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TIME DOMAIN ELECTROMAGNETIC MAPPING OF SALT WATER IN THE FLORIDAN AQUIFER IN NORTHEAST & EAST-CENTRAL FLORIDA

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

OCTOBER 1995

Prepared For

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
P.O. Box 1429
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Contract Number 93G168

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EXECUTIVE SUMMARY

A time domain electromagnetic (TDEM) survey was performed at 24 sites in the St. Johns River Water Management District during the month of May, 1995. The TDEM method is a geophysical technique which, through ground surface based measurement, enables description of the vertical distribution (one-dimensional depth layering) of formation electrical resistivity. As such, TDEM soundings provide a gross approximation of an electrical log as performed in a borehole without the significant expense of drilling, completing, and logging such a borehole. In comparing TDEM soundings to electric logs, the minimum thickness of an interval that can be resolved by TDEM is several orders of magnitude larger than what can be resolved by electric logs. The confidence in the conclusions from TDEM findings can be enhanced when water quality information from nearby wells is available. The objective of the TDEM survey was to determine the depths to the 250 mg/l and 5,000 mg/l isochlors.

The determination of the depth to the 5,000 mg/l isochlor was made at 22 of the 24 sites. Depths ranged from 200 to 1,389 feet (ft) below land surface (bls). At two of the sites (Herlong Airport and Volusia County Landfill), it was not possible to determine the depth to the 5,000 mg/l isochlor because the depth to the isochlor exceeded the effective range of the TDEM system.

The determination of the depth to the 250 mg/l isochlor was made at 10 of the 24 sites. At five of the sites, waters above the 5,000 mg/l isochlor appeared to be brackish. At nine of the sites, the 250 mg/l isochlor could not be determined because the geoelectric model for the site could not distinguish the Holocene to Miocene deposits from the Floridan aquifer. Accordingly, the assumptions used in the empirical relationships to determine the 250 mg/l isochlor were not valid.

Contract Number 93G168
October 25, 1995

This is to certify that I, Michael J. Wightman, have reviewed the figures, tables, and text of the following report.

By:

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SEAL

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1.0 INTRODUCTION

The St. Johns River Water Management District (SJRWMD) has contracted with Subsurface Detection Investigations, Inc. (SDII) to perform a series of Time Domain Electromagnetic (TDEM) survey measurements in northeast and east-central Florida during the month of May, 1995. This latest series of TDEM soundings is a continuation of similar TDEM programs funded by SJRWMD in previous years (Blackhawk, 1990; CEES, 1992; and SDII, 1993 and 1994). The TDEM method is a geophysical technique which, through ground surface-based measurement, enables description of the vertical distribution (one-dimensional depth layering) of formation electrical resistivity. As such, TDEM soundings provide a gross approximation of an electrical log as performed in a borehole without the significant expense of drilling, completing, and logging such a borehole. In comparing TDEM soundings to electric logs, the minimum thickness of an interval that can be resolved by TDEM is several orders of magnitude larger than what can be resolved by electric logs. As formation resistivity is a direct function of formation lithology, porosity, and pore fluid conductivity, *in situ* determination of formation resistivity offers a means of inferring the water quality within given formations through empirical relationships between assumed porosity, pore-water chloride concentration, and the measured value of resistivity.

Given this background, SJRWMD has set the objectives of this TDEM survey as:

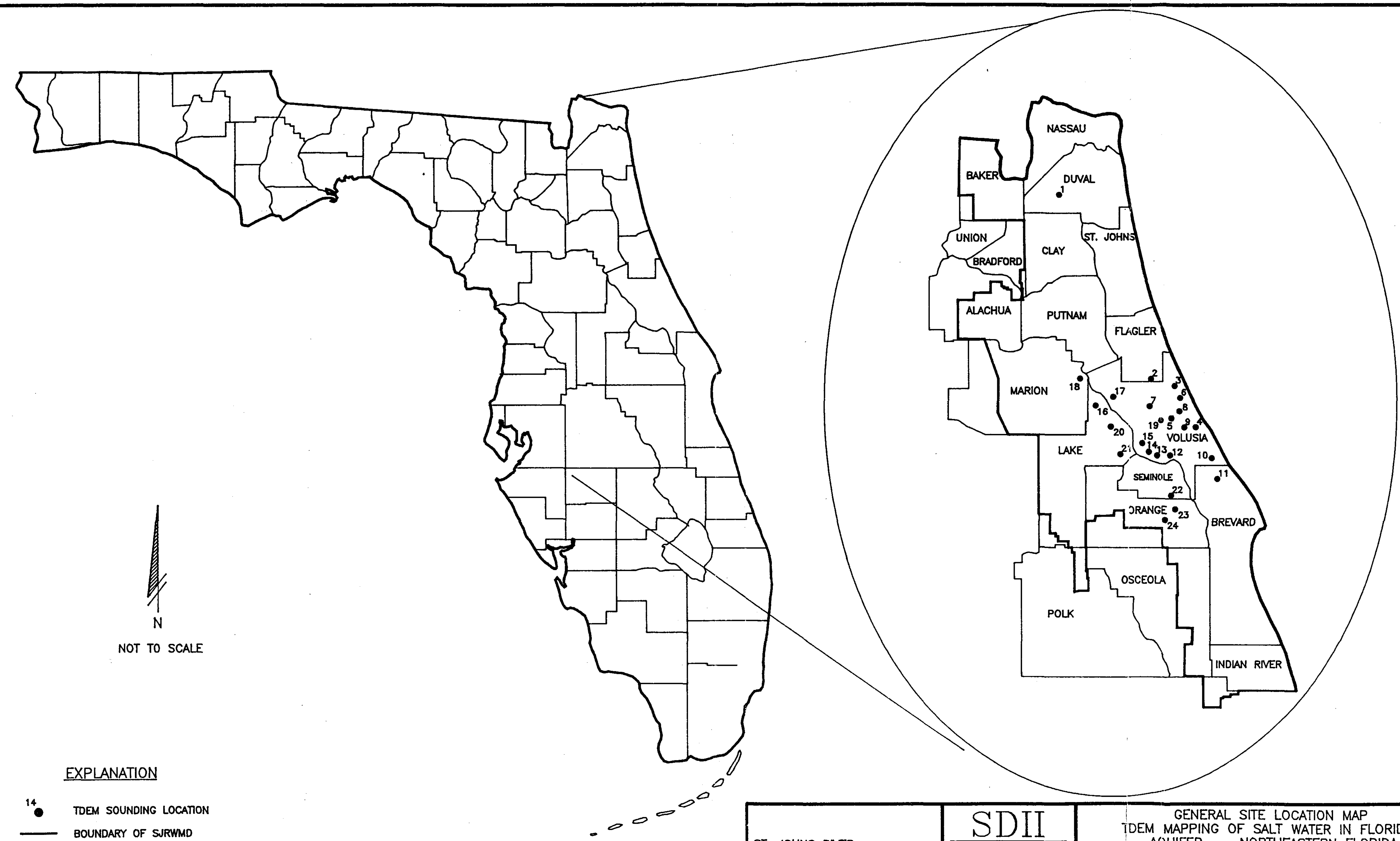
1. determination of the depth to the saltwater interface (water with chloride concentration greater than 5,000 milligrams per liter [mg/l]);

2. determination of the depth within the aquifer (above the saltwater interface) at which chloride concentration of pore waters equals 250 mg/l;

3. estimation of the chloride content of the saltwater layer assuming values of 25, 30, and 35 percent for porosity of that layer.

The principal strength of TDEM is the detection and mapping of depths to the top of a conductive layer within an otherwise resistive medium. As such, the first objective (chlorides greater than 5,000 mg/l) is the easiest to accomplish and is the best resolved. Determination of the second and third objectives relies on empirical relationships derived from studies of wells in Seminole County (in east-central Florida) and, therefore, is a less certain and less well-resolved determination.

This report details the field procedures, data quality control and analyses procedures from a total of 24 sites as selected by SJRWMD personnel. All the sites were within northeastern and east central Florida. Figure 1-1 presents the locations for the 24 TDEM sites.



EXPLANATION

14 ● TDEM SOUNDING LOCATION

—— BOUNDARY OF SJRWMD

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	GENERAL SITE LOCATION MAP TDEM MAPPING OF SALT WATER IN FLORIDAN AQUIFER – NORTHEASTERN FLORIDA		
		Designed By: JEB Checked By: MJW Drawn By: SAB	Proj. No. 95706 DWG LOC–G Date: 06/21/95	Fig. No. 1–1

2.0 HYDROGEOLOGIC SETTING

Ground water is drawn from three principal aquifer systems within SJRWMD (Figure 2-1); the surficial aquifer system, the intermediate aquifer system and the Floridan aquifer system (Scott et al., 1991). The surficial aquifer system consists primarily of Upper Miocene to Holocene age consolidated to poorly indurated siliclastic sediments (Scott et al., 1991). Permeable interbeds within these sediments are locally significant sources of potable water near coastal areas and within St. Johns, Flagler, southern Brevard, Indian River, Seminole, western Clay, and Alachua counties (Fernald and Patton, 1985).

The Miocene-age Hawthorn Group separates the surficial aquifer system from the Floridan aquifer system and creates confining conditions within the Floridan aquifer. The intermediate aquifer system is comprised of high-transmissivity zones within the Hawthorn Group (Figure 2-1). Typically these high-transmissivity zones occur within sandy phosphatic limestone beds. The intermediate aquifer system is a significant source of potable water in southeastern Flagler and eastern Orange counties (Fernald and Patton, 1985).

The primary source of potable water throughout the majority of the SJRWMD is the Floridan aquifer system. The Floridan aquifer is composed of (from oldest to youngest) the Cedar Keys Formation, Oldsmar Formation, Avon Park Formation, Ocala Limestone (where present),the Suwannee Limestone and the lower formations of the Hawthorn Group (where present; Figure 2-1; Scott et al., 1991). The ages of these formations range from Paleocene to Miocene.

LITHOSTRATIGRAPHIC UNIT	HYDROSTRATIGRAPHIC UNIT
UNDIFFERENTIATED PLEISTOCENE–HOLOCENE SEDIMENTS ANASTASIA FORMATION CYPRESSHEAD FORMATION NASHUA FORMATION	SURFICIAL AQUIFER SYSTEM
HAWTHORN GROUP STATENVILLE FORMATION COOSAWHATCHIE FM. MARKSHEAD FORMATION PENNEY FARMS FM.	INTERMEDIATE AQUIFER SYSTEM OR CONFINING UNIT
SUWANNEE LIMESTONE	FLORIDAN AQUIFER SYSTEM
OCALA LIMESTONE AVON PARK FORMATION OLDSMAR FORMATION	
CEDAR KEYS FORMATION	
UNDIFFERENTIATED	SUB–FLORIDAN CONFINING UNIT

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LITHOSTRATIGRAPHIC AND HYDROSTRATIGRAPHIC UNITS SJRWMD

FROM: SCOTT et al. 1991

DESIGNED BY: JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY: MJW	DRAWING NO.:	LTH	2–1
DRAWN BY: RBT	DATE:	06/21/95	

The Floridan aquifer is subdivided into the Upper and Lower Floridan aquifer by a middle semi-confining unit ranging in thickness from nearly 0 to over 1,000 ft. The middle semi-confining unit is leaky and the hydraulic connection between the Upper and Lower Floridan aquifers is variable (Tibbals, 1990). Depth to the division ranges from approximately 300 to 1,200 ft below mean sea level (bmsl) within SJRWMD (Miller, 1986).

The Ocala Limestone is the most productive aquifer within the Floridan aquifer. Along the east coast and southern portion of SJRWMD, the Cedar Keys and Oldsmar Formations typically contain salt water. Chloride concentrations within the Upper Floridan aquifer are usually less than 50 mg/l in the northern and west central portions of SJRWMD and exceed 250 mg/l in the east central and southern portions of SJRWMD (Fernald and Patton, 1985). Areas of mineralized water in the Floridan aquifer are present within the central and southern portion of SJRWMD. Sources of mineralized water include lateral seawater intrusion, seawater upwelling, and connate water (Scott et al., 1991).

3.0 FIELD ACQUISITION PARAMETERS, EQUIPMENT, AND DATA PROCESSING

3.1 Field Acquisition Parameters

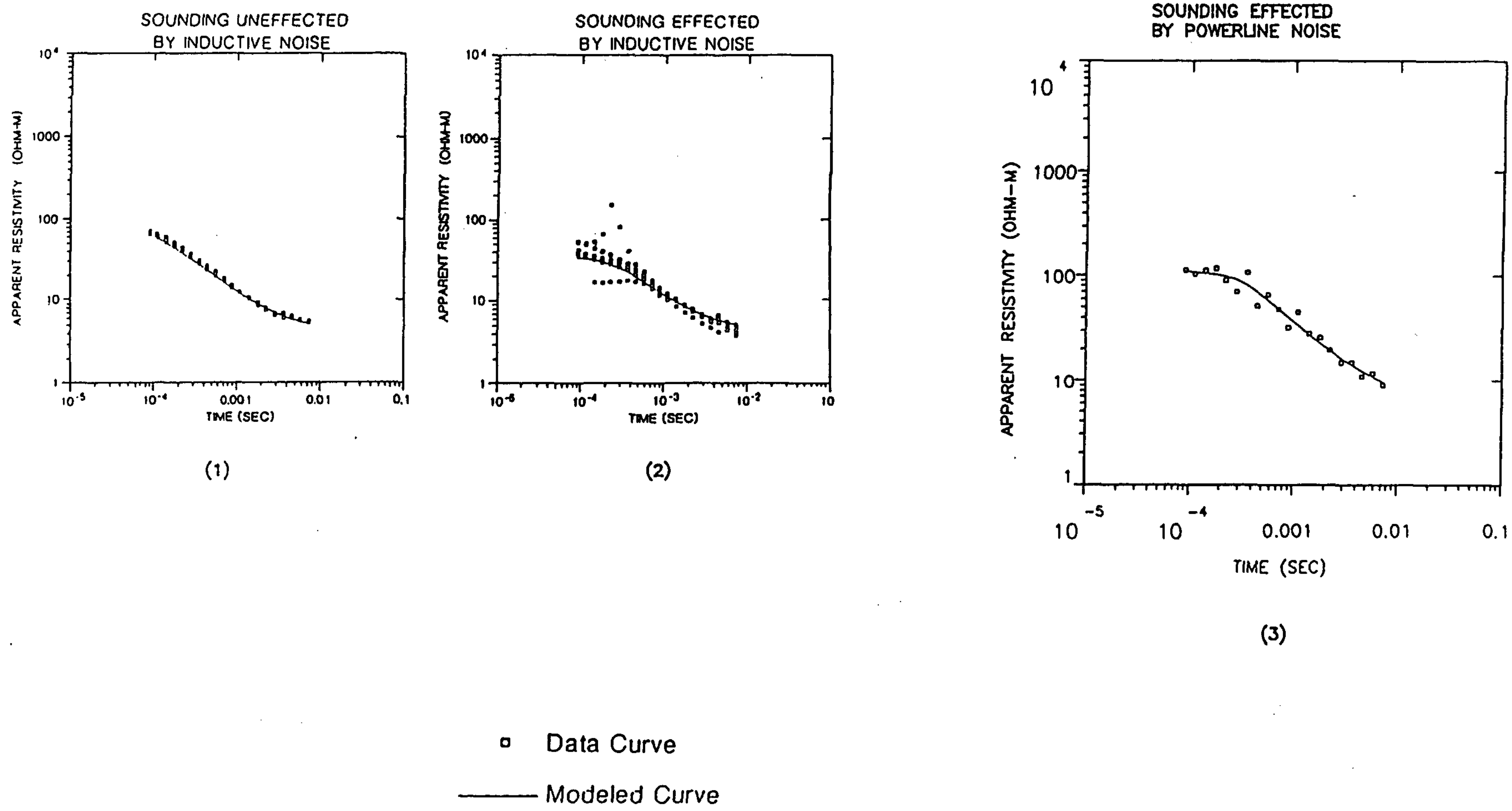
Twenty four sites were selected by SJRWMD for TDEM soundings. The TDEM method involves the laying of 12 gauge AWG wire in an approximately square or rectangular loop on the ground surface over a large area (on the order of 10^6 ft^2 or greater). This is the transmitter, or Tx loop. The Tx loop is energized by a bi-polar electrical current (up to a maximum of 30 amperes). The response of the ground is sensed by a centrally located (midpoint of the Tx loop) search coil (receiver, or Rx coil). The transient response seen by the receiver is recorded digitally by the data-logging module.

