Subaqueous Industrial Waste in WesternWisconsin Lakes: Reducing/ Redirecting the Dredged Materials from Landfills

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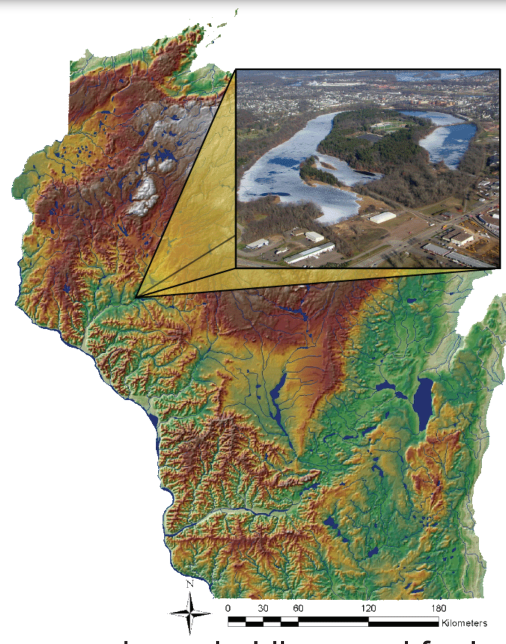
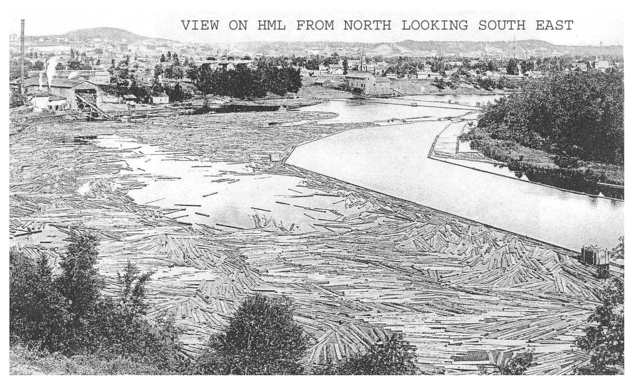
Abstract

Logging was an essential part of western Wisconsin's economy from the 1850s to the 1920s. The logging industry used Half Moon Lake (HML) in Eau Claire as a holding pond awaiting processing at sawmills along the lakeshore. During the logging era, industrial wastes such as bark, sawdust, and slabs, were dumped on top of a former natural lake bottom (fluvial gravels). Although the logging industry use of HML ceased decades ago, the effects of the logging industry on HML's water quality can still be observed today. The industrial waste has been hypothesized to be several meters thick throughout the lake. To investigate the geometry of the industrial waste, a low frequency (50 and 100 MHz) pulseEKKO ground penetrating radar (GPR) survey was undertaken. Radar stratigraphic analysis of the GPR lines allowed for areas of interest to be located and Vibra-Cored to extract sediment samples. To georeference all collected data, a Trimble proXR differential GPS was used. Volume calculations were determined from GPR profiles to create a bathymetric and thickness map of the organic waste in HML.

Background



Half Moon Lake (HML), located in the city of Eau Claire, west central Wisconsin, is presently in a eutrophic state. The abundance of vegetation growth is due to the lake's excess of phosphorus and organic matter that is probably a result of the logging era. Several ways to restore HML have been proposed and could include the removal of the industrial organic waste (dredging) but the exact volume and composition of this sediment is not known.

