UW Extension
University of Wisconsin-Extension

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

3817 Mineral Point Road
Madison, WI 53705-5100
Tel • 608.262.1705
Fax • 608.262.8086
Wisconsin Relay • 711
WisconsinGeologicalSurvey.org

KENNETH R. BRADBURY
DIRECTOR AND STATE GEOLOGIST

March 9, 2016

Town of Lincoln Hydrogeological Characterization – Kewaunee County, Wisconsin – All interested parties

Re: Brief description of the project, field methods employed, and the use of field data

Dear interested party,

The Wisconsin Geological and Natural History Survey (WGNHS), in cooperation with the Town of Lincoln and Kewaunee County are conducting a one-and-a-half-year hydrogeological mapping project in the Town of Lincoln to evaluate (1) depth-to-bedrock, (2) water-table elevation, (3) groundwater recharge, (4) groundwater contaminant susceptibility, and (5) delineate karst landforms (i.e., land surface closed depressions). The project was commissioned by the Town of Lincoln in July 2015 and started on August 1, 2015. The project is scheduled to be completed by February 28, 2017.

For the purposes of the project, maps of depth-to-bedrock, water-table elevation, groundwater recharge, groundwater contaminant susceptibility, and land surface closed depressions, will be generated using a combination of existing and newly collected data. Existing data sets include drillers logs, commonly referred to as well-construction-records (WCRs), which are maintained by the Wisconsin DNR, geologic logs and rock cuttings maintained by the WGNHS, historical water-levels included in the WDNR maintained WCR database, and maps developed by the WGNHS and other researchers.

New field data that we intend to collect include measurements of depth-to-bedrock, water-level, and streamflow. Depth-to-bedrock measurements will be collected using a variety of non-invasive geophysical techniques as well as subsurface boring techniques, while water-levels and stream flows will be manually collected from wells and streams using water-level meters and streamgaging equipment. All data collected is processed, compiled, and maintained by the WGNHS. As part of UW-Extension and the University of Wisconsin system, this data is part of the public record and will therefore be publically available at the completion of the project. The most relevant and pertinent data sets will most likely be published as appendices in the final project report

Estimating depth-to-bedrock

To estimate depth-to-bedrock, several geophysical methods will be used in addition to specialized drilling using a geoprobe-type boring rig. One fast and non-invasive geophysical method for acquiring depth-to-bedrock measurements is the Horizontal-to-Vertical Spectral Ratio Passive Seismic Method (HVSR or Passive Seismic). The measurement instrument has three 1-inch metal legs that are pushed into the ground on a level surface (**see photos 1 and 2**). Data collection takes about 10-20 minutes, depending on ambient ground vibrations and the type of sediment or rock. To prevent non-ambient vibration noise, such as footsteps, everyone should remain at least 20 feet away from the instrument during the measurement. Landowners do not need to be present while the data is being collected, but are welcome to stay and observe. **Photos 1 and 2** show the passive seismic unit being deployed in the field and up close back in the office.

Another geophysical method that will be used to estimate depth-to-bedrock is Ground Penetrating Radar (GPR) Examples of the GPR equipment is included in **photos 3, 4, and 5**. While the Passive Seismic method collects a single data point at each location, GPR can provide a 2D profile image of the ground. The GPR instrument is an antenna that sends out radio waves into the ground through a transmitter, which is typically towed very slowly behind a truck (about 5 mph) or dragged overland by foot. The radio waves sent down from the antenna, bounce off subsurface materials (e.g., sediments and rock) at depth. These radio waves then return to the antenna's receiver. The travel time of the radio waves from the transmitter back to the receiver provides an estimate of depth to specific subsurface features, such as the top of bedrock. The larger 80 MHz antenna can be towed by truck or pulled by foot on lightly travelled public roads, dirt roads, open fields, or grasslands. The smaller 500 MHz antenna is only pulled by foot but provides access to harder to access areas such as near buildings or in fields between rows of corn. Landowners will be asked for permission prior to performing GPR transects on their land.

The drilling, or boring technique that will be used to estimate depth to bedrock utilizes the direct push method, commonly referred to as Geoprobe. This technique effectively pushes a small 1-inch diameter drill string into the ground using a percussion hammering motion. Examples of the Geoprobe equipment is included in **photos 6 and 7**. Subsurface samples can be collected from the the unconsolidated soils and sediments right down into the top of the bedrock dolostone material, providing a physical measure of depth to bedrock. This boring method is ideal for obtaining subsurface samples in unconsolidated materials and will provide a quick and relatively inexpensive way to physically measure depth to bedrock. It will help pinpoint depth to bedrock in areas where no data currently exists as well as in areas where we'd like to confirm depth-to-bedrock measurements as reported in historic well construction reports or estimated using geophysical measurements. Landowners will be contacted for permission to access their lands prior to drilling, Diggers Hotline will be notified, and all boreholes will be fully abandoned.