To attain the depth of exploration required to determine the depth to the saltwater interface within SJRWMD, Tx loop sizes ranging from 550 ft x 300 ft up to 1,000 ft x 1,929 ft were employed where possible. Tx loop sizes at individual sites were prescribed by SJRWMD personnel and adjusted in the field to accommodate field logistical constraints such as obvious metal structures, power lines, or limited areas of access. Tx loops were laid out using premarked cables and a compass. Loop dimensions, transmitter currents, and other site-specific information are included in the individual descriptions of the sounding results (Section 5.0).

In addition to the main sounding data set at a given site, SDII also collected quality control (QC) sounding data using an off-center Rx coil location. That is, if there was an obvious, possible source of noise (pipeline or power line, for example) to one side of a Tx loop, then the coupling of the incident pulse from the transmitter with that possible noise source would impart voltage gradients within the loop that would not exist otherwise. In the absence of noise sources, the voltage measured in the loop is very well behaved; it does not vary much with position of the Rx coil. To check for possible interference sources, several soundings are performed 10-15 percent of the Tx loop length away from the initial Rx coil location. It can be shown that the maximum vertical EMF (electromotive force) occurs at the center of the Tx loop and that the EMF remains relatively flat to about 10 percent L (L being the length of one of the sides of the Tx loop) off center (Blackhawk, 1990). If a shallow noise source is affecting the data quality, it would impose a higher EMF gradient in one or more directions off center from the Tx loop. On Figure 3-1, examples of TDEM data that are; 1) unaffected by induction noise, 2) affected by induction noise (as from buried metal pipelines), and 3) affected by powerlines are provided. None of the TDEM sites surveyed during the SDII investigation appeared to have been affected by noise sources.

QC measurements were generally performed at two to four different locations about the loop center. If the data from the off-center Rx location matches the central-loop data, then the data are not noise-affected. If they diverge significantly, the data are noise-affected and should not be used.

The SDII field crew consisted of one project geophysicist, Mr. James E. Bock, who was assisted by two geophysical field technicians. At several sites, Mr. Bock was assisted by Mr. Michael J. Wightman, P.G., Senior Geophysicist, Vice-President of Operations. All data reductions and analysis was done by Mr. Wightman. A representative of SJRWMD, Dr. David Toth, was also present in the field. Table 3-1 summarizes the daily field activities.



SOURCE: CEES, 1992

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EXAMPLES OF NOISE AFFECTS
UPON TDEM DATA

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DRAWN BY:	RBT	DATE:	06/21/95	

TABLE 3-1
DAILY LOG OF FIELD ACTIVITIES

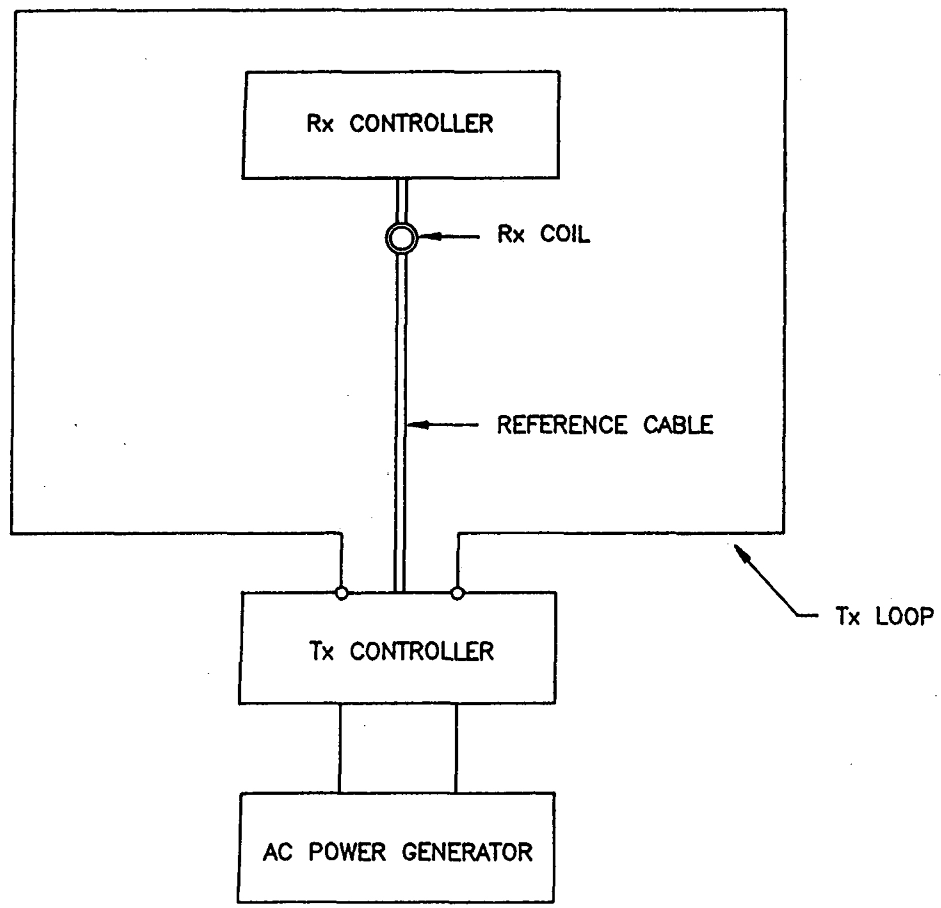
DATE	SITE	ACTIVITIES
5/2/95	Herlong Airport	Read EM-37 TDEM sounding.
5/3/95	Hunters Ridge	Read EM-37 TDEM sounding.
5/4/95	Riviera Country Club	Read EM-37 TDEM sounding.
5/4/95	NSB - West	Read EM-37 TDEM sounding.
5/5/95	Port Orange	Read EM-37 TDEM sounding.
5/5/95	Daytona Beach Country Club	Read EM-37 TDEM sounding.
5/6/95	Tiger Bay WMA	Read EM-37 TDEM sounding.
5/6/95	Reed Canal	Read EM-37 TDEM sounding.
5/6/95	Samsula	Read EM-37 TDEM sounding.
5/7/95	Oak Hill	Read EM-37 TDEM sounding.
5/7/95	Scottsmoor	Read EM-37 TDEM sounding.
5/7/95	Osteen	Read EM-37 TDEM sounding.
5/8/95	Big Lake	Read EM-37 TDEM sounding.
5/8/95	Glen Abbey	Read EM-37 TDEM sounding.
5/8/95	Orange City - East	Read EM-37 TDEM sounding.
5/8/95	Astor Park	Read EM-37 TDEM sounding.
5/9/95	Barberville	Read EM-37 TDEM sounding.
5/9/95	ONF - Hopkins Prairie	Read EM-37 TDEM sounding.
5/10/95	Volusia County Landfill	Read EM-37 TDEM sounding.
5/10/95	ONF - Forest Hills	Read EM-37 TDEM sounding.
5/11/95	Seminole State Forest	Read EM-37 TDEM sounding.
5/11/95	Big Oak Ranch	Read EM-37 TDEM sounding.
5/12/95	Lake Louise	Read EM-37 TDEM sounding.
5/12/95	Rosen Property	Read EM-37 TDEM sounding.

3.2 Equipment

SDII employed the Geonics EM-37 Protem system for the investigation. The principal components of the EM-37 systems are:

- Transmitter (Tx) loop (variable length 12 gauge AWG wire, insulated)
- Gasoline power generator/EM37 transmitter box (maximum 30 ampere, bi-polar square wave)
- Receiver (Rx) coil (100 square meter effective area)
- Protem Receiver Module (system control and parameter selection)

A block diagram of the field setup of the system is given in Figure 3-2. Once setup is completed, a current waveform, as depicted by Figure 3-3, is injected into the Tx loop. The rapid turn-on and turn-off of current in the loop creates a strong EMF which interacts with earth and man-made materials to generate eddy currents within conductive materials. These currents have an associated secondary magnetic field which is detected by the Rx coil as shown on Figure 3-3. Eddy currents close to the Tx coil are induced first and decay below detection limits before deeper currents. Currents in resistive materials also decay faster than currents in conductors. Deeper conductors contribute to responses at later times at the Rx coil than do shallower subsurface features. Thus, by measuring the rate and nature of the decaying magnetic field seen by the Rx coil after Tx shutoff, the distribution of subsurface resistivity can be determined.



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BLOCK DIAGRAM
EM37 FIELD SETUP

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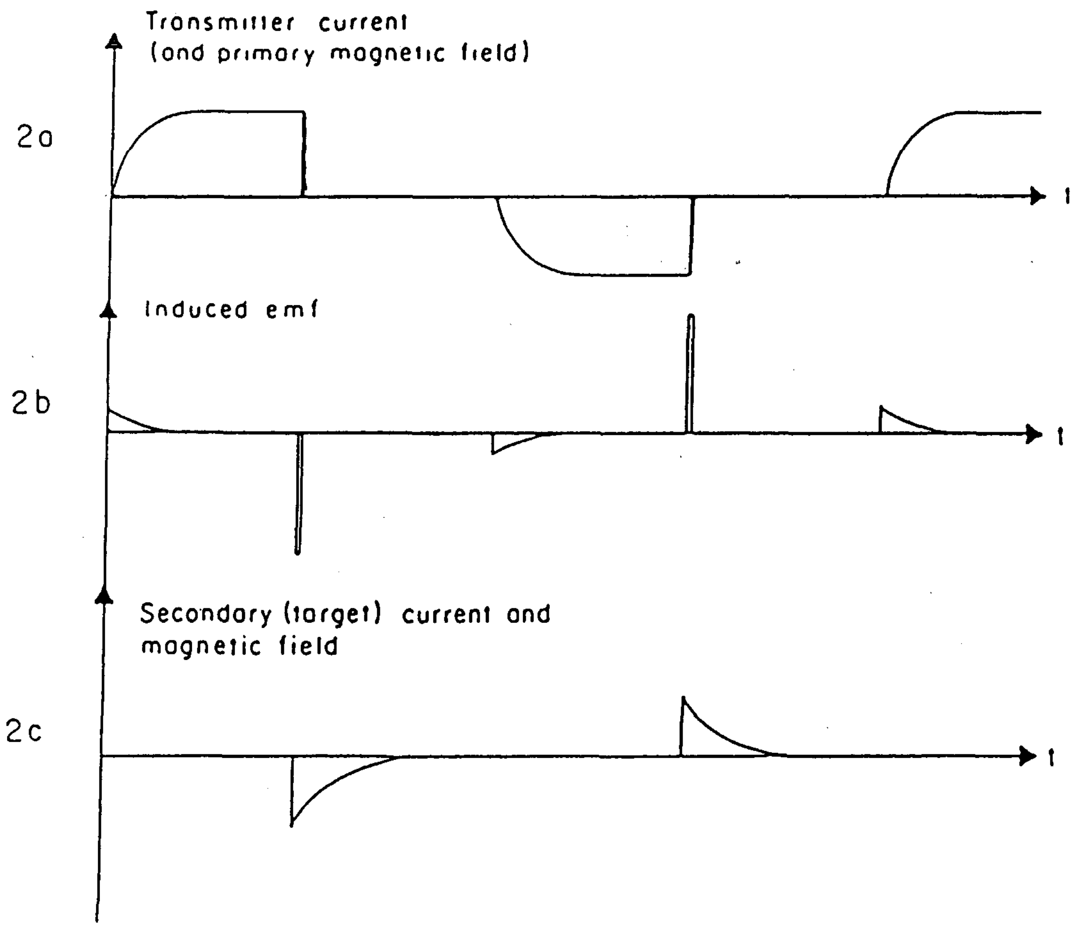

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SYSTEM WAVEFORMS
TDEM

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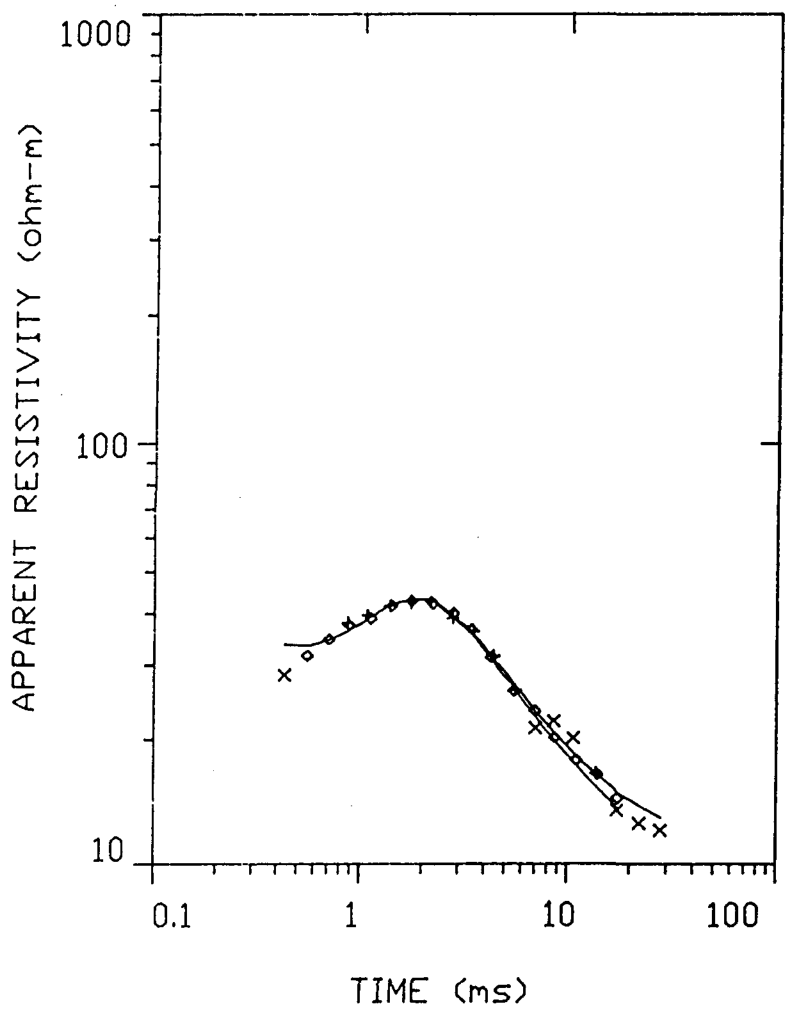
The survey variables that can be selected by the TDEM operator are the size of the Tx coil, Tx coil current (which controls the penetration depth), analog stacking (number of repetitions of summed tests in order to increase signal-to-noise ratio), gain at the receiver, and repetition rate (frequency) of the current cycles. For this investigation SDII used three different frequencies (3 Hz, 7.5 Hz, and 30 Hz) to acquire detailed and overlapping segments of the decay curve which enabled resolution of shallow (30 Hz data) and deeper (3, 7.5 Hz data) portions of the subsurface.

