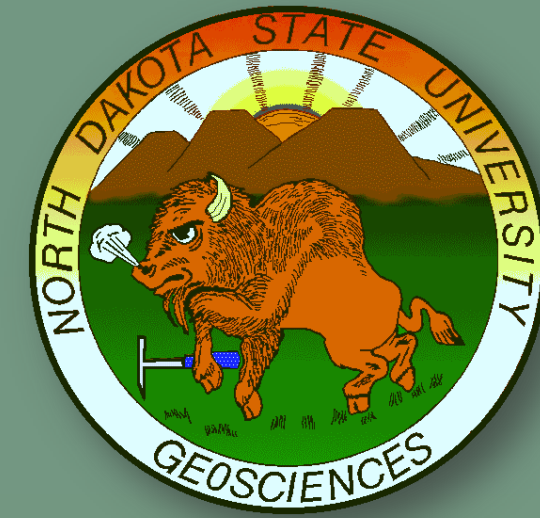
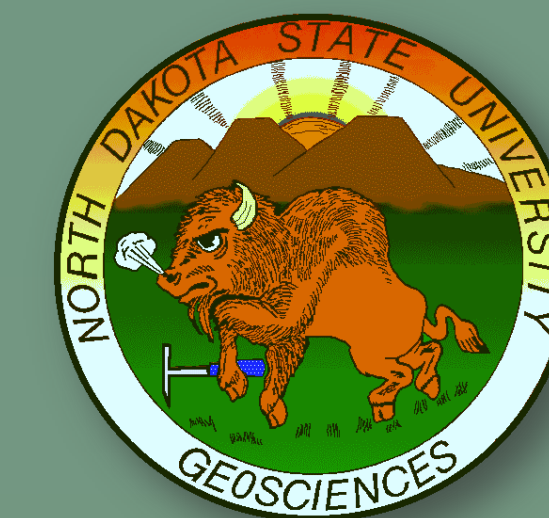


Effect of Freeze/Thaw on Bluff Erosion in South Central Minnesota

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Abstract

Studies have indicated that erosion rates in Minnesota River watershed have increased significantly in last 150 years and the source of sediments in the rivers has shifted from agricultural farmland to river bluffs. As a result bluff erosion is a leading cause of high sediment loads in the Le Sueur River watershed in south central Minnesota. High erosion rates threaten existing infrastructure and the resulting turbidity can lead to loss of biodiversity. It is believed there are primarily three processes that influence bluff erosion: under-cutting, sapping, and freeze/thaw. For this study we investigate the process of freeze/thaw and how it affects the bluff erosion rates in the Le Sueur River watershed. Freeze/thaw processes have been shown to disrupt soil structure making soils more easily eroded. To study this effect on bluffs in south central Minnesota, four sites have been selected, based on their aspect and degree of consolidation. The temperature of the bluff face is measured at varying depths, one closer to surface (approx. 6 inches) and another deeper (approx. 12 inches). The east and west facing bluffs, which are over consolidated, have four sensors on them two measuring temperature, one measuring soil moisture, and one measuring relative humidity and air temperature. The north-east and south-west facing bluffs that are normally consolidated have eight sensors on them four measuring soil temperature, two measuring soil moisture, one measuring relative humidity and air temperature and one measuring radiation. The sensors were deployed in the middle of October 2013 and will be out in the field until at least the middle of May 2014. The selected sites were scanned using Terrestrial Laser Scanning (TLS) initially and will be scanned at four additional times during this period. Partial data obtained from the sensors on January 18th 2014 show that this area experienced at least 38 freeze/thaw cycles. TLS data collected at this time reveal the erosion that has resulted from these temperature changes.

Materials and Methods

- To study this effect on bluffs, four sites have been selected, based on their aspect and degree of consolidation.
- The temperature of the bluff face is measured at varying depths, shallow and deep.
- The bluffs have 4 to 8 sensors on them measuring temperature, soil moisture, relative humidity and radiation
- The sensors were deployed in the middle of October 2013 and will be out in the field until at least the middle of May 2014.
- The selected sites were scanned using Terrestrial Laser Scanning (TLS) initially and will be scanned at four additional times during this period.



