CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Professional Development Trip to the Department of Geology, University of South Florida (20.01402.158.032)

DATE/PLACE: October 15–19, 2001
University of South Florida, Tampa, Florida

AUTHOR: Ronald T. Green

DISTRIBUTION:

CNWRA	NRC-NMSS	SwRI Contracts
W. Patrick	J. Linehan	T. Nagy
CNWRA Directors	D. DeMarco	
CNWRA Element Managers	E. Whitt	
P. Maldonado	B. Meehan	
	J. Greeves	
	J. Piccone	
	W. Reamer	
	K. Stablein	

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Professional Development Trip to the Department of Geology, University of South Florida (20.01402.158.032)

DATE/PLACE: October 15–19, 2001
University of South Florida, Tampa, Florida

AUTHOR: Ronald T. Green

PERSONS PRESENT:

Ronald T. Green

BACKGROUND AND PURPOSE OF TRIP:

The trip was part of ongoing CNWRA professional development. Geophysical evaluation of aquifers was the subject explored during a week-long visit to the Department of Geology at the University of South Florida.

SUMMARY OF PERTINENT POINTS AND ACTIVITIES:

A week-long visit at the Department of Geology at the University of South Florida in Tampa, Florida, was used to investigate the use of surface geophysical survey techniques to characterize aquifers and structural features in aquifers. The visit was arranged in response to an invitation by Dr. Chuck Connor, Chair of the Department of Geology.

Electrical conductivity (frequency domain) and transient electromagnetic (time domain) techniques were evaluated during the visit. Two field sites were evaluated as part of the study. The first site, Cross Bar Ranch, is a well field for Tampa Bay Water, a public water utility. Cross Bar Ranch is located approximately 30 miles north of Tampa, Florida. The second site was Mullet Key, a barrier island located south of St. Petersburg, Florida. The Cross Bar Ranch site was selected for study because of anomalous heterogeneities in hydraulic properties at the well field which lead to an abrupt change in the hydraulic gradient. Mullet Key was selected because of the freshwater/saline water interface located under the island.

Surface conductivity was measured using a Geonics EM-31. The transient electromagnetic survey was conducted using a Geonics EM-47 receiver equipped with a high frequency receiver coil. All equipment was provided by Dr. Stewart Sandberg from the University of Southern Maine, who participated in the surveys. Also participating in the surveys were Drs. Chuck Connor, Mark Stewart, and Sarah Kruse from University of South Florida and three students, two from the University of Southern Maine and Mr. Barry Mayers from the University of the West Indies, Cave Hill Campus, Barbados. Barry Mayers is a PhD student with Dr. David Farrell as his advisor. A fourth student from the Department of Geology at University of South Florida assisted in the second day of the field survey.

A 1.6-km [.994-mi]-long transient electromagnetic transect was performed at the Cross Bar Ranch. The transect was oriented perpendicular to the abrupt change in the hydraulic gradient in the Floridan aquifer at the Cross Bar Ranch. A preliminary transect was performed with eight 40-m [131.23-ft] diameter transient electromagnetic loops at 200-m [656.17-ft] centers to locate the region where changes in the hydraulic gradient are detected. Ten additional 40-m [131.23-ft] loop soundings were conducted within the area of greatest change in electrical response to provide increased resolution. The subsurface at the Cross Bar Ranch is generally characterized as a deep water table (Floridan) aquifer overlain by a discontinuous clay confining layer, which in turn is overlain by a surficial unconsolidated aquifer. The depth of the up-gradient water table transitions from the surficial unconsolidated sediments to the deeper Floridan aquifer toward the down gradient. The hydraulic gradient anomaly is believed to be associated with property changes in the underlying Floridan aquifer. The transient electromagnetic survey effectively detected the changes to the electrical properties of the subsurface associated with the change in the hydraulic gradient. Additional analysis of the transient electromagnetic survey results is required to discern the exact nature of hydraulic property changes.

The Mullet Key survey consisted of both transient electromagnetic and electrical conductivity transects. All transects were conducted perpendicular to the long axis of the barrier island. This orientation was chosen to provide the optimal two-dimensional interpretation of the freshwater/saline water interface beneath the island. The barrier island is bisected by a road and elevated power lines. Electromagnetic measurements were located with adequate clearance from the power lines to avoid cultural interference. Two electrical conductivity and two transient electromagnetic transects of the barrier island were conducted during the investigation. The digital electrical conductivity survey was conducted at 1-m [3.28-ft] spacings. The electrical conductivity surveys were 300-m [984.25-ft] and 350-m [1148.29-ft] long. The transition of freshwater to saline water in the near surface {(i.e., less than 3-m [9.84-ft] depth} was easily detected using the EM-31 electrical conductivity instrument.

In the transient electromagnetic survey 40-m [131.23-ft] diameter loops were used. Preliminary evaluation of the transient electromagnetic survey results indicated that an electrically resistive freshwater lense lies on top of the conductive saline water. The electrically resistive freshwater Floridan aquifer was detected beneath the saline water zone near the center of the island. This aquifer was found to continue toward the open water side of the barrier island. A second transient electromagnetic transect was conducted on the intercoastal waterway side of the barrier island. Preliminary assessment of the second transient electromagnetic transect also indicated the presence of fresh water overlying salient water. The underlying freshwater Floridan aquifer was also detected in the second transient electromagnetic transect. The transient electromagnetic soundings proved to be an effective surface geophysical technique capable of penetrating through the resistive surface freshwater aquifer, through the underlying conductive saline water zone into the underlying resistive freshwater Floridan aquifer.

