Preliminary Results from Helicopter Electromagnetic Surveys Over a Paleovalley Aquifer in Eastern Nebraska

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Project Objectives

- Map subsurface hydrogeology, in particular sand and gravel aquifers within and below glacial deposits.
- Map potential groundwater recharge areas in a glacial setting.
- Understand the connection between aquifers and streams, and between different aquifers.

Relevance to Water in Nebraska

- Seventy percent of Nebraskans live in eastern Nebraska where groundwater resources are limited.
- Much of the groundwater supply in eastern Nebraska is from paleovalley aquifers within and below glacial deposits. These aquifers can be laterally discontinuous and are separate from the High Platte Aquifer that supplies water resources to western Nebraska.
- The paleovalley aquifers have highly variable geometry and are hydrologically heterogeneous.
- Delineation of paleovalley aquifers is critical for management purposes. Contaminants on the surface may infiltrate to these aquifers and degrade their water quality. The quantity of water may also be limited due to the spatially confined nature of paleovalleys.

Project History

Helicopter Electromagnetic (HEM) surveys were conducted at three pilot study sites in 2007 to evaluate mapping technologies in a variety of glacial terrains.

These surveys showed:

- The main limitation in depth of mapping for HEM applications is controlled by the amount of silt or clay in the glacial till overburden.
- Shallow (within 40 meters) sand and gravel aquifers can be mapped in greater detail than possible using available registered well information and is more cost effective than a test-hole drilling campaign.

- Two new sites were flown in 2009--Swedeburg and Crete-Princeton-Adams areas.

Helicopter Electromagnetic System

The transmitter and receiver are enclosed in a tube called a "bird" that is towed 30 meters below the helicopter and 30 meters above the ground surface.

- Six Frequencies were transmitted (400; 1,800; 3,300; 8,200; 40,000; and 140,000 Hertz).
- The surveys in 2007 and 2009 used different upper frequencies (e.g. 25,000 and 115,000 Hz for 2007; and 40,000 and 140,000 Hz for 2009).
- The total magnetic field data has been collected but additional analysis is needed to evaluate the correlation with shallow hydrogeology. There is, however, obvious correlation with magnetic features in the crystalline basement sourced by the mid-continental rift.
- High precision real-time kinematic global positioning system (in both the helicopter and bird) and laser altimeter (in the bird) can create digital "georeferenced" elevation maps.
- The flight-path video recorder can be used to locate possible sources of cultural noise such as metal buildings and power transmission lines.

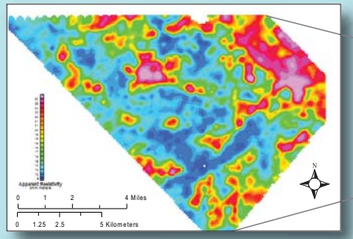
Project Partners

- **U.S. Geological Survey**
- **Conservation and Survey Division (University of Nebraska)**
- **Lower Platte South Natural Resources District**
- **Lower Platte North Natural Resources District**
- **Nebraska Environmental Trust**

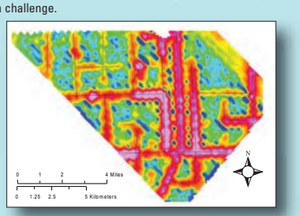
2009 HEM Surveys at Swedeburg and Crete-Princeton-Adams Sites

Swedeburg HEM Resistivity Maps

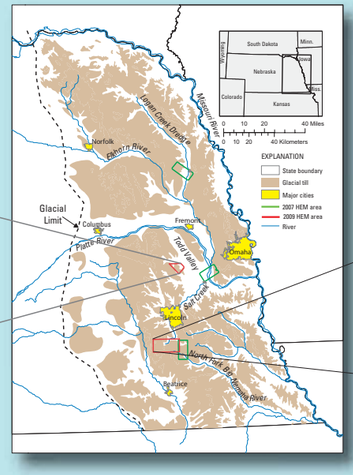
This map shows the apparent resistivity of the subsurface as measured at 8,200 Hz. The survey area is ~ 78 km^2 (30 mi^2). Red and pink areas have high resistivity and generally indicate sand and gravel. Blue areas have low resistivity and generally indicate silt, clay, or glacial till. The ancient alluvial sediments of the Todd Valley are present on the east side of the flight area. The remainder of the flight area shows patterns that are consistent with discontinuous sand pockets that charcterize the glacial terrian of this area and make water supply development and management difficult.