Sites	LS-8216	LS-7756	LS-8989	MP-7706
Consolidation	Over	Normal	Over	Normal
Aspect	East	North East	West	South West
Shallow Sensor	13.97 cm	7.62 cm	10.79 cm	12.7 cm
Deep Sensor	20.31 cm	22.86 cm	25.4 cm	17.78 cm

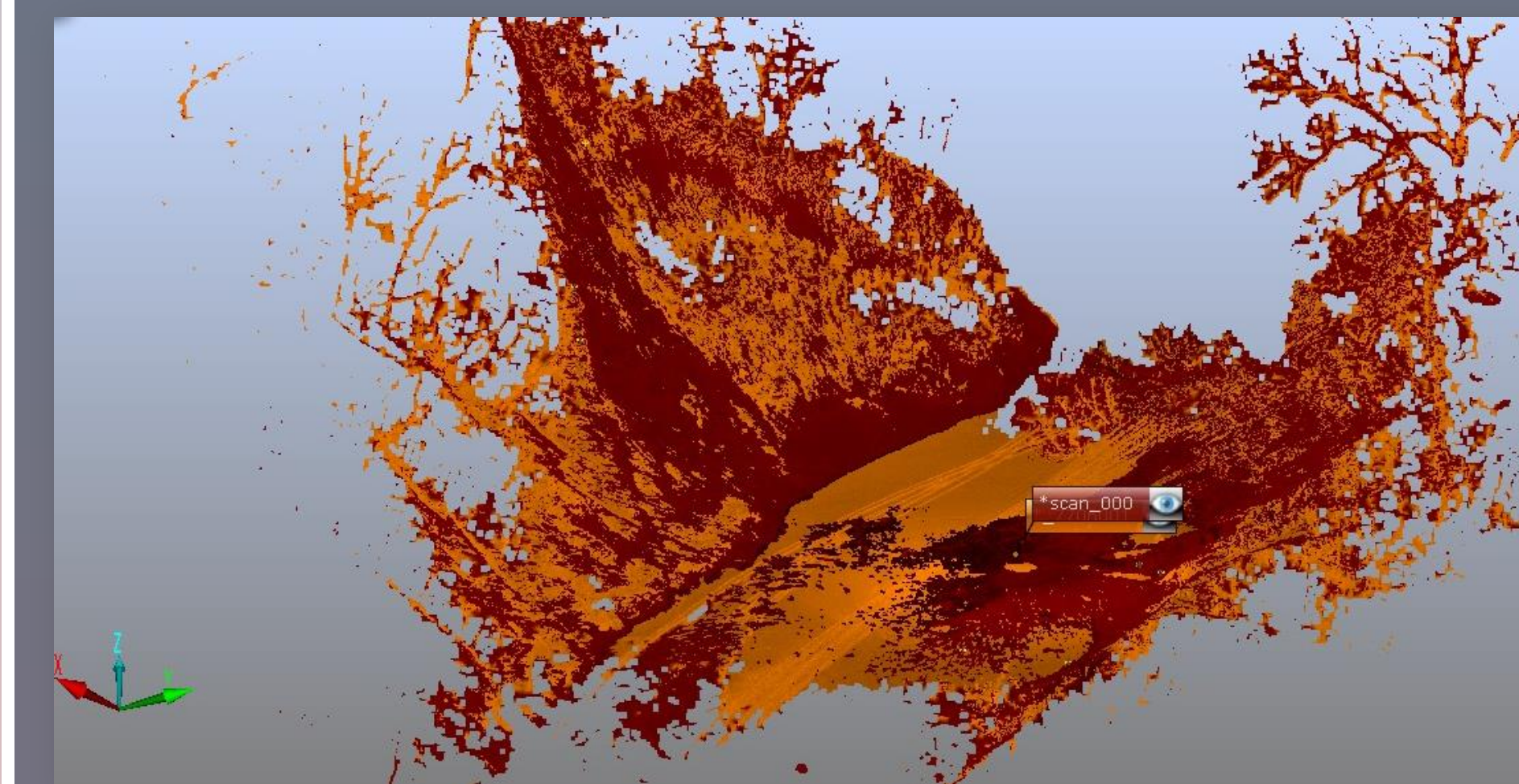
1: Terrestrial Laser Scanner setup for scanning
 2: Sensor setup in one of the bluff
 3: Point cloud generated after TLS scanning
 4: Upstream section of LS-7756 in Le Sueur River

Further Work

- Scan the bluffs 2 additional times.
- Process and analyze the TLS scans.
- Analyze the results using Geomorphic Change Detection (GCD) tool in ArcGIS.
- Compare the results with sensor data obtained from the field.



