U.S. Geological Survey Fact Sheet

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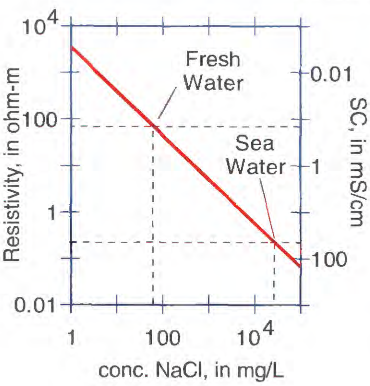
Geophysical mapping of the freshwater/saltwater interface in Everglades National Park, Florida

Water quality in Everglades National Park (ENP) and the discharge of fresh water into Florida Bay are influenced by water use and management policies in South Florida. The flow of fresh water through the Everglades into Florida Bay is critical to the well being of the South Florida Ecosystem (SFE). Restoration activities by Federal agencies are aimed at mitigating the effect of increased demand for water, farming, and flood control practices in South Florida on the SFE. Assessing the effectiveness of restoration efforts is difficult because of inaccessibility of much of this area. Airborne geophysical methods provide a means of rapidly and economically monitoring large areas where ground access is difficult.

Geophysical Measurement of Water Quality

The ability of materials to conduct electricity is called electrical conductivity, which in geologic materials is controlled primarily by the amount of pore space in the rock and the salinity of the water in the pore space. Increasing the pore space or salinity increases the electrical conductivity, while decreasing these quantities has the opposite effect.

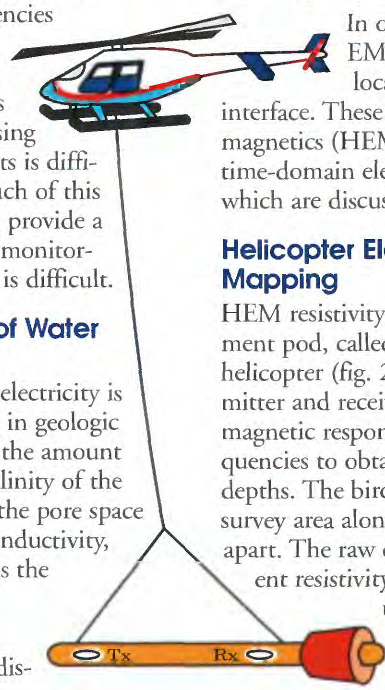
The conductivity of water, which is controlled by the concentration of dissolved ions, shows how well the water conducts electricity. For example, fresh water found in the ENP typically has a chloride ion concentration of 40 mg/L and a specific conductivity (SC) of 0.450 mS/cm. Saline water found in Florida Bay has chloride levels of 15,000–35,000 mg/L and an SC of 20–50 mS/cm (fig. 1). This one-hundred-fold difference in SC can produce a similar difference in the conductivity of geologic materials saturated with fresh or saline water.



▲ *Figure 1. Relationship of specific conductivity (SC) to NaCl concentration.*

Several geophysical techniques can be used to measure the resistivity (the reciprocal of conductivity) of the ground. These techniques make use of a transmitter that induces electrical current flow in the ground, and a receiver that measures the electromagnetic (EM) field produced by these induced currents. By analyzing the electromagnetic fields, information about how the electrical conductivity varies from location to location and with depth below the Earth's surface can be determined and resistivity maps produced.

In our study of the Everglades several EM methods are being used to map the location of the freshwater/saltwater interface. These methods include helicopter electromagnetics (HEM), borehole induction logging, and time-domain electromagnetic soundings (TEM), which are discussed below.