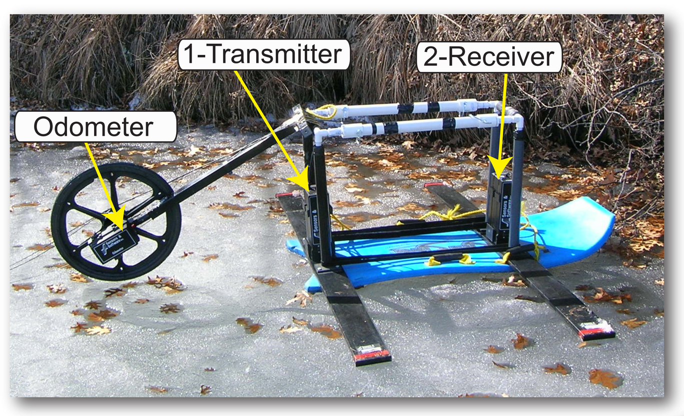


HML was used as a holding pond for logs awaiting milling at the numerous sawmills along the lake's shoreline. In the winter sawmills would deposit mounds of waste (bark, sawdust, and slabs) on the ice. As the ice melted the waste sank to the bottom of the lake. These practices of the logging era filled in several meters of sediment (organic waste) in some areas of HML.

One objective of this study is to estimate the volume of the industrial organic waste by locating, identifying, and mapping industrial organic waste in HML. The second objective is to reduce/redirect the amount of industrial organic waste that would potentially be land filled if HML were dredged (e.g. evaluate if composting is a viable option).

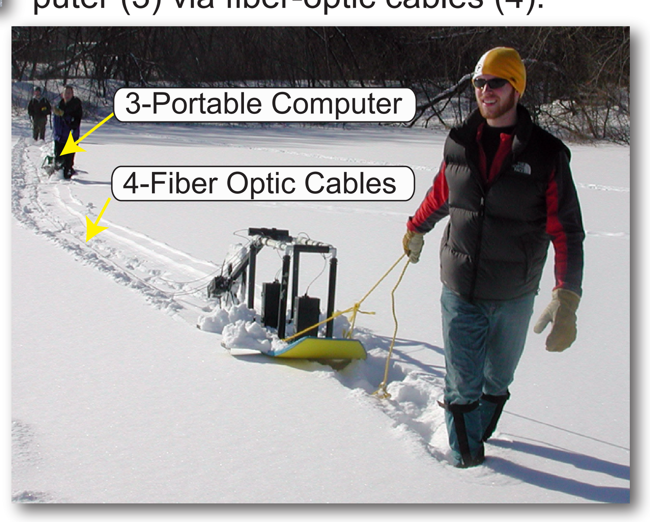
Methods

To investigate, map, and identify industrial organic waste in Half Moon Lake:
1) ground penetrating radar (GPR) was used to collect profiles of the industrial organic waste,
2) a Trimble ProXR GPS was utilized to map and georeference GPR transects,
3) a vibra-core was used to ground truth GPR transects and extract lake sediment cores,
4) a sediment thickness map of industrial organic waste was created, and
5) industrial organic waste was removed in small quantities from HML to evaluate if composting would be a viable alternative to land filling the industrial organic waste if removed.