Colorized point cloud of MP-7706 TLS Scan



TLS data being processed in Faro Scene 5.2

Background

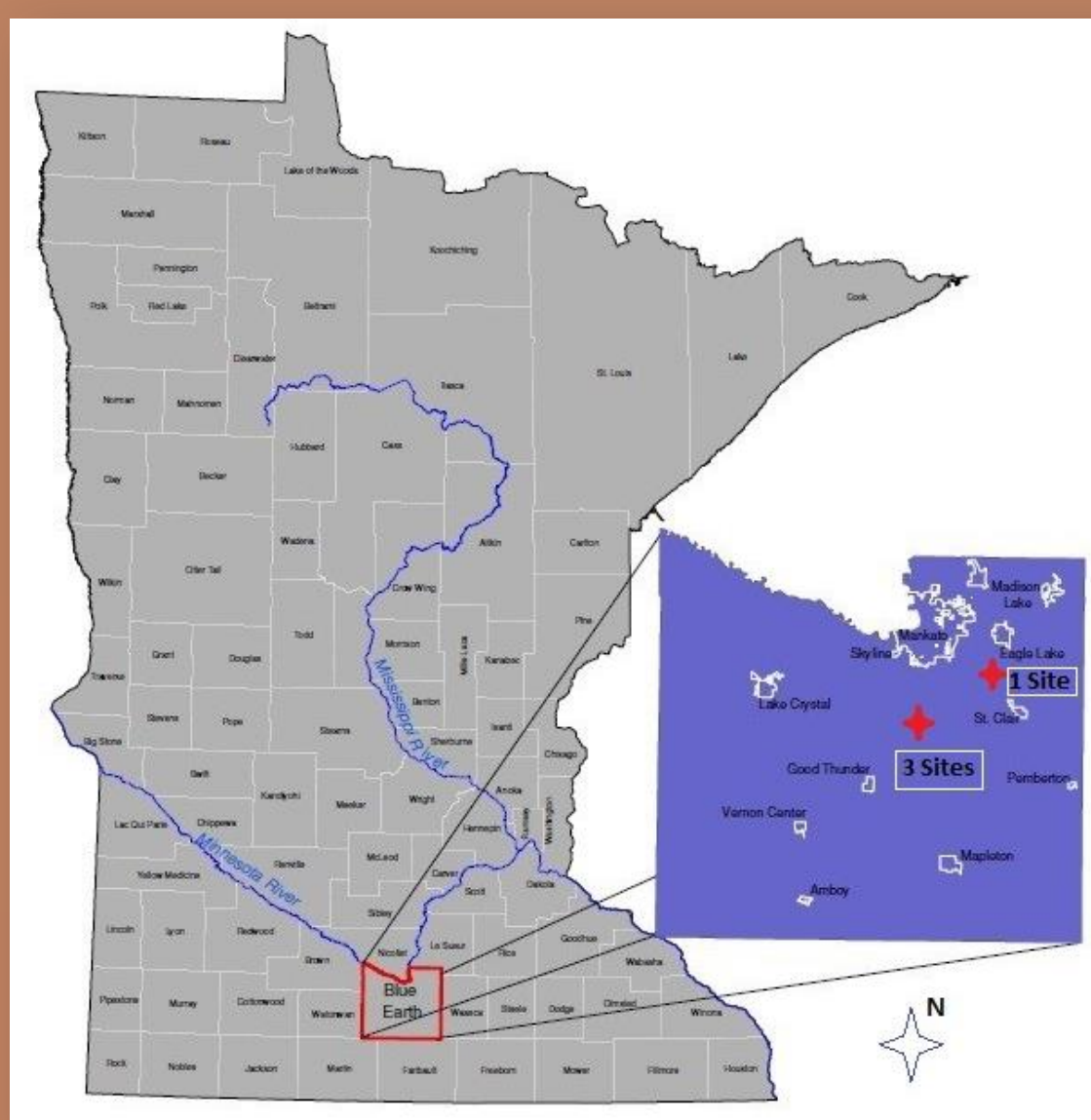
There are primarily three processes that influence bluff erosion:

- under-cutting
- sapping
- freeze/thaw

We investigate the process of freeze/thaw and how it affects the bluff erosion rates in the Le Sueur River watershed. Freeze/thaw processes have been shown to disrupt soil structure making soils more easily eroded.