Additional time was spent working with the transient electromagnetic modeling program of Stewart Sandberg. The current version is DOS based, written in FORTRAN, and requires a number of intermediate data manipulations. An updated version has been translated into C by Chuck Connor. Several intermediate steps are being incorporated into an updated version. Included in the new version is a direct depth analytical transient electromagnetic solution by Meju (Geophysics, 1999). When completed, the new version will allow rapid in-the-field transient electromagnetic data assessments. Rapid assessment will permit more efficient and

directed transient electromagnetic surveys. Currently, transient electromagnetic surveys require the presence of personnel with significant expertise to ensure site complications are adequately addressed in the conduct of the survey. Rapid access to the Meju analytical solution will not completely remove the need for high-level expertise during surveys in geologically complicated localities, but standard transient electromagnetic surveys at less complicated sites should prove to be less challenging with this new capability. The revised modeling program will be available to S. Sandberg and CNWRA to help advance Yucca Mountain activities and other work.

Stewart Sandberg, Chuck Connor, and I met to discuss integrated assessments of the potential for phreatomagmatic volcanic eruptions. The intent of the assessment is to integrate geophysical field investigations with thermal-hydrologic modeling to support a risk assessment of the potential for phreatomagmatic volcanic eruptions. Innovations to this approach were identified and discussed. An National Science Foundation proposal to support this initiative will be submitted at the end of 2001.

I presented an invited talk to the Department of Geology colloquium at the University of South Florida. The talk was titled "Modeling Nonisothermal Vadose Zone Transport Using Dual Continua ." The subject of the talk was of interest to staff and students at University of South Florida who are active in modeling multiphase flow through fractured rock (i.e., karst limestones of the Floridan aquifer). The talk was of particular interest to Dr. Len Vacher and his PhD student, Joe Hughes, who is modifying SUTRA to be able to account for three-dimensional density driven flow resulting from gradients in both temperature and TDS. Current versions of SUTRA have this capability in two-dimensions. The three-dimensional version of SUTRA does not have the capability of simultaneously addressing both density gradients. Joe Hughes is receiving support from the U.S. Geological Survey to effect the modifications. Also in attendance at the talk was Dr. Alberto Sagües from the Department of Engineering at the University of South Florida and a member of the Nuclear Waste Technical Review Board.

Central Florida, in general, and the greater Tampa Bay area, in particular, are facing freshwater supply issues similar to those being faced by the San Antonio area. Much of the water resources for these areas in Florida are provided by karst limestone aquifers. These aquifers are capable of providing the required water supplies during periods of normal or above-normal rainfall. Hardships arise during periods of reduced rainfall or drought. Excessive pumping during these times results in depression of the water-table aquifers, which in turn dewaters surface water bodies and wetlands. Much of the native flora reliant on wetlands are significantly impacted by depressions in the water level. Cypress wetlands, in particular, incur permanent damage by even temporary declines in water levels. Because of this, the South Florida Water District has decreased the allowable pumping levels on well fields to protect the native species when the pumping permits come up for renewal every ten years. Pumping levels for the Cross Bar Ranch were reduced by 40 percent during the most recent permit renewal. In addition, approval for the development of additional well fields is unlikely given the public policy to protect wetlands and native species. Tampa Bay Water faces an uncertain future with serious challenges to meet increasing water resource needs given these constraints.

CONCLUSIONS:

The geophysical technique evaluations conducted during the visit to the University of South Florida will help develop the expertise of CNWRA. The transient electromagnetic instrumentation was demonstrated to be able to effectively image the structural features and a saltwater/fresh water transition. The first day of the survey indicated that the transient electromagnetic approach was able to provide insight on the subsurface features that lead to a change in the hydraulic gradient at the Cross Bar Ranch well field, although interpretation results are only preliminary at this time. The second day of the survey demonstrated that transient electromagnetics could effectively penetrate through the surface fresh water layer, past the underlying salt water zone and into the regional fresh water Floridan aquifer. Transient electromagnetic data interpretation approaches were evaluated to facilitate quick data inspection capabilities at the time of data collection. Participation in the field work, subsequent analyses, and related discussions provided me with added insight into geophysical subsurface interpretations and multiphase modeling.

PROBLEMS ENCOUNTERED:

None

PENDING ACTIONS:

None

RECOMMENDATIONS:

Trips to promote professional development are extremely beneficial to staff. The visit to the University of South Florida provided me an opportunity to focus on technical materials that would not typically be available while conducting day-to-day operations at CNWRA. I strongly urge other staff to pursue similar endeavors to broaden their technical areas of expertise.

SIGNATURES:

Ronald T. Green
Geohydrology and Geochemistry

11/1/01
Date

CONCURRENCE:

English C. Pearcy
Manager, Geohydrology and Geochemistry

11/1/01
Date

Henry Garcia
Director of Administration

11/1/01
Date