Estimating water-level elevation

To measure water-levels in wells, water-level meters are used. For this study two different types of water-level meters may be used, a sonic meter and a submersible water-level meter. Examples of this equipment are included in **photos 8 and 9**. The Sonic water-level meter is held over the open well hole and simply emits a sound wave into the well. The sound wave travels down the well, bounces off the water column, and returns to the sonic water-level meter. This provides a travel-time that is instantaneously converted by the meter to an estimate of depth-to-water. By knowing the location of the well, often recorded in the field using a hand-held GPS unit, and adjusting for the stick-up height of the steel casing above ground surface, we can later correct for land-surface elevation and determine the water-level elevation.

The submersible water-level meter consists of a measurement tape which is lowered into the well on a spool. The tape carries a low-voltage electric charge (produced by a 9V battery) which creates a closed electric circuit when in contact with water. Once the probe tip hits the water column, and the electric circuit is closed, the meter beeps at the surface, and the field technician records the depth marked on the measurement tape. This measurement corresponds to the depth-to-water below the top of the steel well casing and, similarly to the sonic water-level meter, is later converted to a water-level elevation based on corrections for casing height and land surface elevation.

Estimating streamflow

The final type of field data that we intend to collect for this study are streamflow measurements. Streamflow measurements are obtained by performing a streamflow transect across streams and rivers. An example of streamflow data collection is shown in **photo 10**. Typically, it involves two people with one person traversing the stream while carrying the measurement equipment and another person along the river bank recording the streamflow measurements. The best locations for measurements are typically near road crossings where the stream channel is straight and of consistent depth and width. Stream crossings at roadways are also ideal for limiting the need to ask landowners for access to their property since these areas are typically within the public right-of-way. In certain instances, it may be preferable to access streams from private lands, in which case landowners would be contacted beforehand.

A streamflow measurement at a stream crossing is obtained by holding an acoustic Doppler current profiler (ADCP) below the water surface at roughly 10 locations across the stream channel; forming a transect grid or "profile" of the stream channel. At each location along the stream profile, the ADCP unit measures the velocity of water flowing past the unit. By knowing the geometry of the stream channel, the measured velocities (feet per second, or f/s) can be multiplied by the area (i.e., depth x width) of the stream channel around each measurement location (square feet, or ft^2) to provide an estimate of streamflow (cubic feet per second, ft^3/s, or "cfs"). Streamflow measurements can help estimate the rate of groundwater discharge to streams and provides a way of evaluating the groundwater flow system. For this project, we intend to use streamflow measurements as a way of verifying the water-level elevation mapping.

Data collection and data availability

Once geophysical, water-level, and streamflow data is collected, it is not immediately available in the field and must be processed back in the office. A final version of all data collected will be available at the completion of the project. For the purposes of this groundwater study, this type of information will provide valuable insights about the hydrogeologic conditions and help us refine our mapping within the Town of Lincoln.

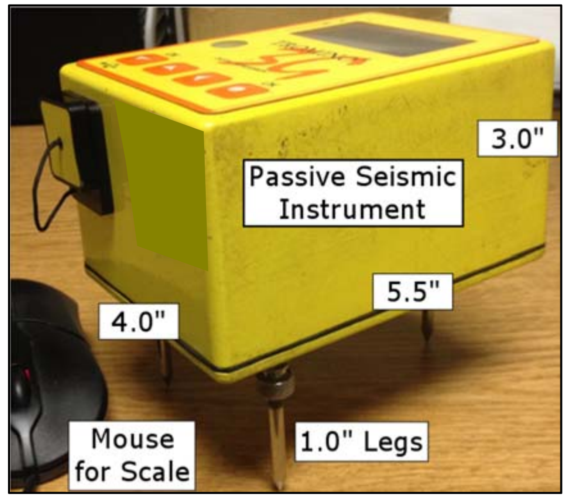
Several photos have been included on the following pages to show the different types of field equipment that will be used over the course of this study.

Feel free to contact me directly should you have any further questions.