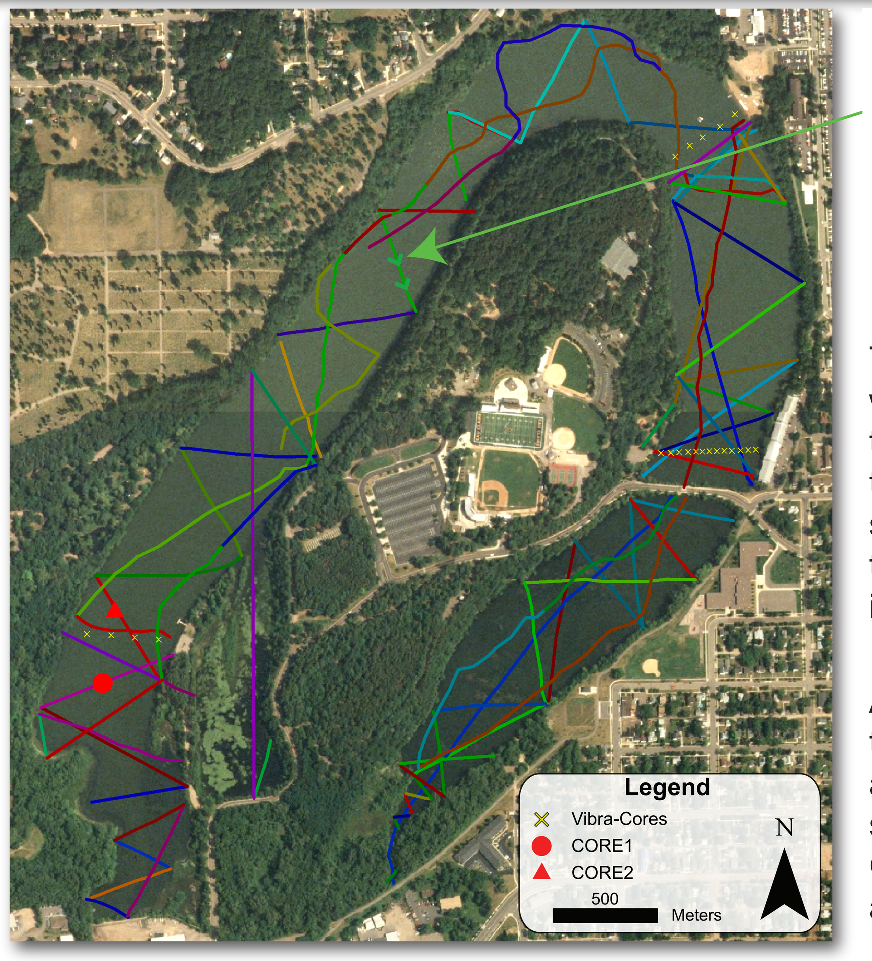


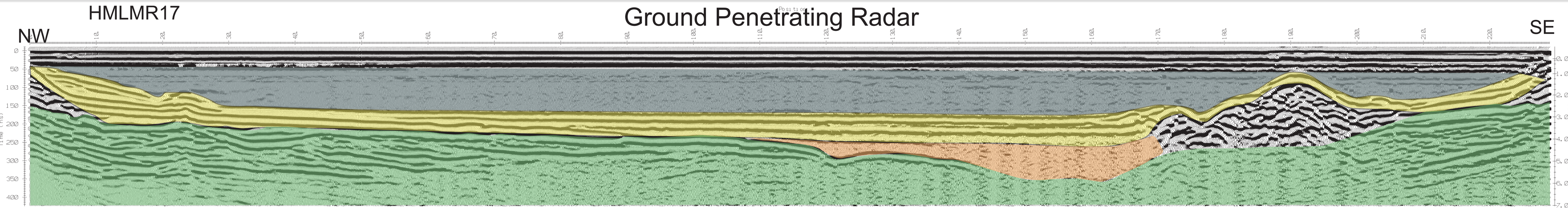
GPR operates by transmitting electromagnetic (EM) pulses into the subsurface and measuring the return time. When the transmitting antennae (1) sends electromagnetic (EM) waves into the ground the waves reflect from layers in the subsurface (e.g. subaqueous deposits) and are picked up by the receiving antennae (2). The digital information travels to the computer (3) via fiber-optic cables (4).

For this project a pulseEKKO 100 GPR system with 100 MHz antennae was used to collect data. In order to efficiently collect data over ice, the GPR antennae were pulled on a sled at a constant rate while an odometer triggered traces to be collected every 0.2 m. In optimum conditions, using this setup one hundred meters of data could be collected in approximately 15 minutes.