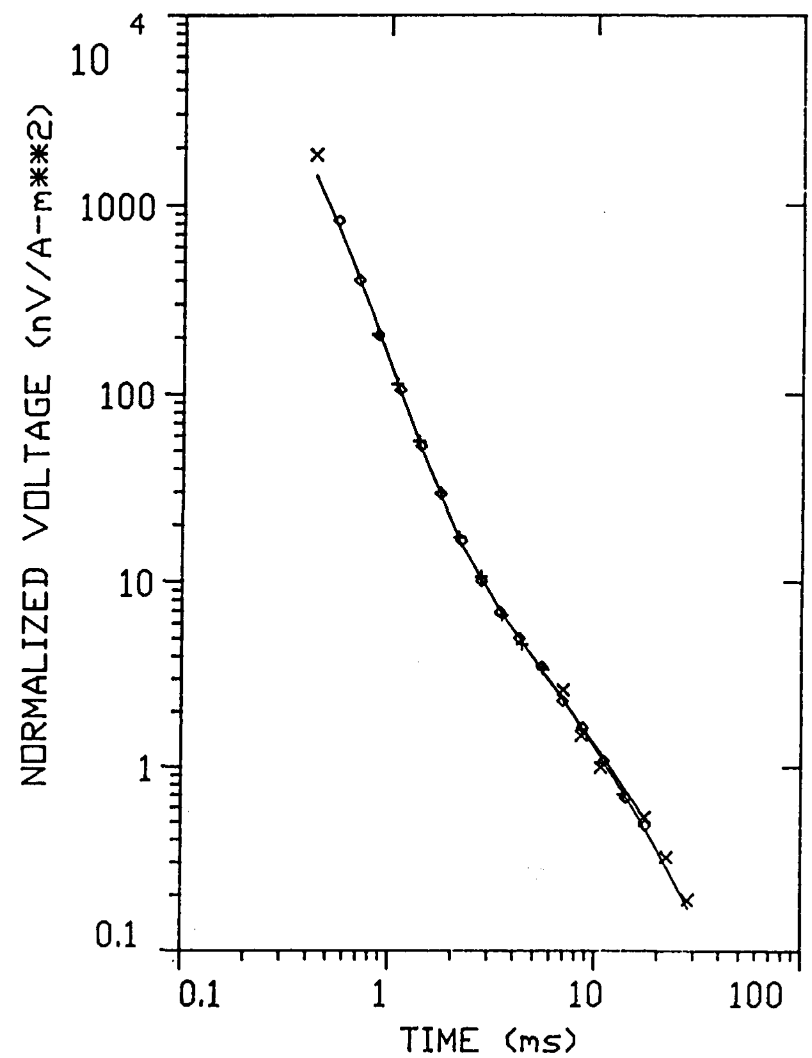
3.3 Data Processing

Data acquired by the Protem receiver is downloaded to a portable computer for data editing, processing, and interpretation (inversion). The primary software program used to process the data was TEMIXGL (Interpex, Ltd.). This program accepts raw data from the Protem receiver module and proceeds through the following general processing steps:

Data Edit - Modification of survey description information, for example, loop size, Tx coil amperage, which may have been entered improperly are performed here. Decay curves for all frequencies and gain values taken at a site are displayed; suspect data points can be deleted and the individual curves for different frequencies and gains are averaged and converted to a single, apparent resistivity versus time (after Tx turn-off) field curve (see Figure 3-4, for an example of voltage data and apparent resistivity versus time curves).

The field curve is comprised of 30 data points, where each data point represents an apparent voltage collected at a particular time or time gate. Each frequency has 20 time gates and each frequency overlaps the proceeding or preceding frequency by 10 time gates.





—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

X APPARENT RESISTIVITY VALUES NOT USED IN MODEL

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DEMONSTRATION TDEM SURVEY RESULTS SHOWING NORMALIZED VOLTAGE AND APPARENT RESISTIVITY VERSUS TIME

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EXM-2	3-4
DRAWN BY:	RBT	DATE:	06/21/95	

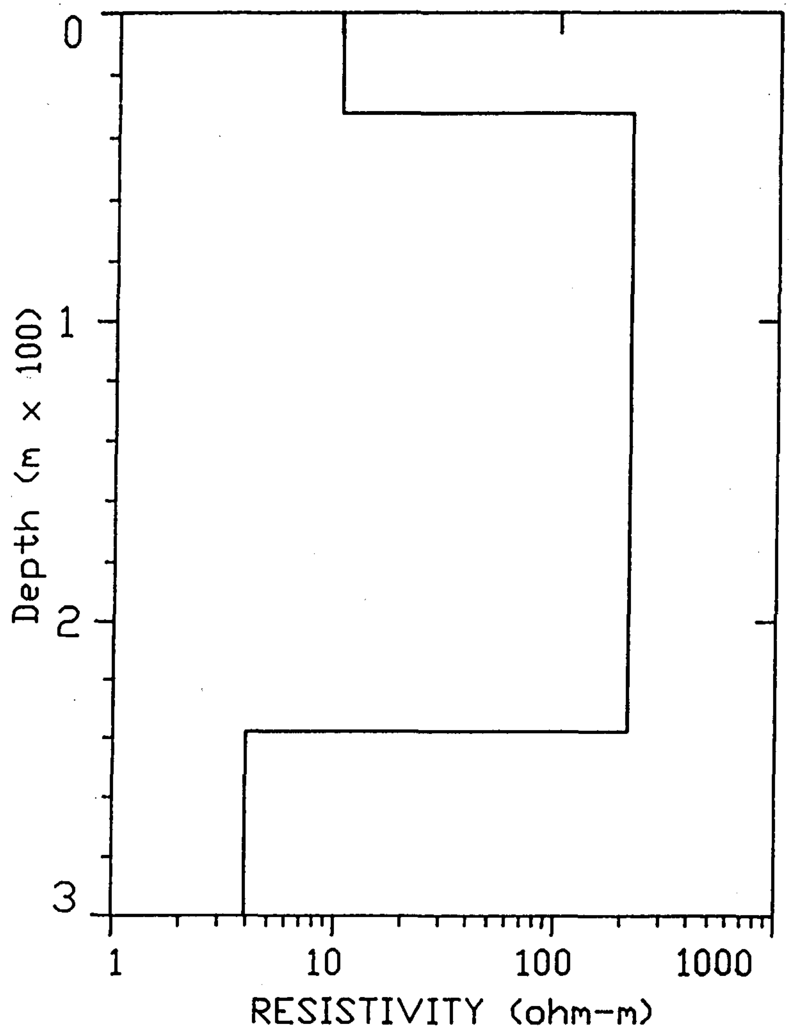
Combining data collected at the 30 Hz and 3 Hz frequency produces one sounding curve with 30 time gates, with an overlap between time gates 10 through 20. Data collected at 7.5 Hz provides apparent resistivity values for time gates 5 through 25. An advantage of using 30, 7.5, and 3 Hz frequencies for all the soundings is that different gains can be used for each frequency. Lower gains can be used at a frequency of 30 Hz to avoid saturating early channels, and higher gains can be used at 3 Hz to amplify weaker signals in later channels. The combined data is interpreted as one sounding curve. The modeled sounding curve does not always appear as a continuous single sounding curve (Figure 3-4). This is because during the modeling process, curves are developed for data collected at each frequency. The calculations for the final geoelectric model, however, are based upon a single average curve which is developed from the data collected at each frequency.

Initial Model - Review of the apparent resistivity curve shape allows a trained geophysicist to make an initial guess as to the true resistivity versus depth (layered) model which would produce the observed data set. After such a model is created, a field curve is calculated from the model and compared with the observed data. The degree of agreement between model and field data is measured statistically and expressed as the fitting error. The geophysicist may then, in an interactive mode, adjust the model to obtain a better fit or can modify the starting model.

As part of the modeling procedure early and late time data is commonly discarded. Typically, apparent resistivity values collected at early times are discarded because the data collected at these times is often not representative of geological conditions because of the affect of the Tx coil shut off not being truly instantaneous. In the final modeling of this data, in may appear that the model curve passes through several of these early time points, but not all the points. In such a case, all the early time data points are discarded because it is not good modeling practice to delete data points from the middle portion of a curve and utilize data points preceding them. Often, later time data is also not representative of geological conditions because the primary EMF field strength has been too dissipated to provide a representative apparent resistivity value. Suspect late time data is also discarded. Poorly fitting data points are marked with a "x", utilized data points are marked with a square (Figure 3-4). Modeled curves quite often demonstrate an upward curvature during early times. This upward curvature is usually due the TDEM response not following theoretical behavior or the affect of the Tx coil shut off not being truly instantaneous. This deviation produces a distortion, however, this distortion has little or no affect on the results from the TDEM survey when the target depth is several hundred ft below land surface (bls).

Automatic Inversion - Based upon the initial model, the program will attempt to create a better fit to the observed data using an iterative, Inman Ridge Regression routine to adjust layer thicknesses and resistivities until a minimum error of fit is realized; our goal was to produce models which fit the observed data within a 5% error of fit. This final model is termed the "best fit" model (see Figure 3-5). Only the data points utilized in the determination of the modeled curve are used in calculation of the fitting error.

Equivalence Analysis - Electrical resistivity methods are, as with other geophysical methods, plagued by the so-called "non-uniqueness" problem. That is, while a best-fit model produces an acceptable fit to field data curves, there are several other models having different thicknesses and resistivities which will also provide a "reasonable" fit to the same data. TEMIXGL will produce a suite of models, using the best-fit model as a start, which would produce a reasonably close fit (see Figure 3-6). If the equivalence model segments (layers and resistivities) are tightly constrained then the layering provided by the best-fit model is very



Fitting Error: 4.091%

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DEMONSTRATION TDEM SURVEY RESULTS
SHOWING BEST-FIT MODEL

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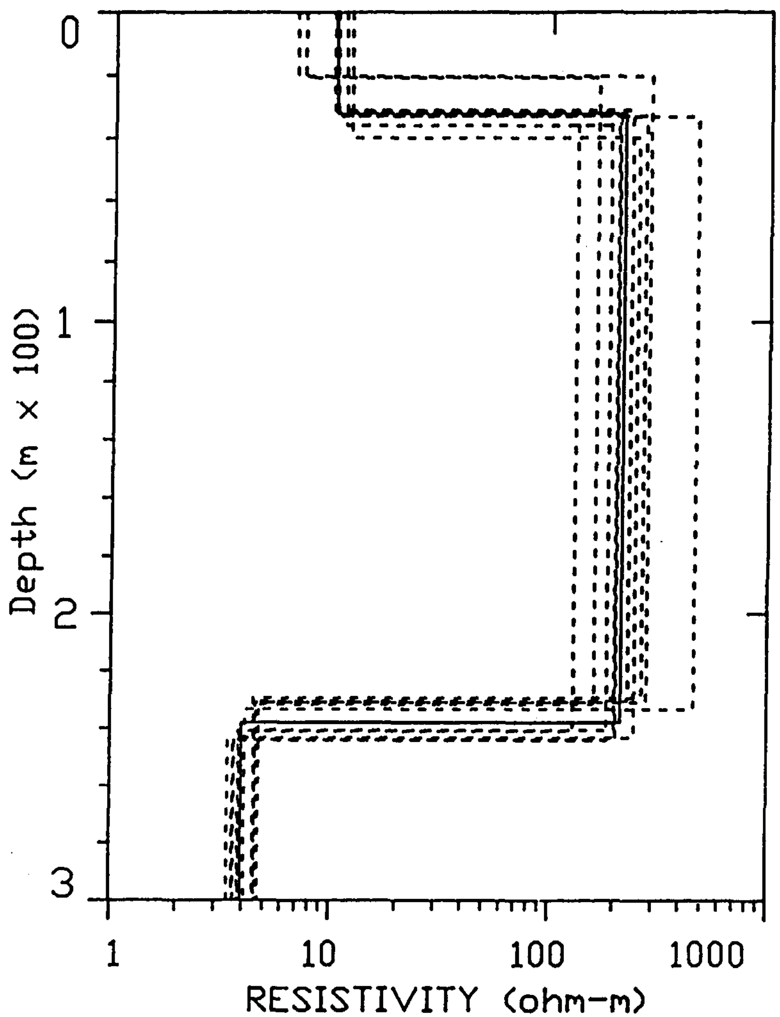

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DEMONSTRATION TDEM SURVEY RESULTS SHOWING RESULTS OF EQUIVALENCE ANALYSIS

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CHECKED BY:	MJW	DRAWING NO.:	EXM-4	3-6
DRAWN BY:	RBT	DATE:	06/21/95	

good. Those parts of the equivalence models that scatter quite a bit around the best-fit model show less confidence in the absolute values of layer thickness and resistivity. A poorly constrained equivalence model for a given layer means either there are too few data points in the raw data to adequately describe that layer or the data is just not very sensitive to that specific layer.

