Steve Pederson
NE contact
8-20-03 meeting

PROJECT PRE-PROPOSAL

(SUBJECT TO REVISION)

Surface Geophysical Survey, Republican River, South-Central Nebraska

PROBLEM

To aid in the understanding of the ground-water flow system and the interrelations between the ground-water system and the surface-water system the Nebraska Platte River Cooperative Hydrology Study (COHYST) has been tasked to generate data and numerical ground-water flow models that will be used to support regulatory and management decisions.

Typically test holes and surficial geologic mapping determine the depth and profile of the bedrock surface underlying unconsolidated sediments. However, many times this information is either not in the area that needs to be defined or data locations are spaced too far apart to adequately define the extent of alluvial aquifer systems. These problems lead to uncertainty in estimating the location of the bedrock surface. Such uncertainties can lead to incorrect assessments of the thickness of the saturated zone used in numerical ground-water flow models. Incorrect saturated thickness can accentuate errors in a ground-water flow model.

Drilling of additional test holes is both time-consuming and expensive. Historically, information on the ground-water system has been obtained through drilling, collection of drill cuttings, sampling of water, and examination of geophysical well logs. An alternative approach would be to combine surface geophysical methods with a drilling program to provide a greater areal coverage with fewer wells.

Surface geophysical techniques are a noninvasive method of supplementing lithological data obtained from borehole logs. However, few surface geophysical data have been collected in Nebraska. Direct Current (DC) resistivity is a surface geophysical technique that can be used effectively to define the geologic framework of aquifer systems, locate hydrologic boundaries, and in some places, to interpret the lithologic character of the aquifer.

The U.S. Geological Survey (USGS) in cooperation with COHYST proposes to use DC resistivity surveys to supplement test hole data along parts of the Republican River in Nebraska. This study will enable ground-water modelers to better understand the overall physical characteristics of the alluvial aquifer.

OBJECTIVE

The objective of this study is to use direct current resistivity surveys (fig. 1) to define the occurrence of the Republican River alluvial aquifer and underlying bedrock surface along 9 survey lines.

APPROACH

The USGS, in cooperation with COHYST, will collect, analyze, and interpret DC resistivity data during this study. Direct current resistivity surveys will be used to locate areas of suspected bedrock high (fig. 2) along 9 north-south survey lines (fig. 3). Geologic cross-sectional data (fig. 2) provided by COHYST illustrates the bedrock high which acts as a hydrogeologic boundary along the northern edge of the Republican River alluvial valley. Data collection will be optimized along each DC resistivity survey line to image suspected bedrock highs. Two DC resistivity survey lines will be located in areas where borehole geophysical data exist. This data will be used to verify the results of the DC resistivity surveys. Test hole data will also be used to construct resistivity models.

METHODS

Sediments display a wide range of resistivity values. Sediments conduct electricity primarily through the interstitial fluid, and resistivity is controlled primarily by porosity, water content, and salinity (Zohdy, 1974). Clay can range in resistivity from 1 to 100 ohm meters whereas alluvium can range from 10 to 800 ohm meters. Typically, finer grain sediments such as clay are relatively more conductive than coarse grain sediments such as sand and gravel (Loke, 2000). Since coarse-grained sand and gravel deposits are more electrically resistive than silt and clay, DC resistivity methods can be used to map the extent and thickness of alluvial deposits.

Resistivity models (fig. 4) will be produced using the borehole data supplied by COHYST. Cross sections will be created on the basis of the known geology and the interpretation of the resistivity data. Resistivity values from the existing borehole resistivity log data will be compared to drillers log data. Using these data, resistivity values can be assigned to the lithologic data from the drillers log. These resistivity data can be used in a model to identify distributions of lithologies that are consistent with the surface resistivity data. Degnan and others (2001) reported an example in which a model solution was reached after numerous iterations, each with a modified model when the resistivity section from the field data and the inverted synthetic resistivity section from the model data approximately match. The model solutions are non-unique; however, with inclusion of known information to the model, such as depth to water or depth to bedrock, the solutions represent a likely interpretation.

QUALITY CONTROL

The resistivity meter will be calibrated using a resistor of known resistance. A contact resistance test also will be performed before data collection to ensure electrodes are properly connected and grounded. The data will be reviewed for accuracy by plotting the root mean square error (RMSE) of the observed and calculated apparent resistivity values in the field. Data with high error will be excluded or recollected. Resistivity data will be stored on a personal computer and taken to the USGS Nebraska District office. The final data will be compared with available borehole data from the Republican River area.

PRODUCTS

The results of the geophysical survey will be reviewed by the USGS office of groundwater's branch of geophysical applications and support (BGAS). After review the results will be provided to COHYST. All results of the geophysical survey will be presented in a USGS Open File Report.