Mapping Industrial Organic Waste





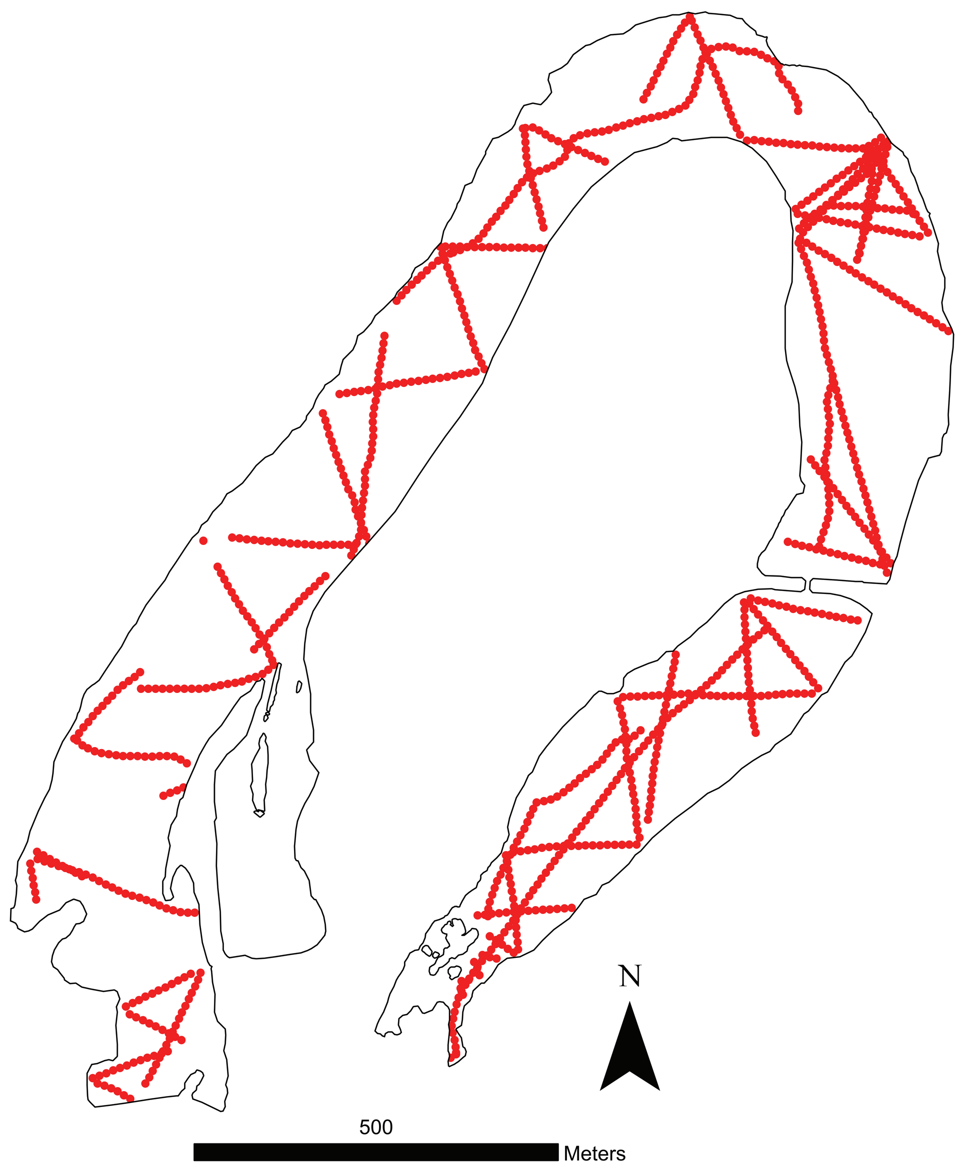
The GPR profile (above) provides an example of how the GPR transects were interpreted for determining depth points needed to create the sediment thickness map. The bathymetric depth (depth to sediment) is illustrated by the shaded blue section. Below the blue shaded section, continuous to semi-continuous horizontal reflection patterns are interpreted as the horizontally bedded industrial organic waste and are shaded yellow. Based on the interpretation of the GPR profiles and vibra-coring, the thickness of the industrial organic waste in HML ranges from 0.5 meters to 3.4 meters. The area below the industrial organic sediment can be differentiated by the continuous to semi-continuous horizontal and dipping reflection patterns, interpreted as bedrock (green). The area below the industrial organic waste but above the interpreted bedrock is a reflection free zone and is interpreted as fluvial gravels (shaded orange). The shaded orange region was ground truthed using a vibra-corer and fluvial gravels were encountered.