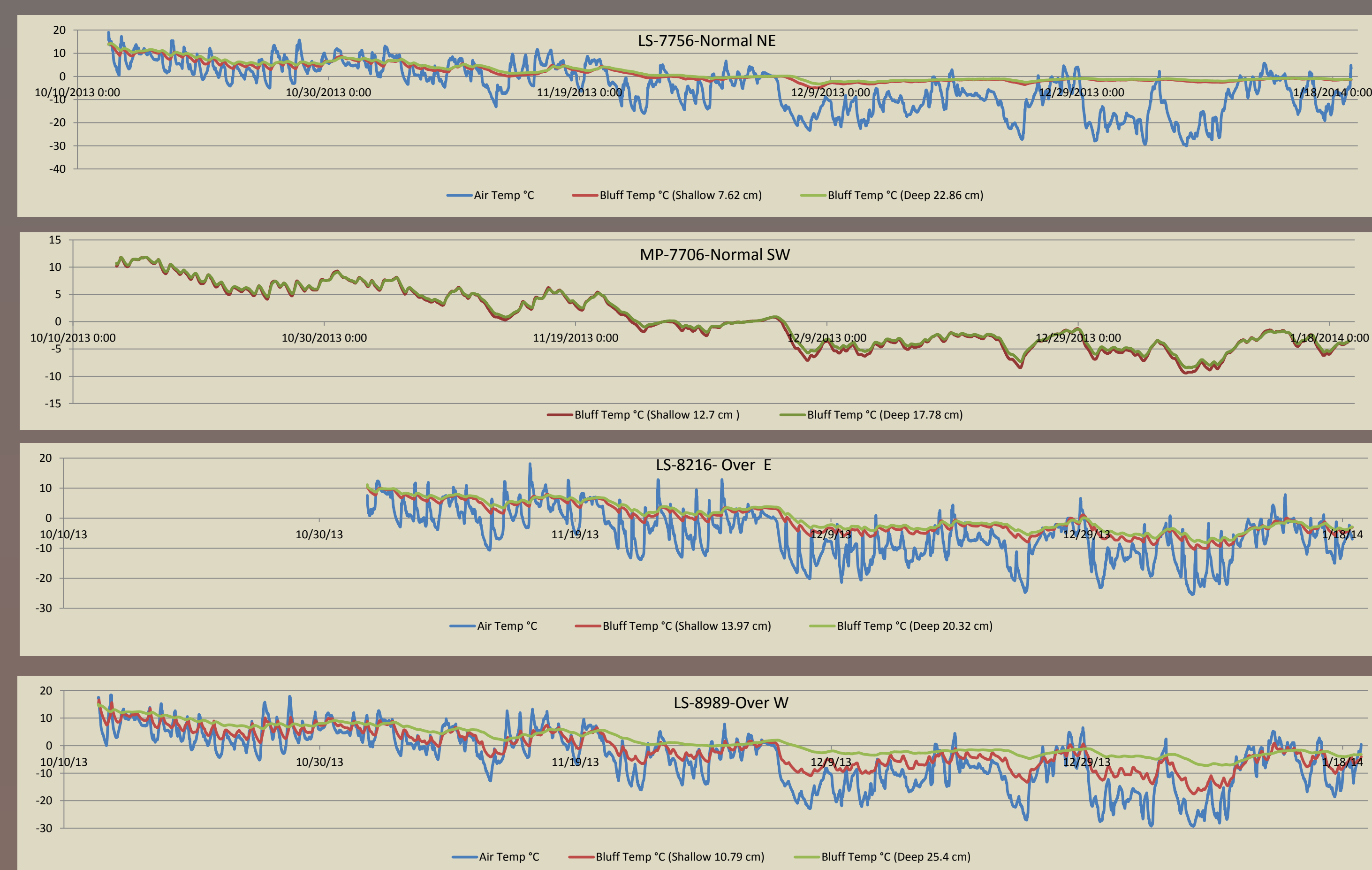
Site Location

The research sites are located in Blue Earth county in Minnesota, within the Le Sueur watershed. There are 3 sites south of Mankato and one south-east of Mankato.