FIGURES

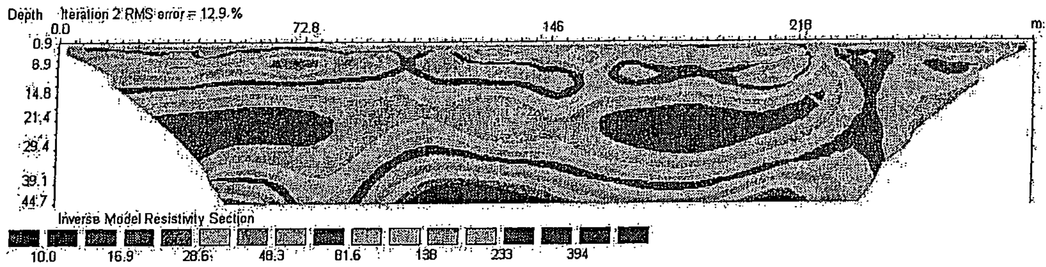

Figure 1. Example of direct current resistivity cross section.

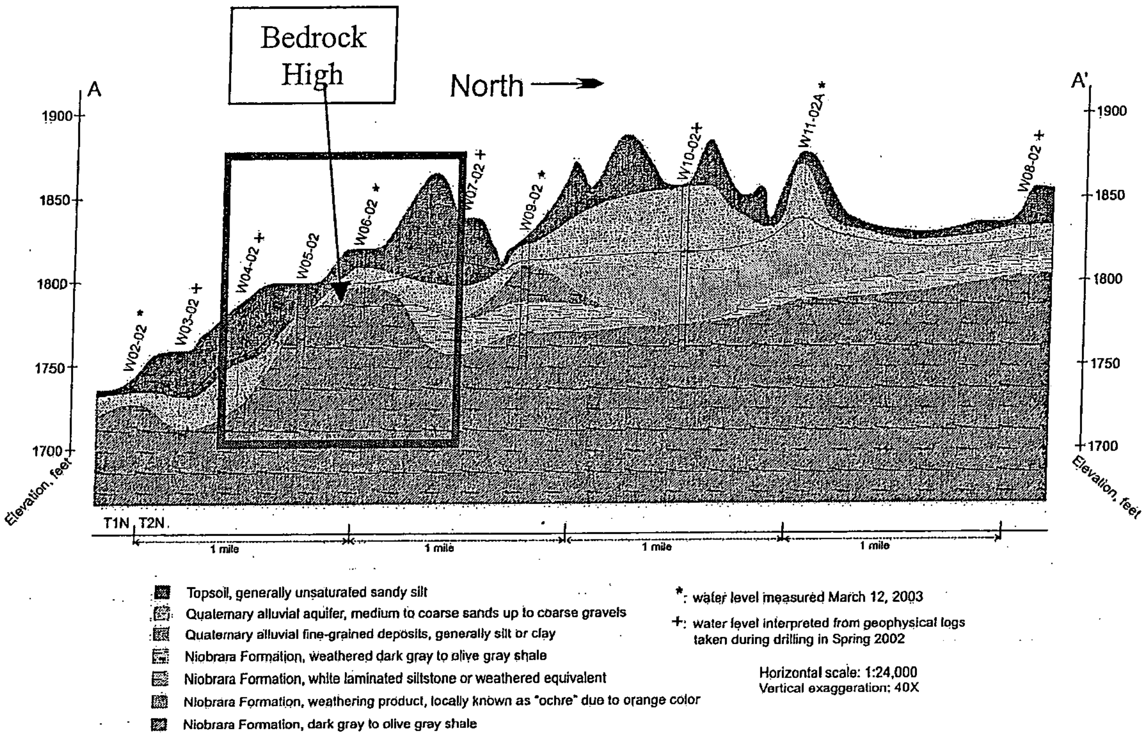

Figure 2. Example cross-section illustrating area of interest.