A GPR coverage map (left) displays the spatial distribution of GPR transects on HML. The map shows a total of 114 GPR transects that were collected and subsequently georeferenced with a Trimble ProXR GPS. In addition, two vibra-core locations as well as test core locations are located on this map.

All 114 GPR transects (excluding GPR antennae testing during summer 2005) were mapped and georeferenced using a Trimble ProXR GPS.

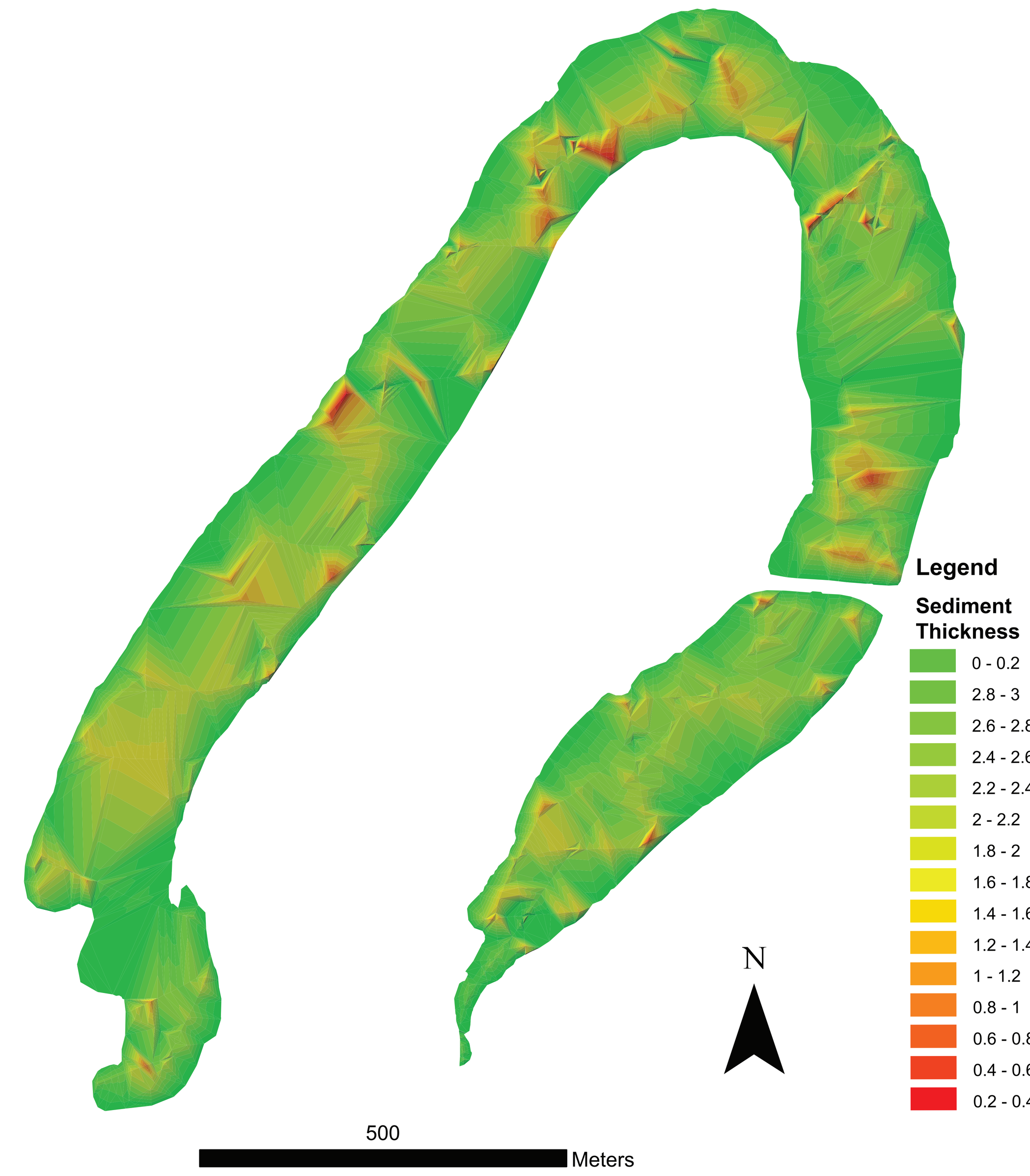
Sediment cores were retrieved using a vibra-corer (left) that was used during the winter when ice created a solid platform from which to work from. The aluminum irrigation pipes were vibrated into the sediment using a cement vibrator.