It is important to note that the interpretations resulting from the TDEM data are, specifically, one-dimensional models of layer thickness and layer resistivity. That is, if the earth subsurface is not, effectively, a one-dimensional horizontal layer, then the produced model may have inherent error. Also, the depths to levels of chloride concentration and not resistivity rely on empirical relationships between resistivity and chloride concentration. This latter point will be detailed further in Section 4.0.

4.0 TECHNICAL APPROACH TO SATISFYING SURVEY OBJECTIVES

4.1 General

As stated previously, the final product of the *geophysical* investigation is a best-fit, one-dimensional model of layer resistivity versus depth. To satisfy the requirements of the survey, these models must be correlated with models of chloride concentration versus depth. Specifically, the resistivity structure must be viewed in terms of determining the depth of occurrence of the 250 mg/l isochlor and the depth to salt water as defined by the 5,000 mg/l isochlor. To ensure that the results from the 1995 TDEM survey are directly comparable to and compatible with the results of TDEM surveys performed in previous years (Blackhawk, 1990; CEES, 1992; and SDII, 1993 and 1994), SDII will utilize the identical relationships between resistivity and isochlor depths for the Floridan aquifer. These relationships and assumptions are detailed in the following sections. However, it must be realized that correlations of TDEM-derived layer conductivities with specific chloride values are approximate and based on several simplifying assumptions.

4.2 Correlation of Inverted Geoelectrical (Resistivity) Profiles to Chloride Concentrations

In previous studies, it was presumed that the depth to salt water was such that this interface was inferred to occur within the Floridan aquifer system. The only noted exceptions to this were soundings in the area of Jacksonville where the great depth (>2,000 ft) and the very low resistivity (< 2 ohm-m) of the deep, low resistivity layer placed the interface below the Lower Floridan aquifer (CEES, 1992). For such sites with very low resistivities (<2 ohm-m) and where the depth to salt water is greater than 2,000 ft, the published relationships between resistivity and chloride concentration cannot be used; it is merely presumed that the chloride concentration at these sites exceeds 5,000 mg/l for the saltwater section.

In cases where the electrical response between the Floridan aquifer and overlying sediments are indistinguishable, the hydrostratigraphic units must be combined into a single geoelectric layer. Similar to the situation where the interface is below the Floridan aquifer, the published relationships between resistivity and chloride concentration are generally invalid and the chloride concentration in ground water above the geoelectric layer cannot be determined. However, if the resistivity of the first layer is greater than 80 ohm-m (see discussion below), the chloride concentration in the portion of the Floridan aquifer in this layer can be concluded to be below 250 mg/l, even though this layer contains sediments above the Floridan aquifer. The reason for this is because of the high resistivity. Surficial sediments, Holocene and Miocene deposits, and the Hawthorn Group have low resistivities. A high resistivity (greater than 80 ohm-m) can only be obtained if the chloride concentration were below 250 mg/l (assuming 25% porosity). Conversely, if the Floridan aquifer contains brackish to salt water and if the resistivity of a layer containing a portion of the Floridan aquifer were below 20 ohm-m, it can be concluded that the 250 mg/l isochlor is not present in the Floridan aquifer.

For the majority of soundings conducted previously, the saltwater interface positions were "inferred to occur within the Floridan aquifer system" (Blackhawk, 1990; CEES, 1992; and SDII, 1993 and 1994) and, therefore, the published relationships between resistivity and chloride concentration are applicable. When the saltwater interface occurred within the Floridan aquifer, the following procedure was used in both this and previous studies (Blackhawk, 1990; CEES, 1992; and SDII, 1993 and 1994).

The carbonate rocks of the Floridan aquifer system (as opposed to the highly variable lithologies of overlying formations) are expected to be uniform and, as such, their resistivities are determined principally by porosity and specific conductance of pore fluids. The governing empirical "law" relating formation resistivity (Ro), fluid resistivity (Rw) and porosity (ϕ) in a clay-free lithology is Archie's Law:

$$F = Ro/Rw = a\phi^{-m} \qquad (1)$$

where F = "formation factor" and "a" and "m" are empirically derived constants which are specific to a given formation in a given area. Previous TDEM reports have used the values of m = 1.6 and a = 1 from Kwader (1982) as being most appropriate for the Floridan aquifer. These values are from studies of wells completed in the Upper Floridan aquifer in Seminole County, Florida.

Kwader (1982) has also established the following relationship from his study of Seminole County wells:

$$Cl = (3500/Rw) - 153 \qquad (2)$$

where Cl is the equivalent chloride concentration in mg/l and Rw is fluid resistivity in ohm-meters. Extrapolating these expressions by Kwader outside of Seminole County presumes that the relative ionic chemistry (especially a chloride/sulfate ratio of 5:1) remains the same or reasonably close to conditions in that area. Significant chemical variation would cause Equation 2 to be, quite likely, invalid.

Because formation resistivity, Ro, is what the geophysical analysis of TDEM data has produced, a combination of equations (1) and (2) allows for determining a functional relationship between chloride concentration, inferred formation resistivity, and porosity:

$$Cl = (3500\phi^{-1.6}/Ro) - 153 \tag{3}$$

or, for an assumed 25% porosity for the Upper Floridan aquifer as per previous TDEM reports:

$$Cl = (32{,}163/Ro) - 153 \tag{4}$$

Linking this relationship to the cited survey objectives, we would expect that a Floridan aquifer with 25% porosity, similar water chemistry (5:1 chloride to sulfate ratio) to the Kwader study, and a 250 mg/l chloride concentration would yield a measured formation resistivity of 80 ohm-m. Higher resistivities than this would indicate fresher water. Chloride concentrations of 5,000 mg/l would correspond to formations resistivities of 6.2 ohm-m; higher concentrations would yield lower resistivities. These values, then, are what we should expect to see for the fresh and saltwater sections of the Floridan aquifer.

One final consideration, besides porosity and similar chemical species/ratios, is made by previous reports (Blackhawk, 1990; CEES, 1992; and SDII, 1993 and 1994) and, again, will be adhered to in this 1995 study. The relationships cited are for a clearly defined, carbonate section within the Floridan aquifer (i.e., beneath Miocene deposits or the Hawthorn Group). If there is a clearly defined thickness of Holocene to Miocene deposits, the Hawthorn Group, or surficial sediments from the electrical sounding results and if that thickness is in agreement with published thicknesses of such deposits for the area of a specific site, then there is presumed to be no affect of the measured formation resistivity for the Floridan aquifer due to interfingering of clay stringers of the Hawthorn Group or Holocene to Miocene deposits. This means that the inversion resistivity results representing the Floridan aquifer layer are valid.

4.3 Determination of Depth to 250 mg/l and 5,000 mg/l Isochlors

The previous discussion of the relationship of formation conductivity to chloride content is particularly applicable to geoelectrical measurements made on a fine, highly resolved scale, such as a borehole electrical log, where an almost continuous measure of resistivity versus depth is available. As known from geophysical logs and water quality studies, the saltwater interface is not a knife-edge interface in the subsurface but is a gradational interface. Within the freshwater section, we would also expect the chloride concentration to follow a gradually increasing-downwards distribution. Therefore, the TDEM sounding, which presents the subsurface as a sequence of a few layers of presumed, uniform resistivity, is not an actual representation of the true subsurface but a low resolution version of it. The saltwater interface (chlorides greater than 5,000 mg/l), which exhibits a much higher gradient of chloride concentration than in the overlying fresher water, comes closest to being a true interface. This is why depth to the saltwater interface from TDEM should be close to the low resistivity layer detected.

Actual reported depth to the 5,000 mg/l isochlor in previous reports (CEES, 1992; SDII, 1993 and 1994) is determined by the contrast in resistivity of the layers above and below the geoelectrical interface. If the contrast is large (e.g., greater than 80 ohm-m above and less than 20 ohm-m below), then the depth to the 5,000 mg/l isochlor is assumed to be 50 ft below the interface depth determined from geoelectrical inversion. If the contrast is small (e.g., a

20-80 ohm-m layer above and less than 20 ohm-m layer below), the depth to the 5,000 mg/l isochlor is taken as equal to the depth of the interface determined from the geoelectrical inversion. These adjustments are intended to correct for the existence of the transition zone.

The criterion used to define the depth to the 250 mg/l isochlor in previous TDEM surveys for SJRWMD (Blackhawk, 1990; CEES, 1992; and SDII, 1993 and 1994) is also a data-based criterion. That is, the final reported position of this isochlor, relative to the boundary between the Floridan aquifer freshwater geoelectrical layer and the saltwater geoelectrical layer depends upon the layer resistivities above and below the interface as determined by the inversion. Four data classes have been defined based upon a reference value for resistivity of 80 ohm-m for a portion of the Floridan aquifer. We reproduce the following criteria for positioning the 250 mg/l isochlor (CEES, Table 4-2, 1992).

Summarizing Table 4-2 in CEES (1992), if the Floridan freshwater section is in excess of 80 ohm-m while the underlying layer is less than 20 ohm-m (so-called Class A geoelectrical section), then the 250 mg/l isochlor is placed at a position 50 ft higher than the saltwater interface depth defined from geoelectrical inversion.

If the Floridan freshwater section is in excess of 80 ohm-m while the underlying layer is between 20-40 ohm-m (so-called Class B section), then the 250 mg/l isochlor is placed 25 ft above the saltwater interface depth defined from geoelectrical inversion.

If the Floridan freshwater section is in excess of 80 ohm-m and the underlying layer is between 40-80 ohm-m (Class C), then the 250 mg/l isochlor is placed at the interface.

Finally, if there is no contrast (i.e., a uniform layer of > 80 ohm-m; Class D), then we are not seeing an expected saltwater interface within the depth of exploration of the field sounding. Also, there is no detectable/mappable 250 mg/l isochlor.

In the above determinations for the 250 mg/l isochlor, the "depth" to the saltwater interface is the depth to the low resistivity layer taken directly from the TEMIXGL inversion and not the corrected 5,000 mg/l depth as discussed previously.

5.0 RESULTS AND DISCUSSION

5.1 Summary of Results

A summary of the 1995 TDEM investigation is presented in this section. The summary includes the resulting geoelectrical inversions, 250 mg/l isochlor depth and the 5000 mg/l isochlor depth. More detailed presentation of the individual site results are contained in the following sections 5.2 through 5.25. Each individual site section will present a site description, site map, apparent resistivity versus time (data) curves, the best-fit geoelectrical section with equivalence analysis, and inferred depths to the 5,000 mg/l (salt water) and 250 mg/l isochlors.

Table 5.1-1 lists the 24 sites with summary information describing site number, name, residing county, latitude, longitude and loop size.

Table 5.1-2 summarizes the results of the TEMIXGL geoelectrical inversion section (number of layers, layer thicknesses and resistivities, and range of equivalence models for each layer parameter).

Table 5.1-3 summarizes the estimated chloride content of the saltwater layer assuming porosities of 25, 30, and 35% for the Floridan Aquifer System.

Table 5.1-4 summarizes the interpreted depths to the 250 mg/l and the 5,000 mg/l isochlors at each site based upon the criteria outlined in Section 4.3 and as utilized in TDEM surveys performed for SJRWMD in previous years (Blackhawk, 1990; CEES, 1992/SJ93-SP1; and SDII, 1993 and 1994). As in previous years, these calculations are made assuming a 25% porosity for the Floridan Aquifer System and a 5:1 chloride-to-sulfate ratio for the ground water chemistry. The estimated chloride-to-sulfate ratios at each of the sites is provided in Table 5.1-4.

TABLE 5.1-1 SUMMARY OF TDEM SITE SURVEY INFORMATION					
SITE NUMBER	**SITE NAME**	**RESIDING COUNTY**	**LATITUDE**	**LONGITUDE**	**LOOP SIZE (in Feet)**
1	Herlong Airport	Duval	30°16'09"N	81°48'38"W	1000 x 1929
2	Hunters Ridge	Flagler	29°16'18"N	81°10'09"W	1075 x 1312
3	Riviera Country Club	Volusia	29°15'27"N	81°03'26"W	558 x 154
4	NSB - West	Volusia	29°00'32"N	81°00'22"W	1000 x 1000
5	Port Orange	Volusia	29°07'26"N	81°02'44"W	801 x 1155
6	Daytona Beach Country Club	Volusia	29°11'09"N	81°01'13"W	138 x 568
7	Tiger Bay WMA	Volusia	29°09'26"N	81°09'46"W	1300 x 715
8	Reed Canal	Volusia	29°09'06"N	81°01'28"W	758 x 246
9	Samsula	Volusia	29°00'33"N	81°03'35"W	1000 x 500
10	Oak Hill	Volusia	28°52'39"N	80°52'15"W	450 x 538
11	Scottsmoor	Brevard	28°46'32"N	80°52'42"W	550 x 300
12	Osteen	Volusia	28°51'07"N	81°09'55"W	1155 x 500
13	Big Lake	Volusia	28°51'43"N	81°12'37"W	500 x 500
14	Glen Abbey	Volusia	28°53'46"N	81°17'49"W	732 x 210
15	Orange City - East	Volusia	28°56'10"N	81°16'21"W	1000 x 500
16	Astor Park	Lake	29°09'35"N	81°34'24"W	800 x 900
17	Barberville	Volusia	29°09'55"N	81°26'54"W	1122 x 1000
18	ONF - Hopkins Prairie	Marion	29°16'16"N	81°40'05"W	1150 x 800
19	Volusia County Landfill	Volusia	29°06'51"N	81°05'42"W	500 x 1150
20	ONF - Forest Hills	Lake	29°00'55"N	81°25'36"W	1300 x 700
21	Seminole State Forest	Lake	28°52'55"N	81°25'42"W	1210 x 1320
22	Big Oak Ranch	Seminole	28°39'33"N	81°05'35"W	500 x 500
23	Lake Louise	Orange	28°35'40"N	81°05'34"W	643 x 912
24	Rosen Property	Orange	28°31'52"N	81°06'35"W	650 x 1283