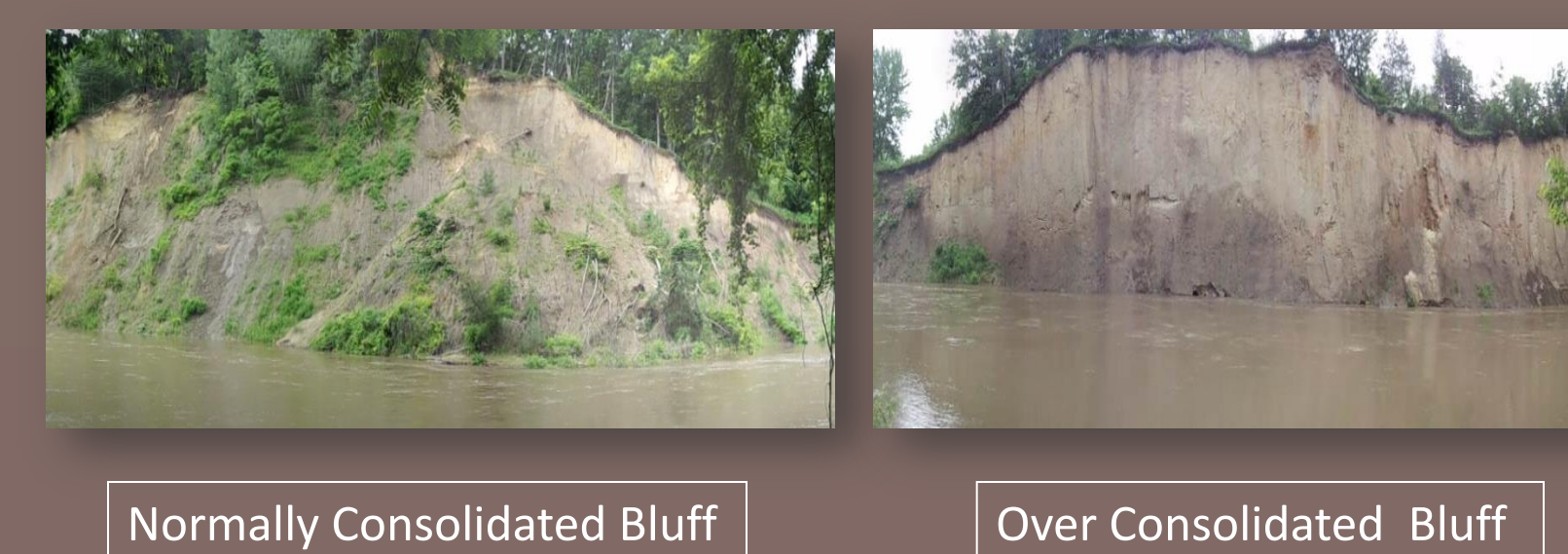


Preliminary Results

- The analysis of the preliminary data indicates that the area went through at least 38 freeze/thaw cycle.
- There is a correlation between west facing bluff and number of freeze/thaw cycles.
- Preliminary results also indicate that the over consolidated bluff went through more freeze/thaw cycles.



Sites	LS-8216	LS-7756	LS-8989	MP-7706
Consolidation/Aspect	Over/East	Normal/NE	Over/West	Normal/SW
Air freeze/thaw cycles	39	38	42	No Data
Shallow Cycles	9	3	12	4
Deep Cycles	1	1	1	3



Normally Consolidated Bluff

Over Consolidated Bluff

Expected Outcome

We expect to see a relation between cycles of freeze/thaw and following parameters:

- Aspect
- Consolidation
- Rate of erosion

Acknowledgements



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