GPR Depth Points



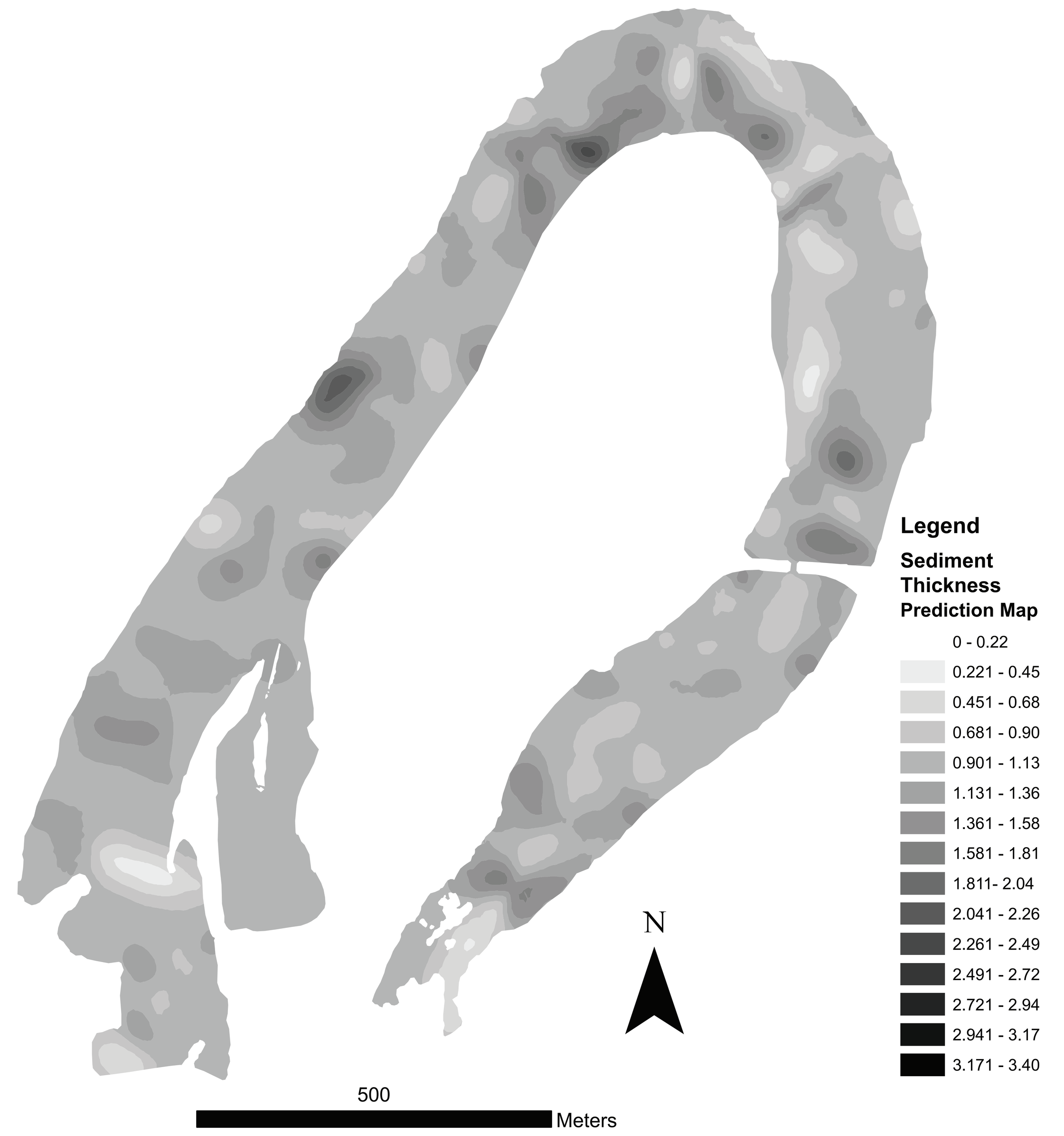
After radar stragraphic analysis and ground truthing of the GPR transects a map showing 1062 depth points (above) were interpreted from the 64 usable GPR transects and then entered into Excel and joined to the matching GPS file. The remaining GPR profiles were 1) collected in the summer and could not be used due to inaccurate GPS positions or 2) several profiles and antennae frequencies were not of high enough resolution to differentiate the industrial organic waste.