This map shows 60 Hz noise from power transmission lines as monitored in the bird. Not all powerlines will radiate high 60 Hz noise, but high values are a good indicator of their location. Powerline noise will mostly affect the lowest frequencies in the survey (400 and 1,800 Hz). Cultural noise and flight considerations to avoid populated areas makes the design of HEM surveys in eastern Nebraska a challenge.



Powerline response channel plotted on "Google^{TM} Earth " map showing cultural features

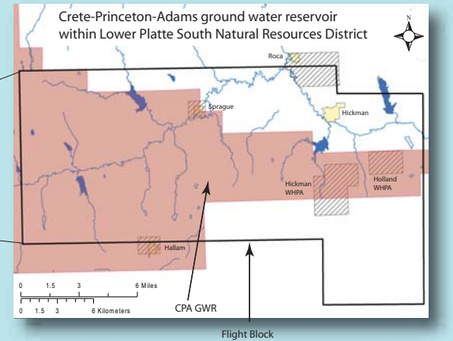


Coal-fired power plant that withdraws water from the Crete-Princeton-Adams aquifer.

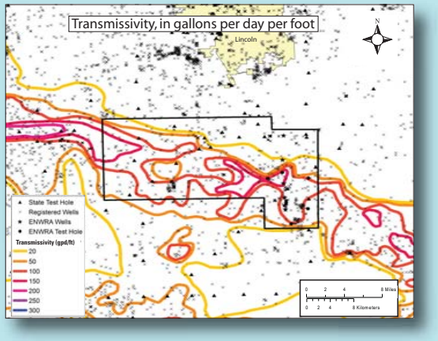
Swedeburg Area viewing Todd Valley to the northeast

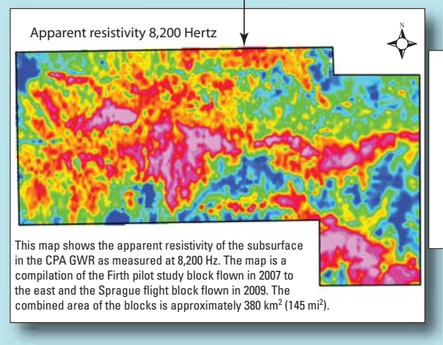
Crete-Princeton-Adams Paleovalley Aquifer Site

The overlap between the Crete-Princeton-Adams Ground Water Reservoir (CPA GWR) within the Lower Platte South Natural Resources District, the HEM flight area, and the designated Wellhead Protection Areas (WHPAs) for the small communities of Hickman, Hallam, Roca, and Sprague illustrates an important application of HEM data in this project. More detailed and spatially complete data on the occurrence and nature of the paleovalley sediments will assist local water managers in further refining WHPA boundaries.

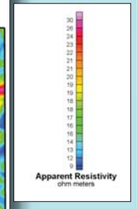


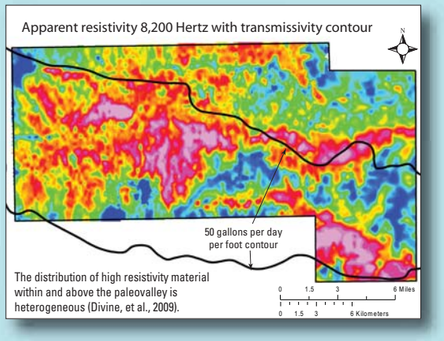
The location of the paleovalley is indicated by hydraulic transmissivity countour lines based on information compiled from registered well logs.





This map shows the apparent resistivity of the subsurface in the CPA GWR as measured at 8,200 Hz. The map is a compilation of the Firth pilot study block flown in 2007 to the east and the Sprague flight block flown in 2009. The combined area of the blocks is approximately 380 km^2 (145 mi^2).





The distribution of high resistivity material within and above the paleovalley is heterogeneous (Divine, et al., 2009).

Preliminary Results

- Hydrogeologic features (sands and silts) are mapped by the HEM apparent resistivity;
- Apparent resistivity maps show greater detail in spatial mapping than is available from well logs;
- Discrete resistive (sand) units are mapped in the Swedeburg area, and;
- The interpretation of buried hydrogeologic features such paleovalleys, as illustrated by the Crete-Princeton-Adams aquifer, is complex and will require an integrated interpretation based on hydrology, geology, and geophysics.

Divine, D. P., Joeckel, R.M., Korus, J.T., Hanson, P.R., and Lackey, S.O., 2009, Eastern Nebraska Water Resources Assessment (ENWRA), Introduction to a Hydrogeology Study, published by the University of Nebraska – Lincoln Institute of Agricultural and Natural Resources and the Conservation and Survey Division School of Natural Resources, Bulletin 1 (New Series), 31 p.