TABLE 5.1-2
SUMMARY OF GEOELECTRICAL SECTIONS WITH RANGE OF EQUIVALENCE

SITE NAME	NUMBER OF MODELED LAYERS IN GEOELECTRICAL SECTION	LAYER 1						LAYER 2						LAYER 3						TOTAL DEPTH TO DEEPEST CONDUCTOR WHICH IS INTERPRETED AS SALT WATER (Meters)*		
		RESISTIVITY ρ_1 (ohm-m)			THICKNESS h_1 (meters)*			RESISTIVITY ρ_2 (ohm-m)			THICKNESS h_2 (meters)*			RESISTIVITY ρ_3 (ohm-m)			THICKNESS h_3 (meters)*					
		Min	Best	Max	Min	Best	Max	Min	Best	Max	Min	Best	Max	Min	Best	Max	Min	Best	Max	Min	Best	Max
1 Herlong Airport	3	75	80	86	104	116	128	17	23	31	27	38	57	398	490	658	--	--	--		Not seen	
2 Hunters Ridge	2	55	55	56	258	261	263	1.3	1.4	1.6	--	--	--	--	--	--	--	--	--	258	261	263
3 Riviera Country Club	3	18	19	20	42	49	56	51	64	81	72	83	91	1.3	1.6	2.0	--	--	--	132	132	134
4 NSB - West	3	27	27	28	64	70	79	56	59	66	213	224	231	2.9	3.2	4.3	--	--	--	292	293	295
5 Port Orange	2	39	40	41	196	207	216	8.0	9.6	11.5	--	--	--	--	--	--	--	--	--	196	207	216
6 Daytona Beach Country Club	2	17	17	18	68	70	72	1.5	1.7	1.9	--	--	--	--	--	--	--	--	--	68	70	72
7 Tiger Bay WMA	2	93	94	95	331	337	341	1.3	1.4	1.6	--	--	--	--	--	--	--	--	--	331	337	341
8 Reed Canal	2	48	49	50	191	193	195	1.8	2.1	2.4	--	--	--	--	--	22	--	--	--	191	193	195
9 Samsula	3	27	29	32	26	26	26	55	60	65	229	258	274	5.3	8.6	14.5	--	--	--	255	284	300
10 Oak Hill	2	20	20	21	89	92	94	1.9	2.1	2.2	--	--	--	--	--	--	--	--	--	89	92	94
11 Scottsmoor	2	39	40	42	60	61	63	3.8	3.9	4.0	--	--	--	--	--	--	--	--	--	60	61	63
12 Osteen	2	45	47	51	102	108	114	6.6	7.7	8.9	--	--	--	--	--	--	--	--	--	102	108	114
13 Big Lake	2	157	278	881	77	79	82	3.2	3.5	3.8	--	--	--	--	--	--	--	--	--	77	79	82
14 Glen Abbey	2	50	51	52	192	197	202	4.7	5.5	6.5	--	--	--	--	--	--	--	--	--	192	197	202
15 Orange City - East	3	151	156	158	187	193	199	15.7	18.0	20.3	89	94	98	2.3	3.1	3.6	--	--	--	284	287	289
16 Astor Park	3	42	44	46	31	31	31	153	161	171	317	323	328	12.7	14.2	16.2	--	--	--	347	354	358
17 Barberville	3	22	23	25	40	40	40	128	167	240	216	222	227	2.6	3.2	3.9	--	--	--	255	261	266
18 ONF - Hopkins Prairie	2	85	94	107	105	113	120	12.6	13.6	14.7	--	--	--	--	--	--	--	--	--	105	113	120
19 Volusia County Landfill	2	60	62	64	178	202	226	19	24	29	--	--	--	--	--	--	--	--	--		Not Seen	

20 ONF - Forest Hills	3	93	102	113	32	32	32	190	202	214	369	376	383	11.7	14.4	17.8	--	--	--	401	408	415
21 Seminole State Forest	3	85	88	92	149	160	169	18	21	24	182	199	213	3.5	5.0	6.8	--	--	--	344	359	372
22 Big Oak Ranch	3	31	33	35	24	24	24	80	89	100	125	128	130	5.6	5.9	6.2	--	--	--	150	152	154
23 Lake Louise	3	39	41	44	43	43	43	61	65	72	207	223	234	7.3	9.4	12.3	--	--	--	250	266	277
24 Rosen Property	3	35	36	37	95	109	124	84	106	142	207	232	258	9.6	13.0	19.2	--	--	--	328	341	356

* 1 meter equals 3.28 ft.

TABLE 5.1-3
ESTIMATED DEPTHS TO SALT WATER AND ESTIMATED CHLORIDE CONCENTRATIONS
AT THREE POROSITIES

SITE	FORMATION RESISTIVITY (ohm-m)	INTERPRETED DEPTH OF SALT WATER[1/] (ft)	CHLORIDE CONCENTRATION (mg/l) = 25%	CHLORIDE CONCENTRATION (mg/l) = 30%	CHLORIDE CONCENTRATION (mg/l) = 35%
1 Herlong Airport	Not present	Beyond system limit	-	-	-
2 Hunters Ridge	1.4	856	22821	17008	13257
3 Riviera Country Club	1.6	433	19949	14863	11581
4 NSB - West	3.2	961	9898	7355	5714
5 Port Orange	9.6	679	3197	2350	1803
6 Daytona Beach Country Club	1.7	230	18767	13980	10891
7 Tiger Bay WMA	1.4	1106	22821	17008	13257
8 Reed Canal	2.1	633	15163	11288	8787
9 Samsula	8.6	932	3587	2641	2030
10 Oak Hill	2.1	302	15163	11288	8787
11 Scottsmoor	3.9	200	8094	6007	4661
12 Osteen	7.7	354	4024	2967	2285
13 Big Lake	3.5	259	9037	6711	5211
14 Glen Abbey	5.5	646	5695	4215	3260
15 Orange City - East	3.1	942	10222	7597	5903
16 Astor Park	14.2	1161	2112	1539	1169
17 Barberville	3.2	856	9898	7355	5714

18 ONF - Hopkins Prairie	13.6	371	2212	1614	1227
19 Volusia County Landfill	Not Present	Beyond System Limit	--	--	--
20 ONF - Forest Hills	14.4	1339	2081	1515	1151
21 Seminole State Forest	5.0	1178	6280	4652	3602
22 Big Oak Ranch	5.9	499	5298	3919	3029
23 Lake Louise	9.4	873	3269	2403	1844
24 Rosen Property	13.0	1119	2321	1695	1291

1/ Depth below land surface

TABLE 5.1-4 DEPTH TO 5,000 mg/l and 250 mg/l ISOCHLOR AS DETERMINED BY TIME DOMAIN ELECTROMAGNETICS			
SITE	**ESTIMATED CHLORIDE-TO-SULFATE RATIO[1]**	**INTERPRETED DEPTH 5,000 mg/l ISOCHLOR (ft bls)**	**INTERPRETED DEPTH 250 mg/l ISOCHLOR (ft bls)**
1 Herlong Airport	1:1	Cannot be determined	Cannot be determined
2 Hunters Ridge	5:1	856	Cannot be determined
3 Riviera Country Club	5:1	433	Not present
4 NSB - West	5:1	961	Not present
5 Port Orange	5:1	679	Cannot be determined
6 Daytona Beach Country Club	5:1	230	Not present
7 Tiger Bay WMA	5:1	1156	1056
8 Reed Canal	5:1	633	Cannot be determined
9 Samsula	5:1	932	Not present
10 Oak Hill	5:1	302	Cannot be determined
11 Scottsmoor	5:1	200	Cannot be determined
12 Osteen	5:1	354	Cannot be determined
13 Big Lake	5:1	309	209
14 Glen Abbey	5:1	646	Cannot be determined
15 Orange City - East	5:1	942	583
16 Astor Park	5:1	1211	1111
17 Barberville	5:1	906	806
18 ONF - Hopkins Prairie	5:1	421	321
19 Volusia County Landfill	5:1	Cannot be determined	Cannot be determined
20 ONF - Forest Hills	2:1	1389	1289
21 Seminole State Forest	5:1	1178	525
22 Big Oak Ranch	5:1	549	449
23 Lake Louise	5:1	873	Not present
24 Rosen Property	5:1	1169	1069

1/ All Chloride-to-Sulfate ratios from Sprinkle, 1981, except for Site 22 which is from Kwader, 1982.

The effect of a chloride to sulfate (Cl/SO_4) ratio less than 5:1 would be for waters with equivalent conductivity to have different Cl values. SO_4 is less conductive than Cl for an equivalent mass volume. If for example the ratio is less than 5:1, it will take a higher conductivity (lower resistivity) to get a 250 mg/l chloride value. That is, for sites where the 5:1 ratio is 1:1, resistivities would have to be less than 80 ohm-m to reach a chloride content of 250 mg/l.

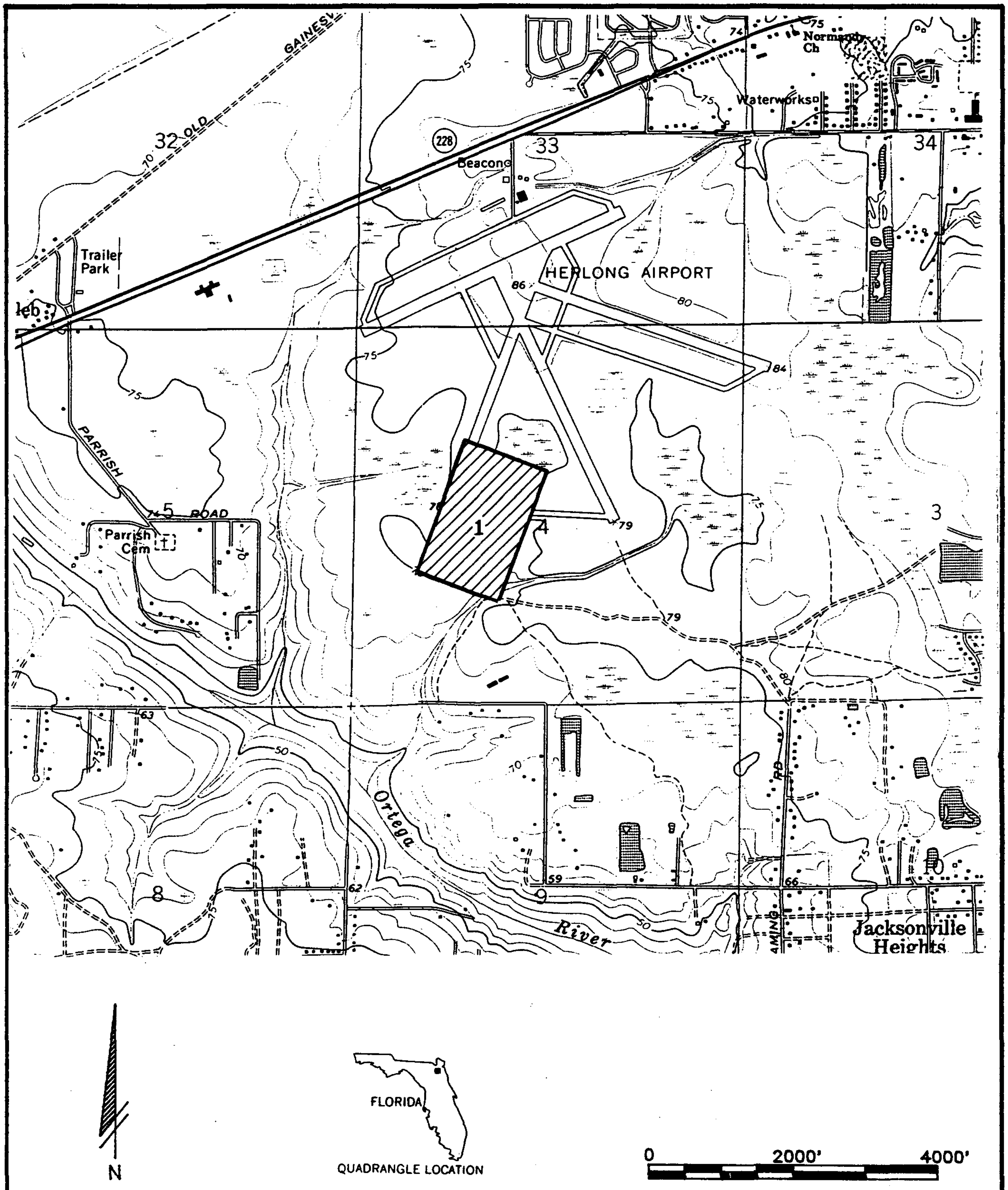
5.2 TDEM Site 1 - Herlong Airport

5.2.1 Location Description and Geoelectrical Section

The site is located at the Herlong Airport in south-central Duval County, Florida (Figure 5.2-1). The site is located on an abandoned runway. Suspected underground utilities in the area of the site were potential sources of interference. QA soundings were performed 200 ft north and 100 ft east of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

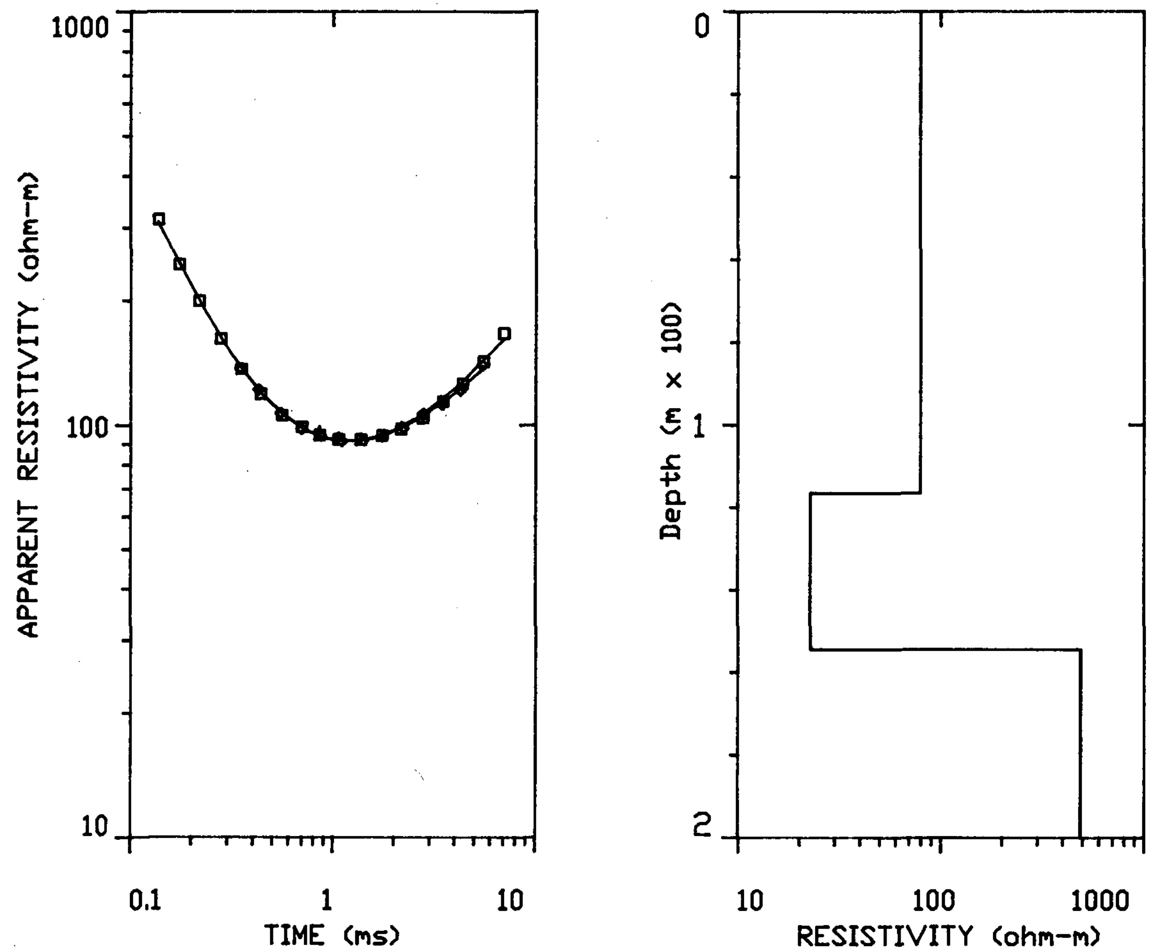
The Floridan aquifer occurs at an approximate depth of approximately 440 ft bmsl or 515 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at an approximate depth of 2,400 ft bmsl (Miller, 1986). The thickness of the Upper Floridan aquifer is approximately 400 ft and the depth to the top of the Lower Floridan aquifer is approximately 1,075 ft bls (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.2-2. The interpreted geoelectrical section consists of a three-layer subsurface.