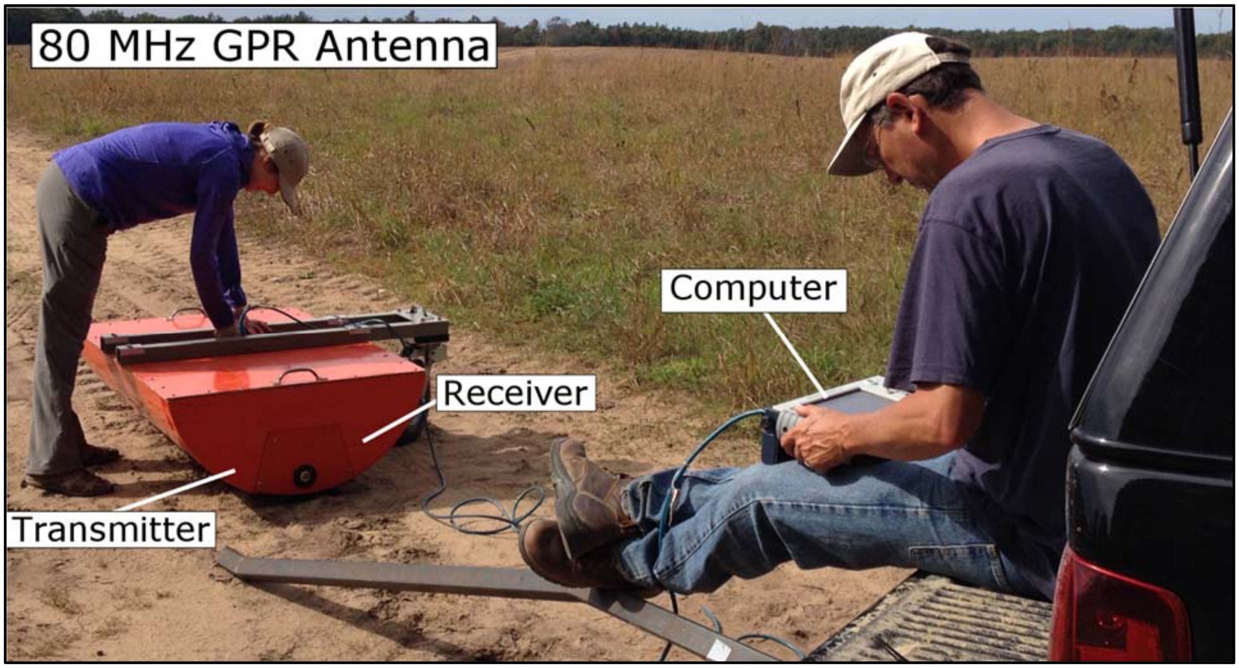
Sincerely,

Mike Parsen
Hydrogeologist
3817 Mineral Point Rd.
Madison, WI 53705
michael.parsen@wgnhs.uwex.edu
(608) 262-9419 (direct)

Enclosures:
Photos 1 and 2 – Passive Seismic equipment
Photos 3 and 4 – 80 MHz Ground Penetrating Radar (GPR) equipment
Photo 5 – 500 MHz GPR equipment
Photos 6 and 7 – Geoprobe drilling rig
Photos 8 and 9 – Water-level meters
Photo 10 – Streamflow gaging



Photos 1 and 2: The Passive Seismic instrument shown in the field (left) and up close (right). The three 1-inch metal legs are inserted into the ground to record ambient ground vibrations for bedrock depth data collection. A computer mouse is shown for scale in the photo on the right. Ambient ground vibrations occur due to movement of objects at the ground surface penetrating down into the earth, such as the roots of a tree vibrating as the tree blows in the wind.



Photos 3 and 4: The 80 MHz Ground Penetrating Radar (GPR) equipment during set-up (above) and in action on the roads in the Town of Lincoln (below). This unit is typically pulled behind a pickup truck along roads or open fields at slow speeds (about 5 mph).

Photo 5: The smaller 500 MHz Ground Penetrating Radar (GPR) antenna can be used wherever the larger 80 MHz antenna can be used; however, it is smaller and can easily maneuverable in tight areas, such as in a field between rows of corn. The 80 MHz might temporarily flatten taller standing grasses and weeds, but they usually recover after a day. If the 80 MHz is being towed by truck, the minimal damage would be a result of the truck.

Photos 6 and 7: Subsurface borings will be collected using a Geoprobe drilling rig, allowing for physical measurement of depth-to-bedrock.

Photos 8 and 9: Water-levels in wells will be measured using a sonic water-level meter (photo to left) or a submersible water-level meter (photo to right).

Photo 10: Streamflow measurements will be measured directly in stream channels using Acoustic Doppler Current Profiler (ADCP) equipment. In this photo, the field technician is collecting one of several measurements along a stream transect.