Republican River Geophysical Survey

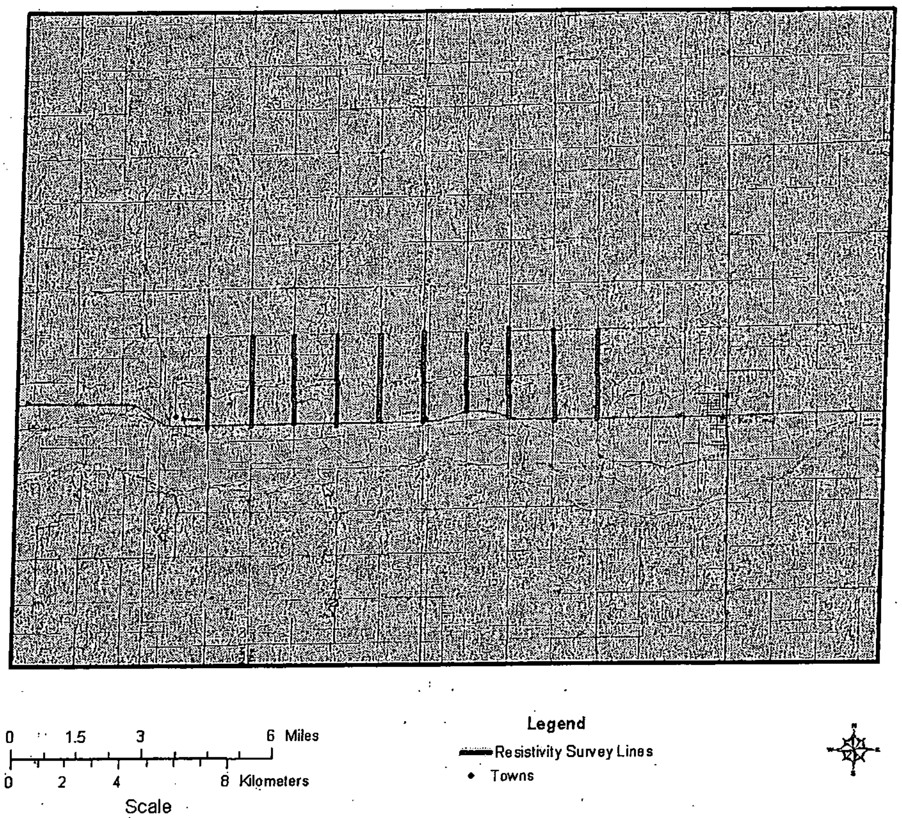

Figure 3. Approximate location and length for data collection.

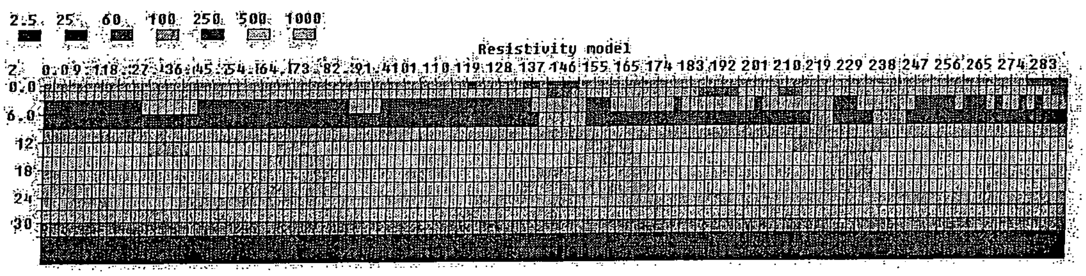

Figure 4. Example of two-dimensional resistivity model.

RELEVANCE AND BENEFITS

The proposed work is consistent with the USGS's Strategic Direction for the Water Resources Division (WRD). One of the priority issues of the WRD is to make a valuable contribution to the issue of drinking water availability and quantity. The proposed pilot study will benefit the cooperator by providing geophysical data so that informed decisions can be made on ground-water management alternatives.

BUDGET

Funding Distribution	
Fiscal Year 04	
Geophysical Data Collection and Processing	
Direct Current	
Data collection	$26,400
Data processing	$14,300
Modeling	$5,800
Transportation/Travel	$6,000
Supplies	
Printer supplies, salt, wire, etc.	$1,900
COHYST contribution	$49,400
USGS contribution	$5,000
Total Budget 04	$54,400

WORKPLAN and SCHEDULE

The project will begin in October of 2003 and will be completed by May 2004. The planned work schedule is listed below:

Timeline and Activity

October 6-10 2003	Organize data for the study and collect well information.
October 13-25 2003	Conduct DC resistivity geophysical surveys.
October 27- 2003	Process DC resistivity geophysical data.
November 2003	BGAS data reviews.
January 2004	Construct resistivity models.
February 2004	Present preliminary data to COHYST.
March 2004	BGAS final data review.
May 2004	Final data will be provided to COHYST.

SELECTED REFERENCES

Degnan, J. R., Moore, B. M., Mack, T. J., 2001, Geophysical Investigations of Well Fields to Characterize Fractured-Bedrock Aquifers in Southern New Hampshire: U. S. Geological Survey Water-Resources Investigations Report, 8 p.

Loke, M.H., 2000, Electrical imaging surveys for environmental and engineering studies---a practical guide to 2-D and 3-D surveys: accessed September 1, 2000, at URL http://www.agiusa.com/literature.shtml

Zohdy, A.A.R., Eaton, G.P., and Mabey, D.R., 1974, Application of surface geophysics to ground-water resources investigations: U.S. Geological Survey Techniques of Water-Resources Investigations, book 2, chap. D1, p. 8-20.