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 1 – HERLONG AIRPORT DUVAL COUNTY, FLORIDA

DESIGNED BY: JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY: MJW	DRAWING NO.:	LOC–1	5.2–1
DRAWN BY: RBT	DATE:	06/21/95	



— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION SITE 1 – HERLONG AIRPORT DUVAL COUNTY, FLORIDA

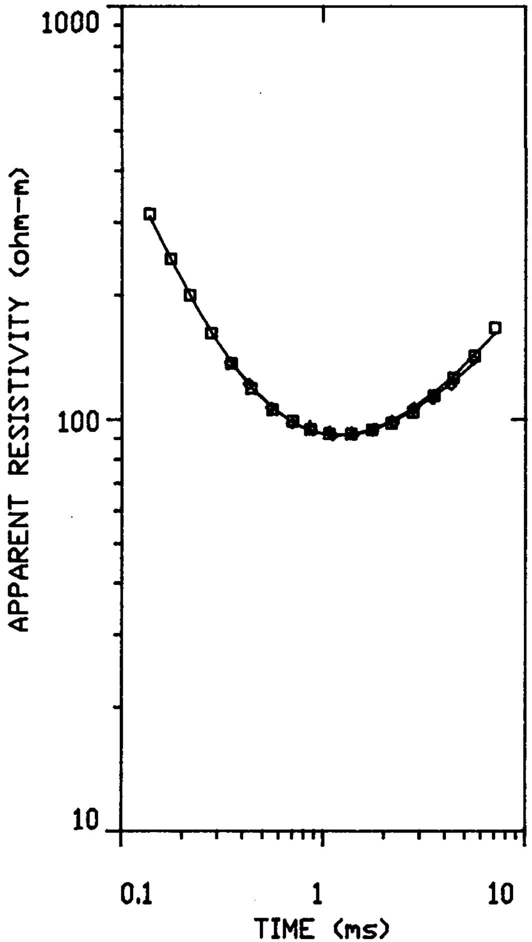
DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-1	5.2-2
DRAWN BY:	SAB	DATE:	07/26/95	

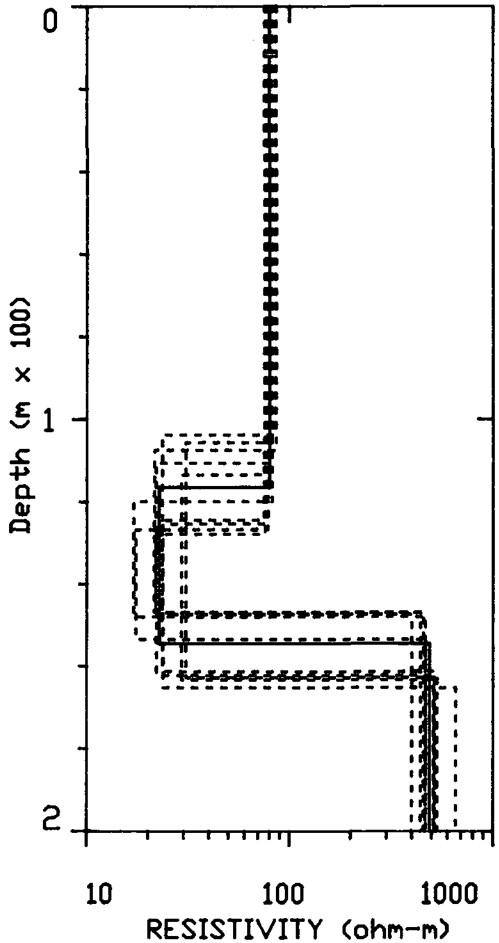
5.2.2 Geological Interpretation of Geoelectrical Model

A three-layer geoelectrical section, where saltwater was not detected, was observed during this study (Figure 5.2.2). The implication is that, for this site, the depth to the saltwater interface is beyond the depth capacity of the measurement system as defined by the loop size and current amperage. The combined thickness of Layer 1 and Layer 2 equals 153 m (502 ft) which is considered to represent the Holocene to Miocene deposits overlying the Floridan aquifer. Layer 3, with a resistivity of 490 ohm-m, is considered to represent a freshwater-saturated Floridan aquifer.

5.2.3 Depth to Occurrence of Salt Water

The saltwater interface is not apparent in this data set. To model the sensitivity to the existence of a possible saltwater interface, a forward modeling/sensitivity analysis was performed. The TDEM data which would have been observed if a fourth layer of low, 3 ohm-m resistivity had been present, was modeled. The resistivity of the upper three layers and the thickness values of the upper two layers were fixed as per the original inversion, a 3-ohm-m base layer was added, and then the thickness of Layer 3 was varied. The depth to salt water (Layer 4) is equal to the sum of the thicknesses of the first three layers. The behavior of fit error was viewed (compared to the real data) as a function of Layer 4 depth (Figure 5.2-4). If the saltwater interface is greater than 1,850 ft deep (-1,775 ft msl), it cannot effectively be seen. If the layer was 1,800 ft or shallower, there would have been significant indications of its existence such that a reasonable fit to the data would not have been possible with a four-layer model. Accordingly, it appears that the depth to the saltwater interface exceeds 1,850 ft bls and, quite possibly, is much deeper in this area.





—— BEST-FIT MODELED CURVE

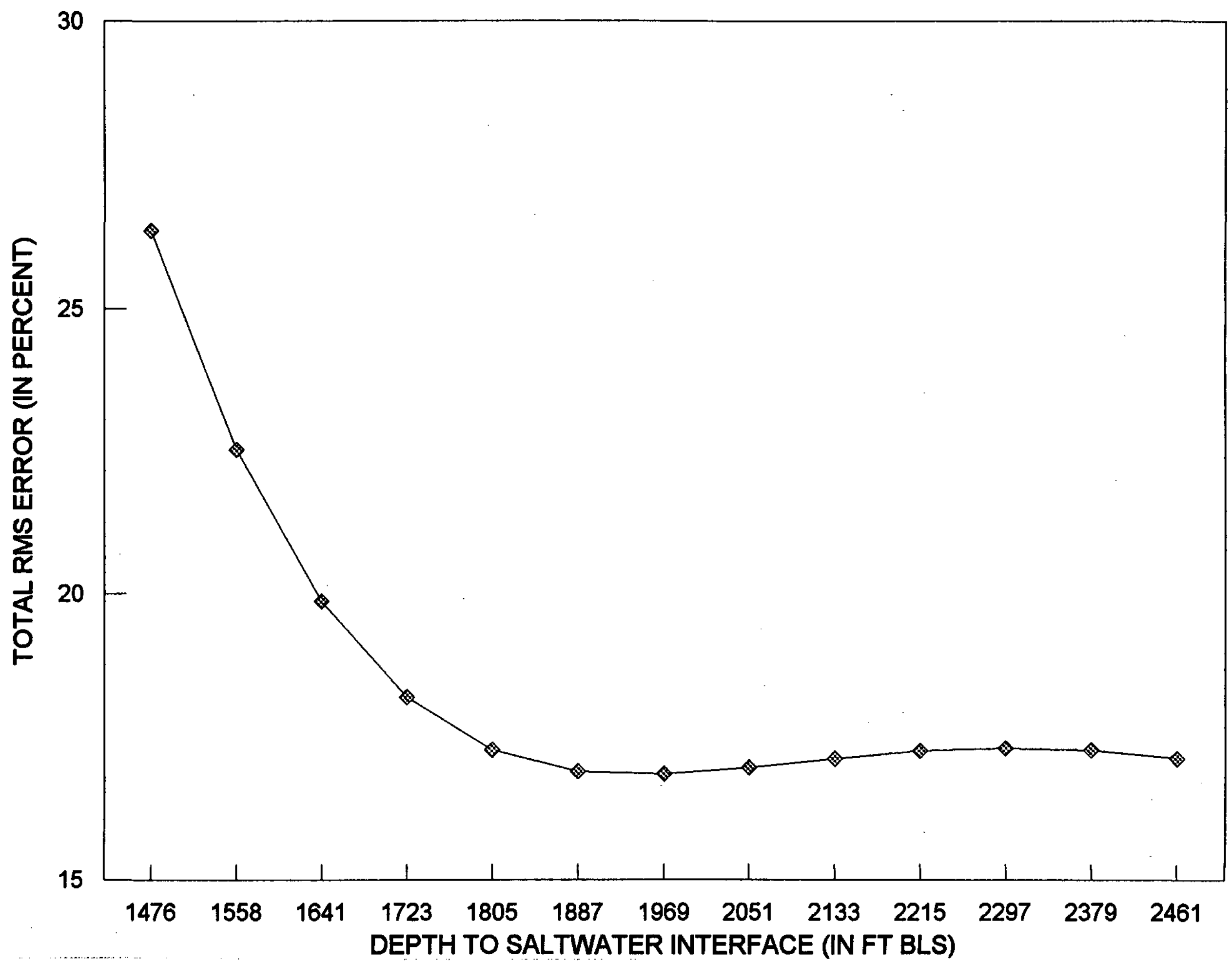
□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 1 - HERLONG AIRPORT
DUVAL COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-1	5.2-3
DRAWN BY:	SAB	DATE:	07/26/95	



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	SENSITIVITY ANALYSIS SHOWING EFFECT ON TOTAL RMS ERROR BY INTRODUCING SALTWATER SATURATED FOURTH LAYER – HERLONG AIRPORT		
		DESIGNED BY: JEB CHECKED BY: MJW DRAWN BY: SAB	PROJECT NO.: 95706 DRAWING NO.: TBL-1 DATE: 07/26/95	FIGURE 5.2-4

The saltwater interface was not present in the Floridan aquifer at Cecil Field and Garden Street which are located approximately 7 miles southwest and 9 miles northwest of Site 1 (CEES, 1992/SJ93-SP1). The base of the Floridan aquifer occurs at -1,950 and -2,125 ft msl at Cecil Field and Garden Street, respectively (Miller, 1986). At both of these sites, the interface is assumed to occur at the base of the Floridan aquifer. For this site, that depth is -2,400 ft msl (Miller, 1986).

5.2.4 Depth of Occurrence of the 250 mg/l Isochlor

The resistivity of Layer 2, 490 ohm-m, corresponds to a chloride content of less than 250 mg/l, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. The depth to the 250 mg/l isochlor cannot be determined, however, because the saltwater interface was not detected at this site.

5.2.5 Accuracy of Measurement and Interpretation

Figure 5.2-3 is the equivalence analysis at this site and the inversion table (Table 5.2-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. A depth to the low resistivity layer could not be determined.

The equivalence range of the resistivity of Layer 3 is from 398 to 658 ohm-m which corresponds to a chloride concentration of less than 250 mg/l. The chloride-to-sulfate ratio at the site is 1:1 (Table 5.1-4), rather than 5:1. Accordingly, equation (4) may not be valid.

5.2.6 Summary of TDEM Sounding at Herlong Airport (Site 1)

- The depth to salt water (5,000 mg/l isochlor) was not detected at this site. However, modeling sensitivity analysis indicates that the saltwater interface must be greater than 1,850 ft (-1,775 ft msl).
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration of less than 250 mg/l. The depth to the 250 mg/l isochlor could not be determined.