Sediment Thickness Map-TIN



The industrial organic waste sediment thickness map was created by using a Triangulated Irregular Network (TIN) analysis. The thickest industrial organic waste layers are on the northwest portion of HML which correlates well with the documented sawmill locations. Using the TIN derived sediment thickness map, a volume of 412,526.18 cubic meters of industrial organic waste is estimated.

Sediment Thickness Map-Kriging



Another interpolation tool in ArcMap (Kriging) was used to create a cartographically pleasing sediment thickness map. The map shows that the majority of the lake has at least 1 meter of industrial organic waste on the lake bottom. The Kriging map better illustrates the spatial variation with the quantity of interpolated GPR transects obtained on HML.

Composting

If the industrial organic waste was to be dredged, one of the objectives of the project is to evaluate if composting would be a viable alternative to land filling the dredged sediment. To study this problem, several cubic meters of industrial organic waste were removed from HML using the City of Eau Claire's weed harvester (left).

Half Moon Lake Sediment Sample 1		
Isotope	Concentration in ng/g (ppb)	Standard Deviation
Pb206(MR)	32115.296	167.889
Pb208(MR)	35419.165	218.572
Zn66(MR)	107500.1	544.755
Zn68(MR)	114419.778	593.419
Mn55(MR)	463946.103	2961.615
Fe56(MR)	8951392.811	71817.473
Fe57(MR)	9118326.786	88295.969
Cu63(MR)	63863.33	441.615
Cu65(MR)	57668.319	267.188
Cr52(MR)	23744.163	182.586
Cr53(MR)	21318.213	267.43
As75(HR)	5937.531	88.178

*Samples one and two were dried prior to analysis. Concentrations may be higher due to preconcentration effect of water evaporation.
** Samples three and four were analyzed as is.

Summary Results	
Cadmium	200 ppb
Lead	17 ppm
Zinc	30 ppm
Iron	4500 ppm
Copper	30 ppm
Manganese	168 ppm
Arsenic	3 ppm
Iron	9118 ppm

Two different samples of the lake sediment were allowed to compost over the summer. The first sample contained the industrial organic waste mixed with some curly pond leaf. The second sample contained just the organic waste. Both samples contained large woody debris and rubbish. The samples were turned weekly and allowed to compost over the summer.

The industrial organic waste was tested for heavy metal concentrations. There were elevated amounts of Fe present in the samples (originating from groundwater). There were also notable amounts of Cadmium, Zinc, Lead, and Copper but none of the heavy metal concentrations exceeded EPA regulations for health implications..

Summary

1) GPR, GPS, and vibra-coring were utilized to locate, identify, and map industrial organic waste in HML.
   a) 114 GPR transects were collected with 1026 depth points were interpreted to create the sediment thickness map.
   b) Half Moon Lake has 0.5-3.4m of organic rich sediment throughout the lake
   c) The total estimated volume of industrial organic waste is 412,526.18 cubic meters.
2) Samples of the organic waste were collected and allowed to compost over the summer. The results of compost viability are in progress.
3) This innovative method of creating a sediment thickness map can be applied to other lakes with similar problems.

Acknowledgements

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