum Type Steel Probe

The one inch vacuum type steel probe performed the poorest of all sampling methods studied. However light and easy to handle, this method proved to be hard to push into both the sandbar and riverbed. Each attempt at taking a sample at both sandbar and stream locations this probe failed to push into the ground – likely due to the small diameter of the probe end. Failing to extract any sample (Table 5) this probe was determined to be inadequate for the uses of sampling within a riverine system. Along with sampling with each probe, a soil pit was dug at the sandbar sampling location with a spade in attempt to view a clear soil profile (Photos 33 and 34). The soil pit proved that the sediment was highly saturated at a depth of less than three inches.

It was hypothesized that Swanson's vacuum concept would have produced the best results while sampling, but this was not the case. I assume that the water column was spread throughout both the sandbar and the stream bed due to the coarseness of the sediment. The principle of the vacuum simply would not work with the amount of saturation present in the sediments sampled, proved by digging a soil pit (Photos 33 and 34). Swanson's method was proven to perform well in a wetland setting that likely harbored soil that was more compacted, so saturation did not hinder the method.

Given the opportunity to continue researching an efficient sampling method, I would likely build upon the 2-inch Tapered End probe. First I would have acquired a butterfly valve (i.e. one way valve) attachment to the probe, which would open when pushed into the sediment and close when pulled out. I would like to perform the same tests with a similarly built probe, but fabricate the probe to allow the application on Swanson's vacuum method as well.

Methodology of sampling could be expanded greatly to provide a more scientific approach. If time would have permitted, incremental transects (i.e. 50ft, 200ft, 500ft, ¼ mile, ½ mile, ¾ mile, 1 mile) would have been determined up and downstream of an actual causeway location, shortly prior to and shortly after construction (Attachment 6). These transects should then be monitored over time at a pre-determined set of locations sampled along each transect. Identification of a sampling method that provides a superior method, can be executed by an individual biologist, that is portable, and could be used to obtain multiple sediment samples on both sandbar and riverbed would be crucial when sampling as described above, because there may be transects completely composed of sandbar and others of open water. Assumptions aside, I suggest that the USFWS and the EPA join with NDOR to study the impact of sediment deposition on river ecology through the building and removal of causeways. NDOR and the EPA should be responsible for implimenting the plans set above to study sediment depostion, while the USFWS study the possible impacts on pallid sturgeon egg production. The USFWS could also implement that causeways are not to be in the river when pallid sturgeon are in spawning season.