DATA SET: SITE 1

CLIENT:	SJRWMD	DATE:	02-MAY-95
LOCATION:	HERLONG AIRPORT	SOUNDING:	1
COUNTY:	DUVAL COUNTY	ELEVATION:	22.90 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	305.000 m by 588.000 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		

SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 1.767 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			22.90	
1	79.81	116.4	-93.53	1.45
2	22.56	37.99	-131.5	1.68
3	489.6			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	75.146	79.819	85.869
	2	16.928	22.565	30.581
	3	398.091	489.695	658.493
THICK	1	103.725	-0.240	127.899
	2	26.708	1.000	57.117
DEPTH	1	103.725	116.436	127.899
	2	146.882	154.432	165.153

CURRENT:	16.20 AMPS	EM-57	COIL AREA:	100.00 sq m.
FREQUENCY:	30.00 Hz	GAIN: 4	RAMP TIME:	230.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.138	38941.3	39894.6	-2.44
2	0.175	31311.7	31050.1	0.835
3	0.218	24478.1	24275.4	0.828

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SOUNDING DATA TABLE SITE 1 – HERLONG AIRPORT DUVAL COUNTY, FLORIDA PROJECT NO.: 95706 TABLE: 5.2–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.278	18315.7	18006.3	1.68
5	0.351	13168.9	13037.9	0.994
6	0.438	9334.3	9225.9	1.16
7	0.558	6088.2	6006.7	1.33
8	0.702	3779.9	3818.6	-1.02
9	0.858	2450.6	2479.7	-1.18
10	1.06	1478.0	1491.0	-0.877
11	1.37	791.3	796.3	-0.632
12	1.74	419.6	419.6	0.0154
13	2.17	229.2	224.7	1.96
14	2.77	113.3	110.1	2.83
15	3.50	55.03	53.47	2.82
16	4.37	27.21	26.85	1.31
17	5.56	12.40	12.24	1.25
18	7.03	5.44	5.70	-4.81

CURRENT: 16.20 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 4 RAMP TIME: 230.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
19	0.346	13565.8	13318.4	1.82
20	0.427	9589.7	9624.3	-0.360
21	0.550	6203.8	6175.0	0.464
22	0.698	3905.3	3867.0	0.981
23	0.869	2383.6	2412.5	-1.21
24	1.10	1361.2	1359.4	0.129
25	1.40	748.7	751.3	-0.358
26	1.75	417.0	415.2	0.428
27	2.22	214.2	212.4	0.860
28	2.79	107.3	109.4	-1.97
29	3.42	59.50	58.88	1.03
30	4.26	30.71	30.25	1.47
31	5.49	13.19	13.60	-3.07

CURRENT: 16.20 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 6 RAMP TIME: 230.00 muSEC

No. TIME emf (nV/m sqrd) DIFFERENCE

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SOUNDING DATA TABLE SITE 1 – HERLONG AIRPORT DUVAL COUNTY, FLORIDA PROJECT NO.: 95706 TABLE: 5.2–1

	(ms)	DATA	SYNTHETIC	(percent)
32	0.857	2399.9	2489.3	-3.72
33	1.06	1460.4	1493.8	-2.28
34	1.37	786.4	798.9	-1.58
35	1.74	421.7	421.9	-0.0512
36	2.17	225.7	226.7	-0.468
37	2.77	113.7	111.9	1.60
38	3.50	56.28	54.91	2.44
39	4.37	27.57	27.99	-1.54

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.94				
P 2	0.04	0.59			
P 3	0.06	-0.07	0.54		
T 1	0.07	0.04	-0.11	0.87	
T 2	-0.03	-0.44	-0.07	0.14	0.42
	P 1	P 2	P 3	T 1	T 2

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 1 – HERLONG AIRPORT
DUVAL COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.2–1

5.3 TDEM Site 2 - Hunter's Ridge

5.3.1 Location Description and Geoelectrical Section

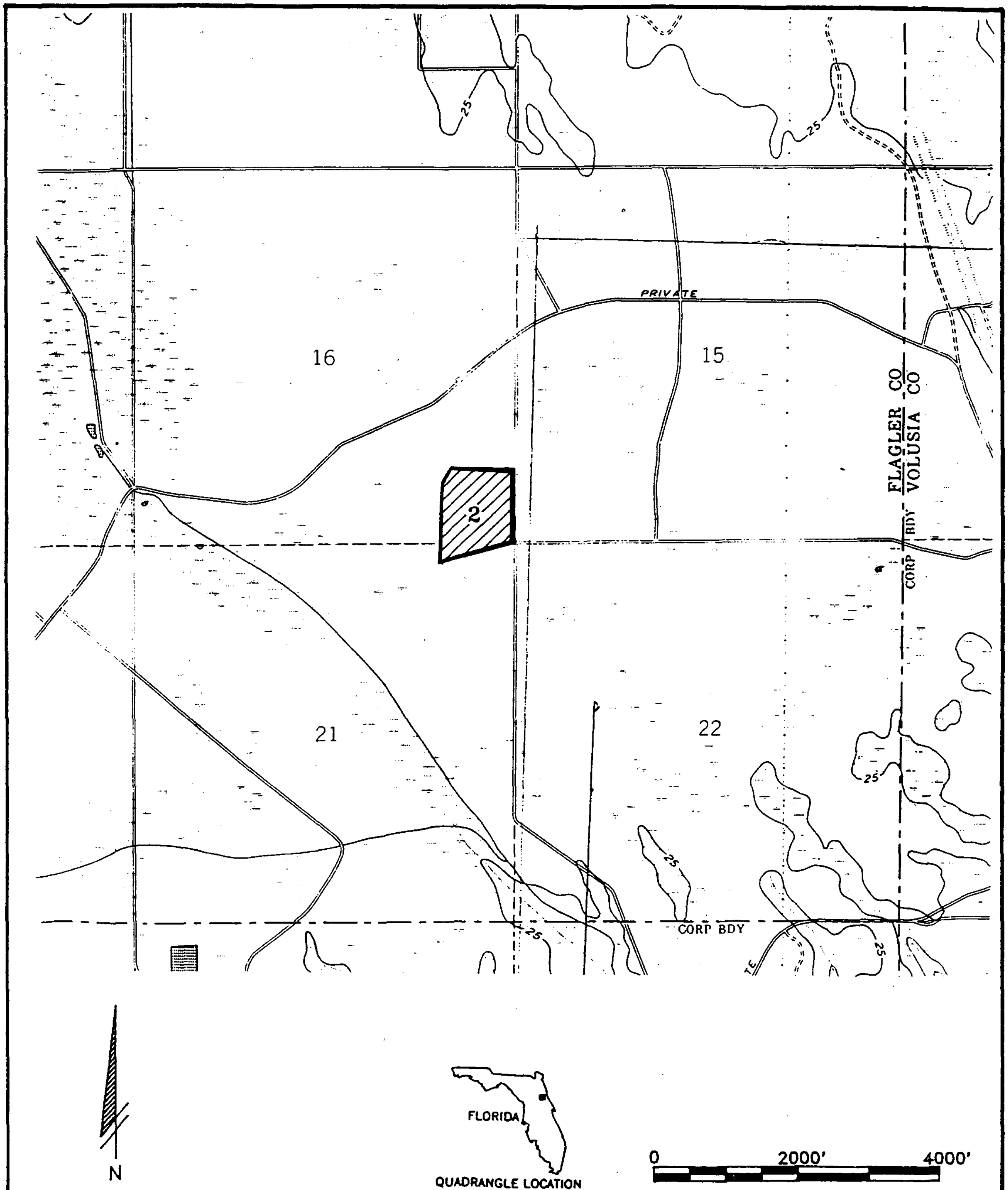
The site is located in southeastern Flagler County, Florida (Figure 5.3-1). The site is located within a forested area. No possible sources of interference were observed within the vicinity of the site. QA soundings were performed 90 ft east and 100 ft south of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 60 ft bmsl or 85 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at approximately 2,100 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 400 ft and the depth to the top of the Lower Floridan aquifer is approximately 875 ft bls (Miller, 1986). Chloride concentrations in the Upper Floridan aquifer are less than 100 mg/l in this area (Navoy and Bradner, 1987).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.3-2. The interpreted geoelectrical section consists of a two-layer subsurface.

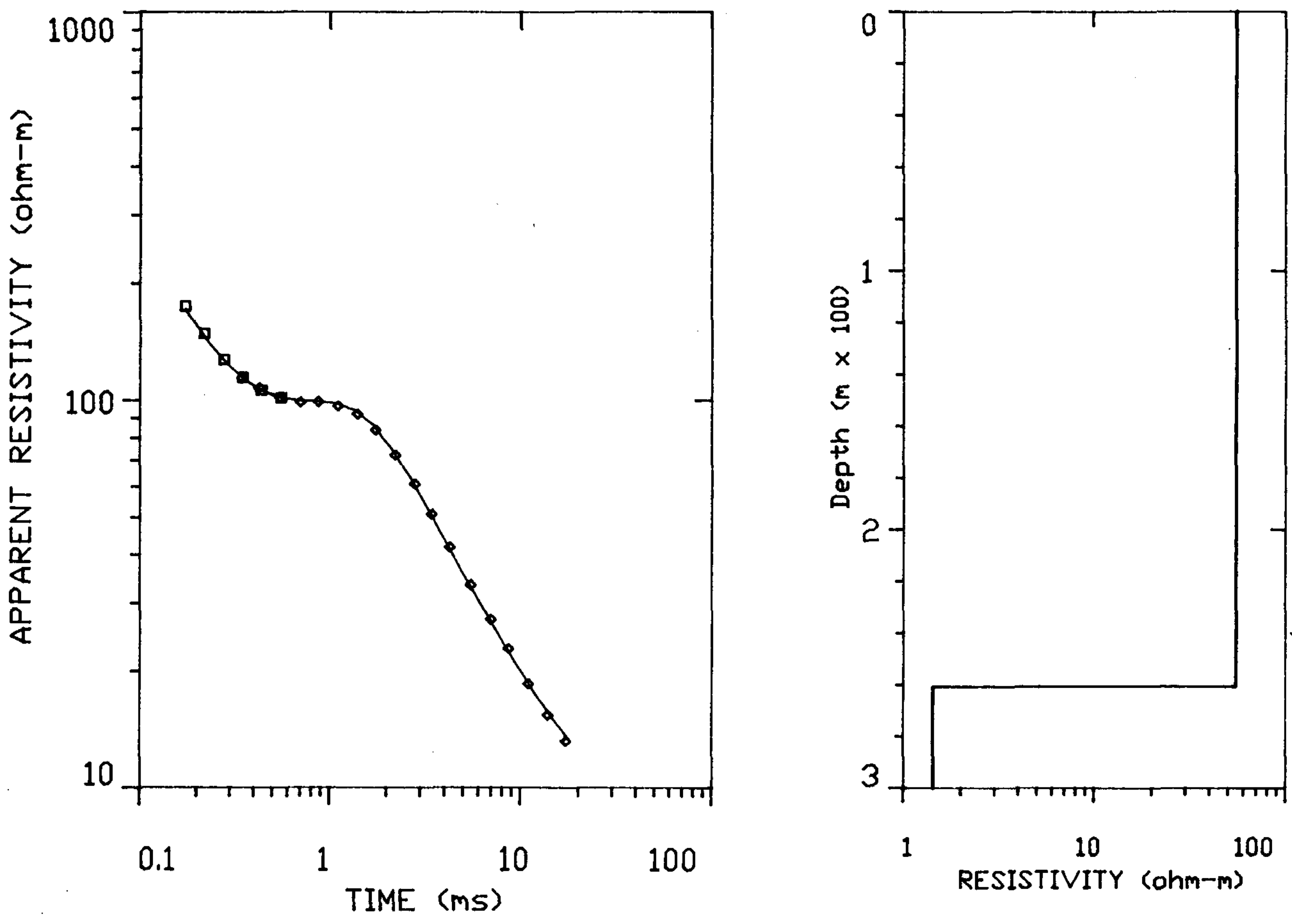
5.3.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the Holocene to Miocene deposits and the underlying Floridan aquifer to distinguish the two. Fixing the thickness of the upper layer does not resolve this dilemma; therefore, it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (261 m = 856 ft) surface layer of intermediate resistivity (55 ohm-m) overlying a low resistivity layer (1.4 ohm-m). The Holocene to Miocene deposits and part of the Floridan aquifer system exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater saturated Floridan aquifer at a depth of 856 ft bls.



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 2 – HUNTERS RIDGE FLAGLER COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE	
CHECKED BY:	MJW	DRAWING NO.:	LOC-2	5.3-1	
DRAWN BY:	RBT	DATE:	06/21/95		



——— BEST–FIT MODELED CURVE

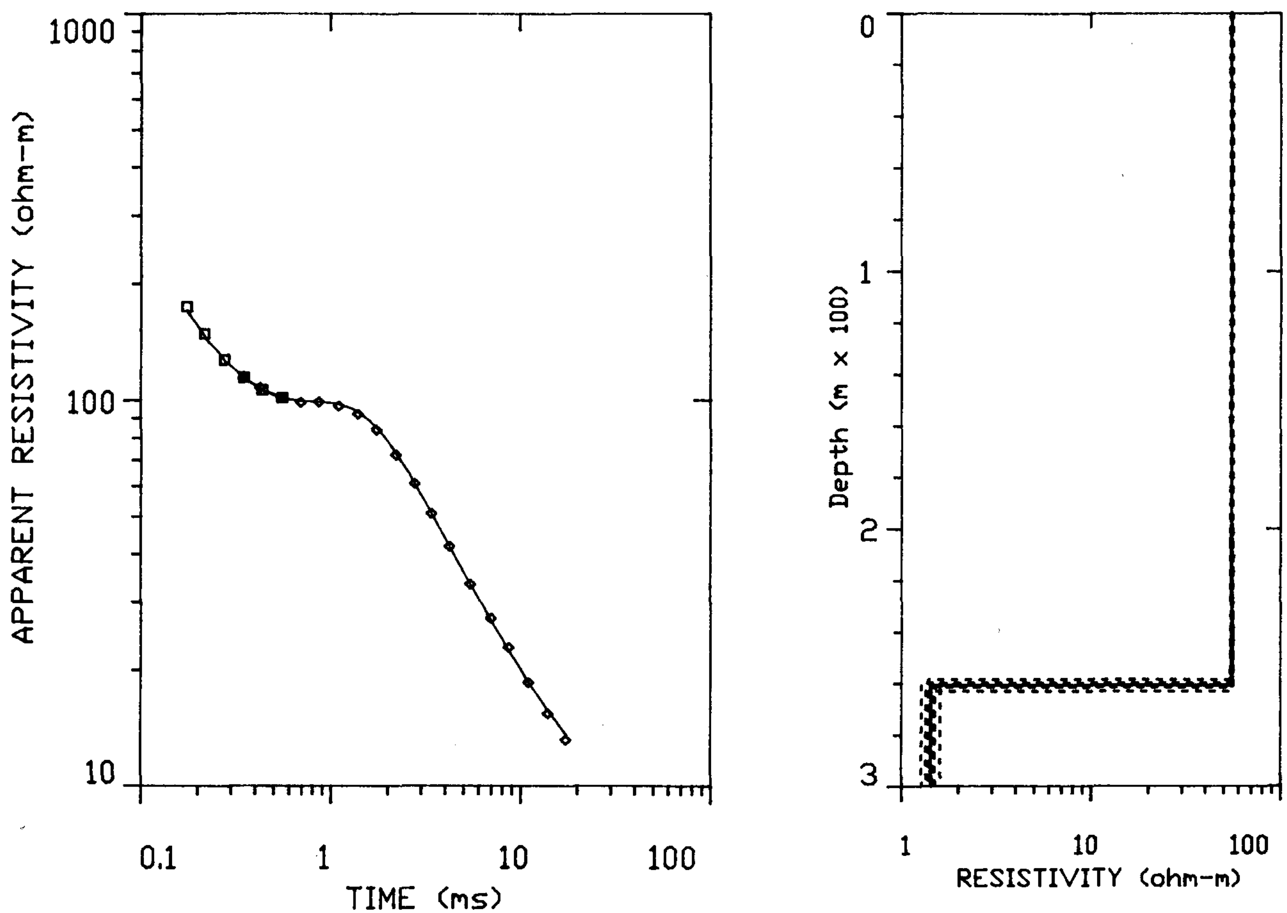
□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1–D INVERSION
SITE 2 – HUNTERS RIDGE
FLAGLER COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL–2	5.3–2
DRAWN BY:	SAB	DATE:	07/26/95	



— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 2 - HUNTERS RIDGE
FLAGLER COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-2	5.3-3
DRAWN BY:	SAB	DATE:	07/26/95	

5.3.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 1.4 ohm-m, is interpreted to represent salt water. It occurs at a depth of 856 ft (-831 ft msl). Because the resistivity of Layer 1 (55 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken at the depth of the geoelectrical interface, or at 856 ft depth (-831 ft msl). The resistivity of Layer 2 (1.4 ohm-m) corresponds to a chloride concentration in excess of 20,000 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

5.3.4 Depth of Occurrence of the 250 mg/l Isochlor

Because of the inability to segregate the Floridan aquifer from the overlying Holocene to Miocene deposits, the effective chloride concentration of Layer 1 cannot be calculated.