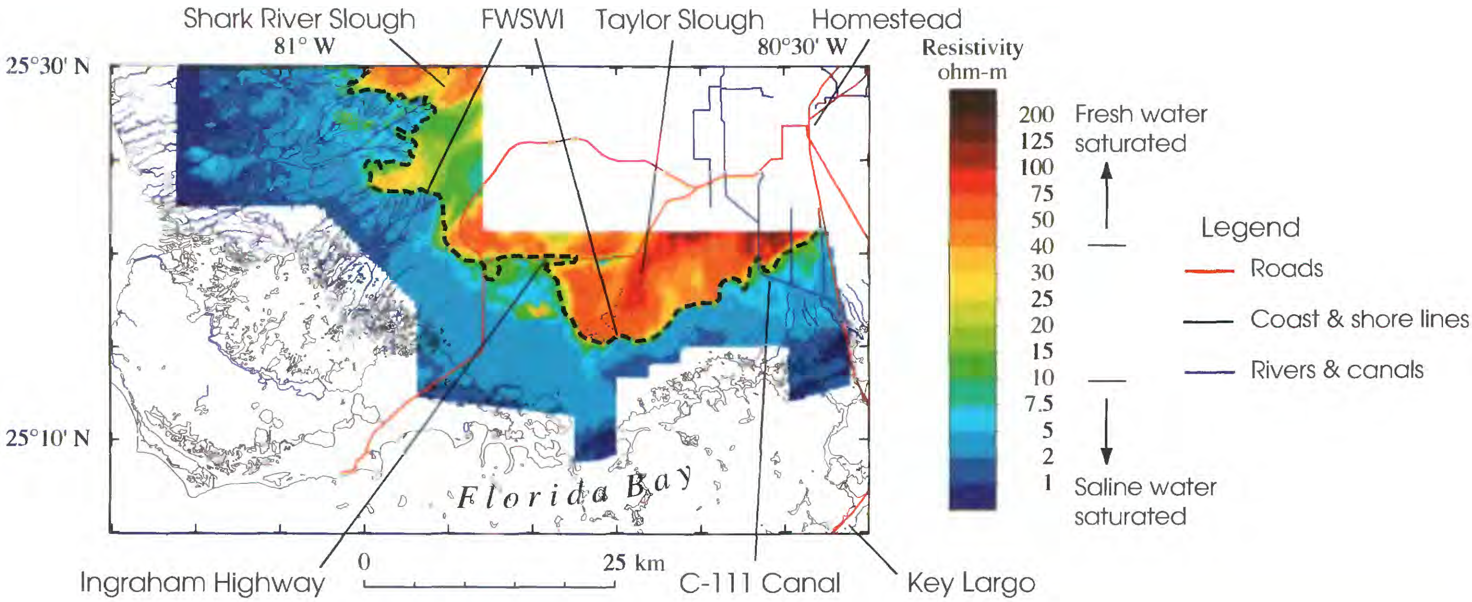


▲ *Figure 2. Helicopter and "bird" showing location of transmitter (TX) and receiver (RX) coils.*

Helicopter Electromagnetic Resistivity Mapping

HEM resistivity mapping makes use of an instrument pod, called a "bird," which is slung below a helicopter (fig. 2). The bird contains pairs of transmitter and receiver coils which measure the electromagnetic response of the ground at different frequencies to obtain information from different depths. The bird is flown back and forth over the survey area along parallel lines about 400 m (1/4 mi) apart. The raw data are processed to produce apparent resistivity maps such as the one shown on figure 3. By interpreting the apparent resistivity maps from different frequencies, information about how resistivity varies with depth can be determined.

The apparent resistivity map shows several interesting features including the prominent transition from higher resistivities in the landward direction to lower resistivities toward the shore. This feature is the freshwater/saltwater interface (FWSWI) and is marked on figure 3. In the region of Shark River Slough the FWSWI follows the terminus of rivers that have tidal flow. Taylor Slough, one of the primary sources of water for Florida Bay, shows up as a resistive feature. The influence of manmade features is seen where the FWSWI crosses the C-111 canal where a control structure on the canal produces a distortion in the interface. A conductive feature is seen along the old Ingraham Highway where saline water flowed inland in the canal adjacent to the highway.



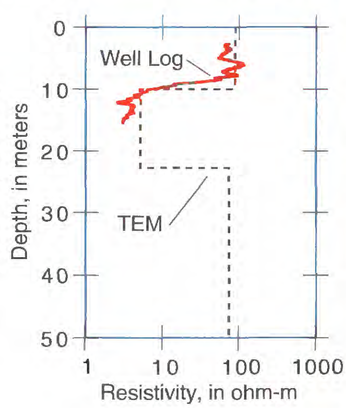
▲ *Figure 3. Helicopter electromagnetic apparent resistivity map of a portion of Everglades National Park.*

Borehole and Surface Geophysical Measurements

To refine the interpretation of the airborne geophysical data, we rely on borehole and surface geophysical measurements, and water quality samples. Figure 4 shows an induction log and time-domain electromagnetic (TEM) sounding from near the FWSWI. The induction log, which is measured with a tool lowered into a well, provides detailed information on how resistivity varies with depth near the well. The TEM sounding, which is a surface measurement, also gives information on resistivity-depth variations. The transition from high resistivity surface water to low resistivity saline water is seen in both measurements at a depth of 10 m, and has been confirmed by water-quality data. Repeat borehole logs are being made to monitor seasonal and long-term changes.

Monitoring of Restoration Activity

Repeat HEM surveys have been made at the end of the dry and rainy seasons. Comparison of these results show that there are significant changes associated with increased fresh-water flows during the wet season. This result indicates that periodic repeat HEM surveys can be used to monitor changes in the ground-water system caused by restoration activity such as increasing flows of fresh water into Taylor Slough.



▲ *Figure 4. Comparison of surface and borehole geophysical measurements.*

Plan of Study

Additional airborne surveys are planned. These and other geophysical data will be used for restoration monitoring and development of ground-water models.

Product Plans:

- Helicopter electromagnetic apparent resistivity maps.
- Interpreted resistivity-depth maps showing the location of the fresh/saline water interface.
- Interpretation of ground-based geophysical measurements.
- Summary of geophysical logs from drill holes in study area.

Anticipated Schedule:

- April 1994–First helicopter airborne survey flown.
- December 1994–Repeat HEM survey flow.
- March 1995–HEM apparent resistivity maps produced.
- December 1995–New ground-water monitoring wells installed.
- February 1996–Geophysical logging of new monitoring wells completed.
- July 1996–Fly repeat helicopter electromagnetic survey.
- September 1996–Complete layered model interpretation of helicopter surveys.
- September 1996–Complete interpretation of time-domain electromagnetic soundings.
- April 1997–Fly repeat helicopter electromagnetic survey.

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