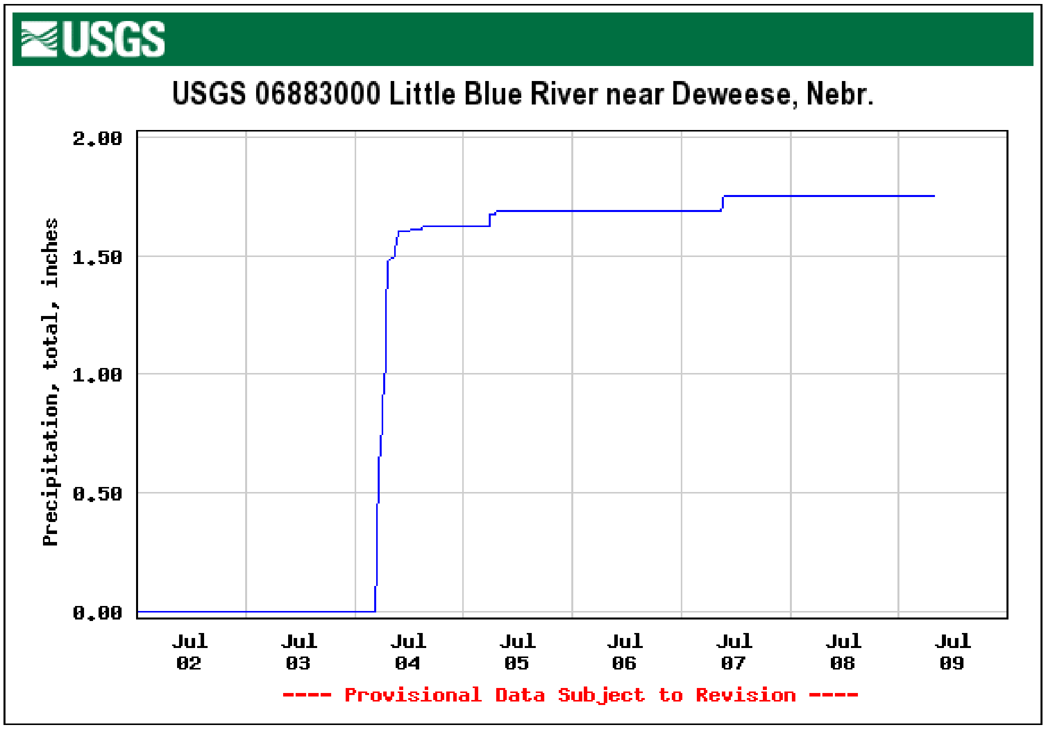


Table 6: 24 hour rainfall event prior to sampling

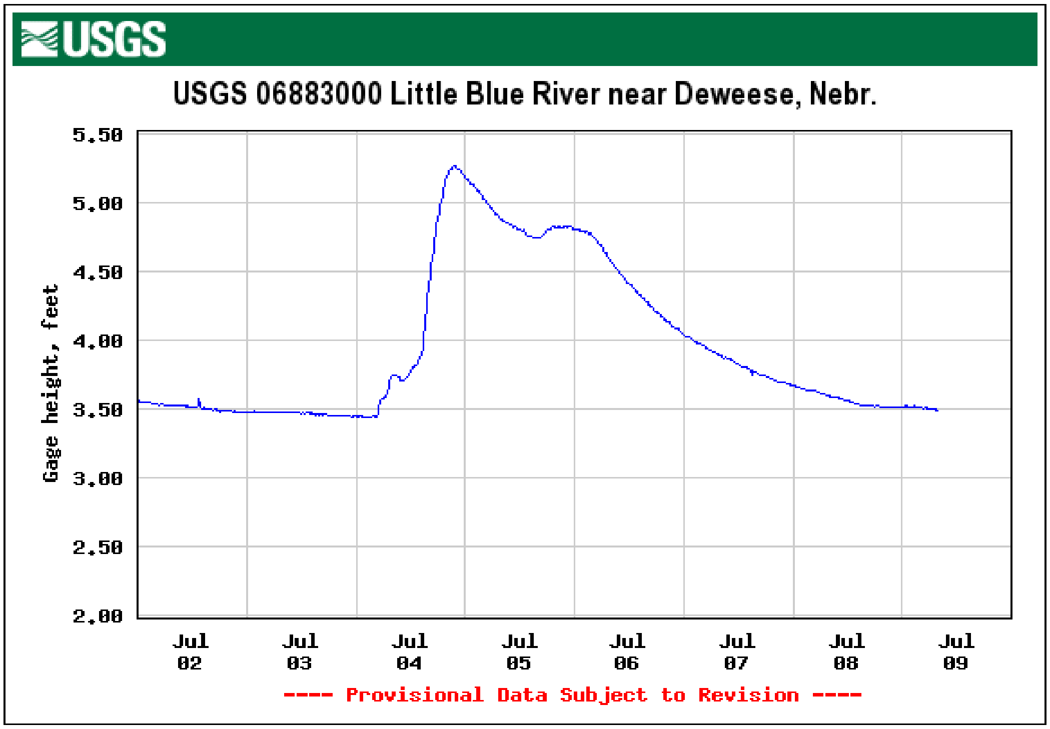


Table 7: Stream height at time of sampling

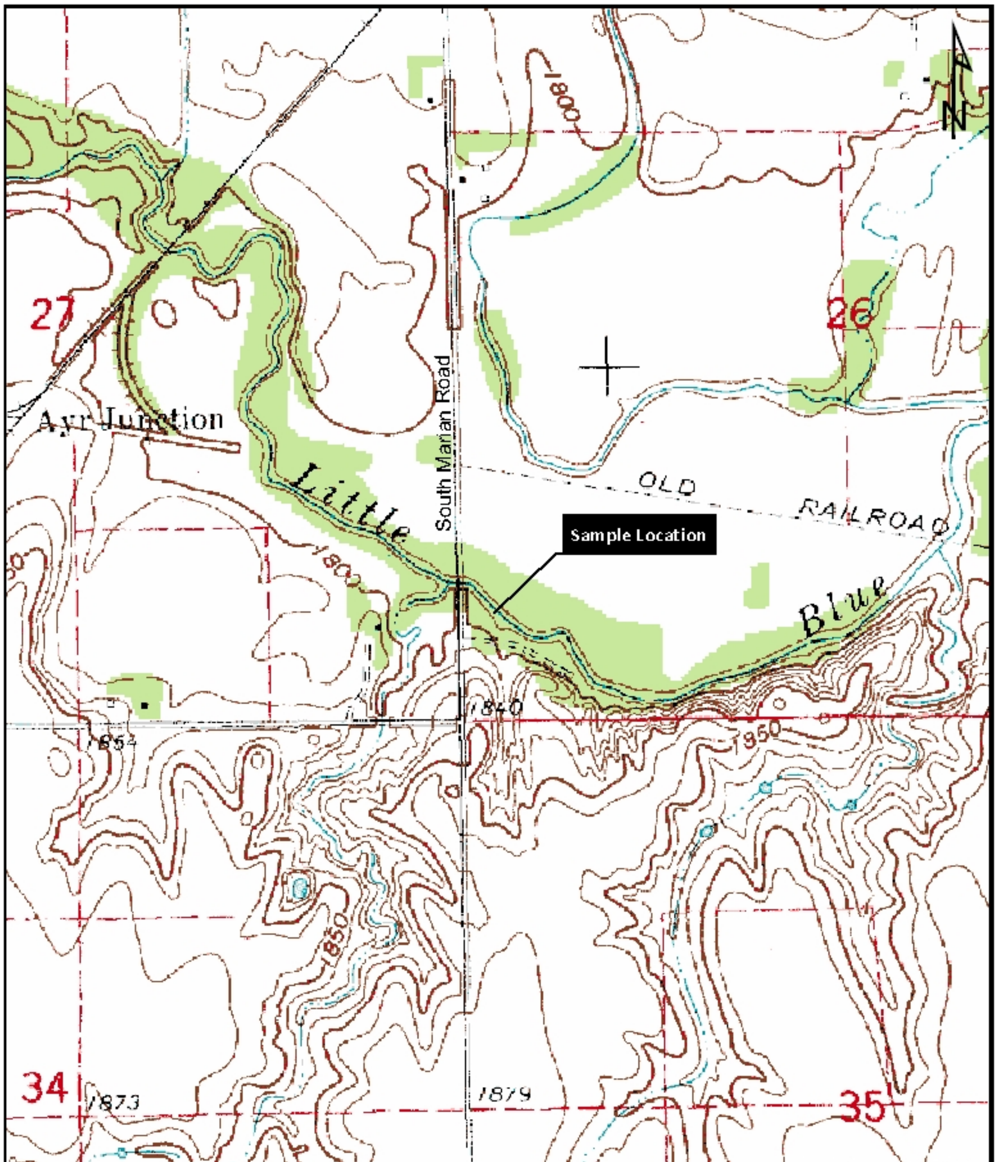

N
Data: NDOR Aerial: Google Earth 2007
University of Nebraska Lincoln
Platte River Bridge
Interstate 80
Pre Causeway Construction (2003)
Attatchment 1
Site Location
Cass/ Sarpy County


N
Data: NDOR Aerial: Google Earth 2007
Platte River Bridge
Interstate 80
Causeway In Place (2006)
Attatchment 2
Site Location
Cass/ Sarpy County

University of Nebraska Lincoln

Platte River Bridge
Interstate 80
Post Causeway Removal (2009)

Attachment 3
Site Location
Cass/ Sarpy County



University of Nebraska Lincoln

Little Blue River

Site Location

Attatchment 4

USGS Topographic

Adams County


N
South Marian Road
Sample Location
Little Blue River
Data: NDOR Aerial: Google Earth 2007
Little Blue River
South Marian Road
North East of Ayr, NE
Attatchment 5
Site Location
Adams County

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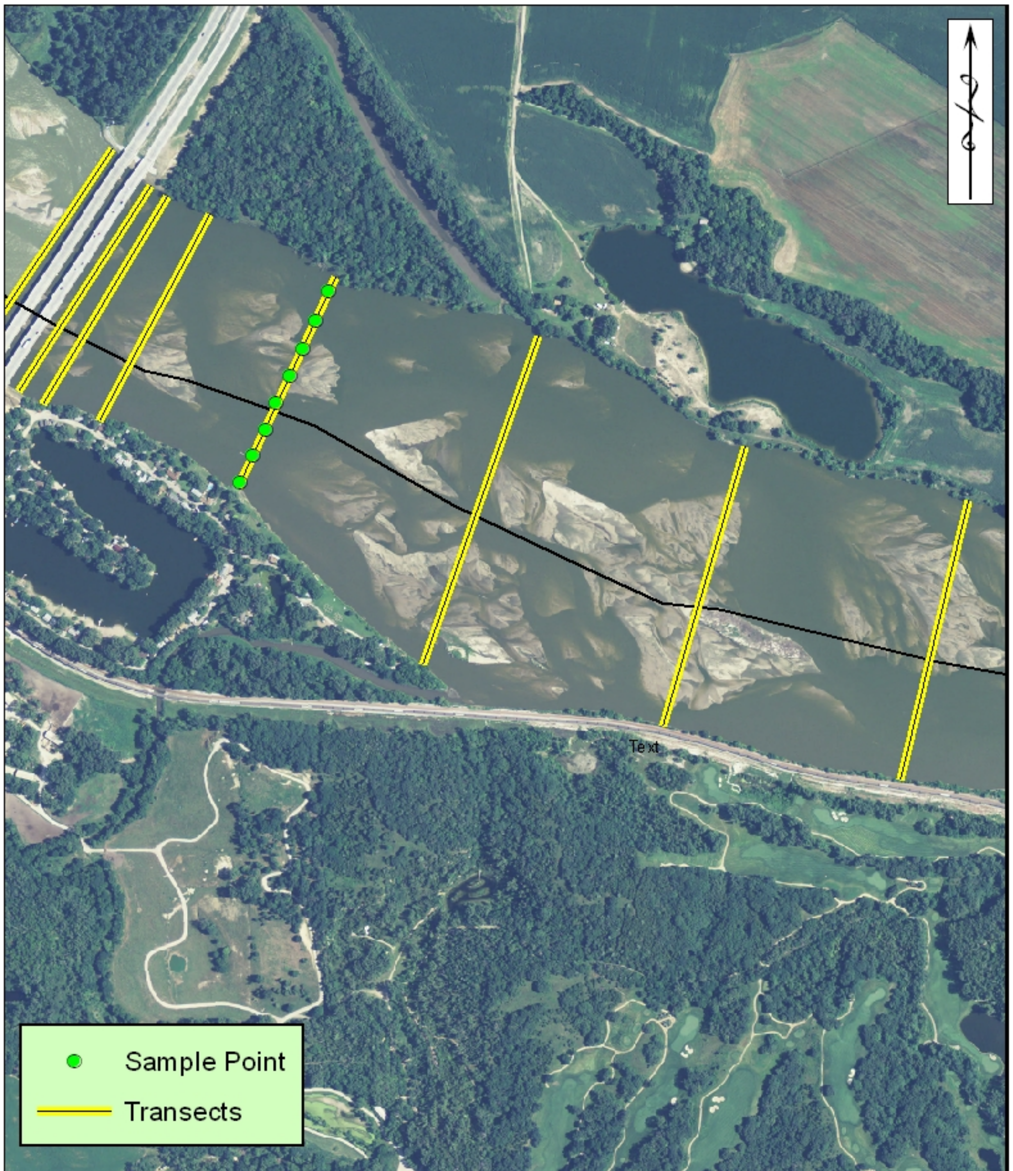

University of Nebraska Lincoln	**Platte River Bridge** **I-80** Sarpy/ Cass County	**Attachment 6** **Ideal Sampling**

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