5.3.5 Accuracy of Measurement and Interpretation

Figure 5.3-3 is the equivalence analysis at this site and the inversion table (Table 5.3-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. The range of equivalence in determining the depth to the low resistivity layer is about ±2 m (7 ft) which is 1% of the total depth. The resistivity of this layer has a range from 1.3 to 1.6 ohm-m. This corresponds to a range in interpreted chloride concentration in excess of 20,000 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 1 is from 55 to 56 ohm-m. A corresponding chloride concentration cannot be determined because Layer 1 is in part comprised of Holocene to Miocene deposits. Accordingly, equation (4) may not be valid.

5.3.6 Summary of TDEM Sounding at Hunter's Ridge (Site 2)

- The depth of occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 856 ft (-831 ft msl).
- The quality of ground water within the Floridan aquifer at this site cannot be interpreted because the analysis of the TDEM data does not allow the Holocene to Miocene deposits to be distinguished from the Floridan Aquifer System.

DATA SET: SITE2

CLIENT:	SJRWMD	DATE:	03-MAY-95
LOCATION:	HUNTER'S RIDGE	SOUNDING:	1
COUNTY:	FLAGLER COUNTY	ELEVATION:	7.60 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	328.000 m by 400.000 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		
SOUNDING COORDINATES:	E: 0.0000	N:	0.0000

FITTING ERROR: 1.881 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			7.60	
1	55.41	260.7	-253.1	4.70
2	1.43			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	54.641	55.417	56.139
	2	1.278	1.435	1.607
THICK	1	258.440	1.000	263.004
DEPTH	1	258.440	260.721	263.004

CURRENT:	19.50 AMPS	EM-57	COIL AREA:	100.00 sq m.
FREQUENCY:	30.00 Hz	GAIN: 4	RAMP TIME:	230.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	emf (nV/m sqrd) SYNTHETIC	DIFFERENCE (percent)
1	0.175	43599.4	45057.8	-3.34
2	0.218	32063.9	32876.7	-2.53
3	0.278	22037.0	22195.2	-0.717
4	0.351	14398.6	14524.7	-0.875
5	0.438	9253.2	9277.1	-0.258
6	0.558	5411.3	5397.7	0.250

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WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 2 – HUNTERS RIDGE
FLAGLER COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.3–1

CURRENT: 19.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 6 RAMP TIME: 230.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
7	0.346	14997.7	14992.1	0.0376
8	0.427	9688.7	9851.4	-1.68
9	0.550	5624.1	5643.9	-0.352
10	0.698	3228.6	3191.8	1.13
11	0.869	1858.0	1852.8	0.281
12	1.10	1050.6	1029.6	1.99
13	1.40	626.3	611.1	2.42
14	1.75	415.2	405.2	2.41
15	2.22	286.4	283.6	0.964
16	2.79	209.2	210.5	-0.602
17	3.42	164.5	165.9	-0.868
18	4.26	127.6	129.3	-1.37
19	5.49	94.88	96.13	-1.31
20	6.96	71.25	72.50	-1.74
21	8.66	53.53	54.93	-2.61
22	11.06	39.74	39.68	0.136
23	14.00	29.10	28.30	2.75
24	17.47	21.16	20.20	4.51

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

	P 1	P 2	T 1
P 1	1.00		
P 2	-0.02	0.77	
T 1	0.00	-0.01	1.00

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PALATKA, FLORIDA

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SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 2 – HUNTERS RIDGE
FLAGLER COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.3–1

5.4 TDEM Site 3 - Riviera Country Club

5.4.1 Location Description and Geoelectrical Section

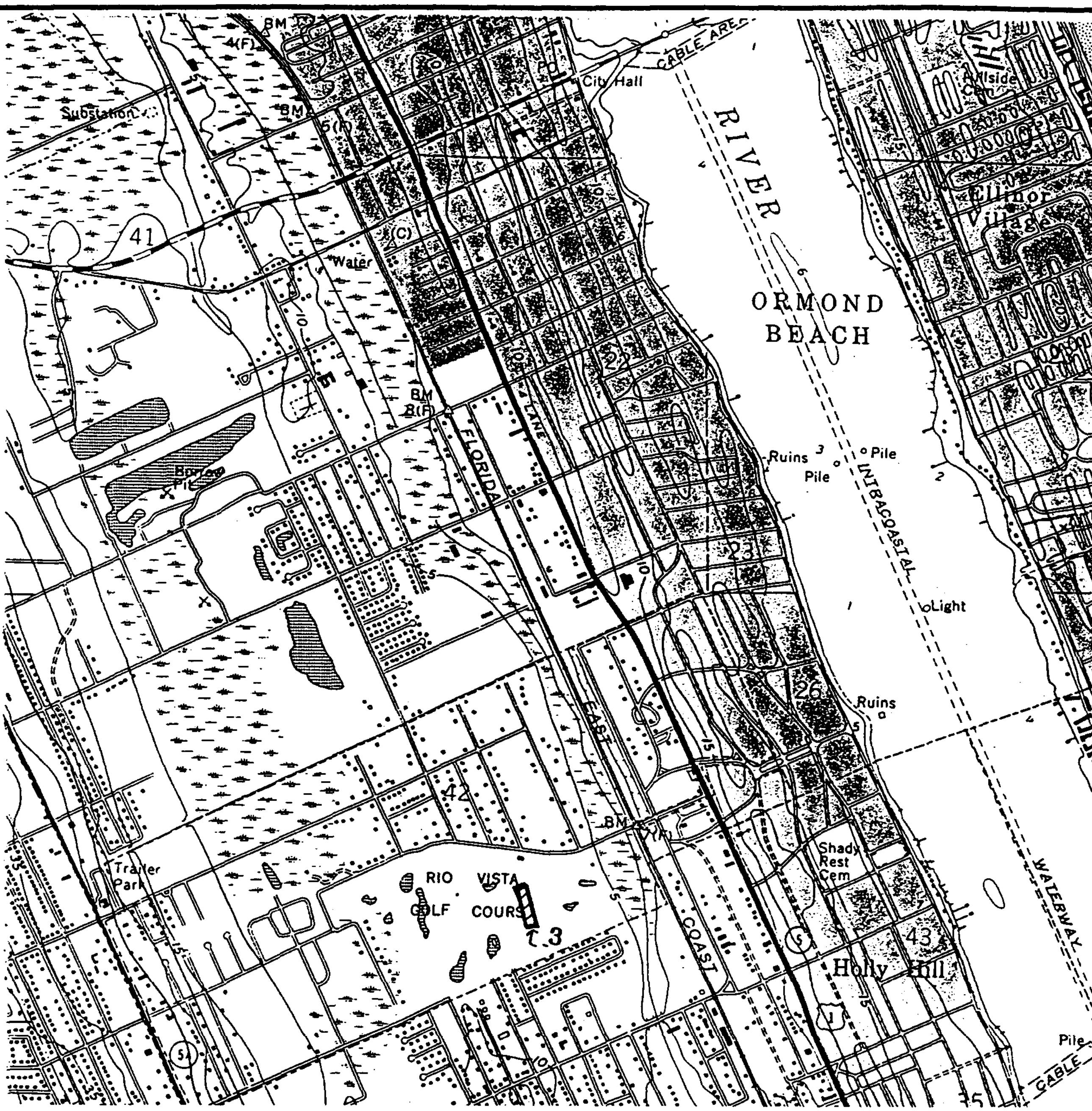
The site is located in north-eastern Volusia County in Holly Hill, Florida (Figure 5.4-1). The site is located on a golf course. Possible sources of interference at the golf course included underground pipelines suspected to be present at the site. QA soundings were performed 56 ft to the north and south and 16 ft to the west of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 80 ft bmsl or 85 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at approximately 2,150 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 400 ft and the depth to the top of the Lower Floridan aquifer is approximately 850 ft bls (Miller, 1986). Chloride concentration in the Upper Floridan aquifer is below 250 mg/l in this area (Rutledge, 1985).

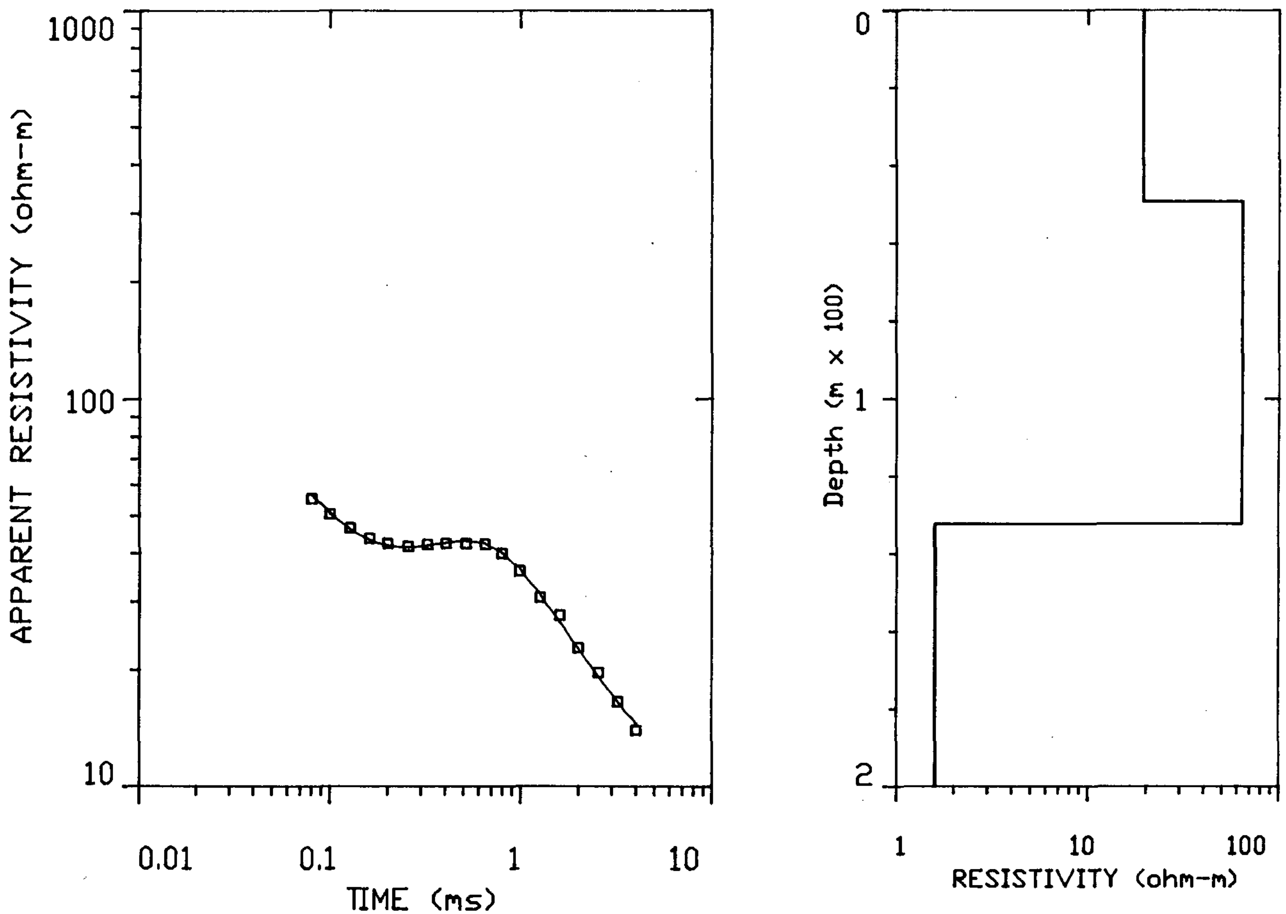
The resistivity sounding data and best-fit model inversion are presented on Figure 5.4-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.4.2 Geological Interpretation of Geoelectrical Model

There is a sufficient electrical resistivity contrast to distinguish two geological layers above a third saltwater saturated layer. The first layer occurs at a depth of 49 m (161 ft) and not at the hydrostratigraphic contact (85 ft bls) between the Holocene to Miocene deposits and the Floridan Aquifer System. The first layer has a low resistivity (19 ohm-m) and is considered to be the combined Holocene to Miocene deposits and the upper portion of the



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 3 – RIVIERA COUNTRY CLUB VOLUSIA COUNTY, FLORIDA		
		DESIGNED BY: JEB CHECKED BY: MJW DRAWN BY: RBT	PROJECT NO.: 95706 DRAWING NO.: LOC-3 DATE: 06/20/95	FIGURE 5.4-1



—— BEST–FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII

SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1–D INVERSION
SITE 3 – RIVIERA COUNTRY CLUB
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL–3	5.4–2
DRAWN BY:	SAB	DATE:	07/26/95	

Floridan aquifer. The second layer also has low resistivity (64 ohm-m) which, because it is less than 80 ohm-m, suggests the Floridan aquifer at this site contains brackish water. The thickness of the brackish section is 83 m (272 ft), placing the depth to the low resistivity (saltwater) layer at 132 m (433 ft) below ground surface near the base of the Upper Floridan aquifer. The resistivity of the saltwater saturated layer is 1.6 ohm-m.

5.4.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 1.6 ohm-m, is interpreted to represent salt water. It occurs at a depth of 433 ft (-428 ft msl). Because the resistivity of Layer 2 (64 ohm-m) is interpreted to represent brackish water within the Floridan aquifer (is less than 80 ohm-m), the interpreted depth to the 5,000 mg/l isochlor is equal to the depth of the geoelectrical interface, or at 433 ft depth (-428 ft msl). The resistivity of Layer 3 (1.6 ohm-m) corresponds to a chloride content of approximately 20,000 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

5.4.4 Depth of Occurrence of the 250 mg/l Isochlor

The resistivity of Layer 2, 64 ohm-m, corresponds to a chloride concentration above 250 mg/l, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. As the interpreted chloride concentration exceeds 250 mg/l, the 250 mg/l isochlor does not occur within the Floridan aquifer at this site. This conclusion does not agree with the chloride concentration mapped in Rutledge (1985).

5.4.5 Accuracy of Measurement and Interpretation

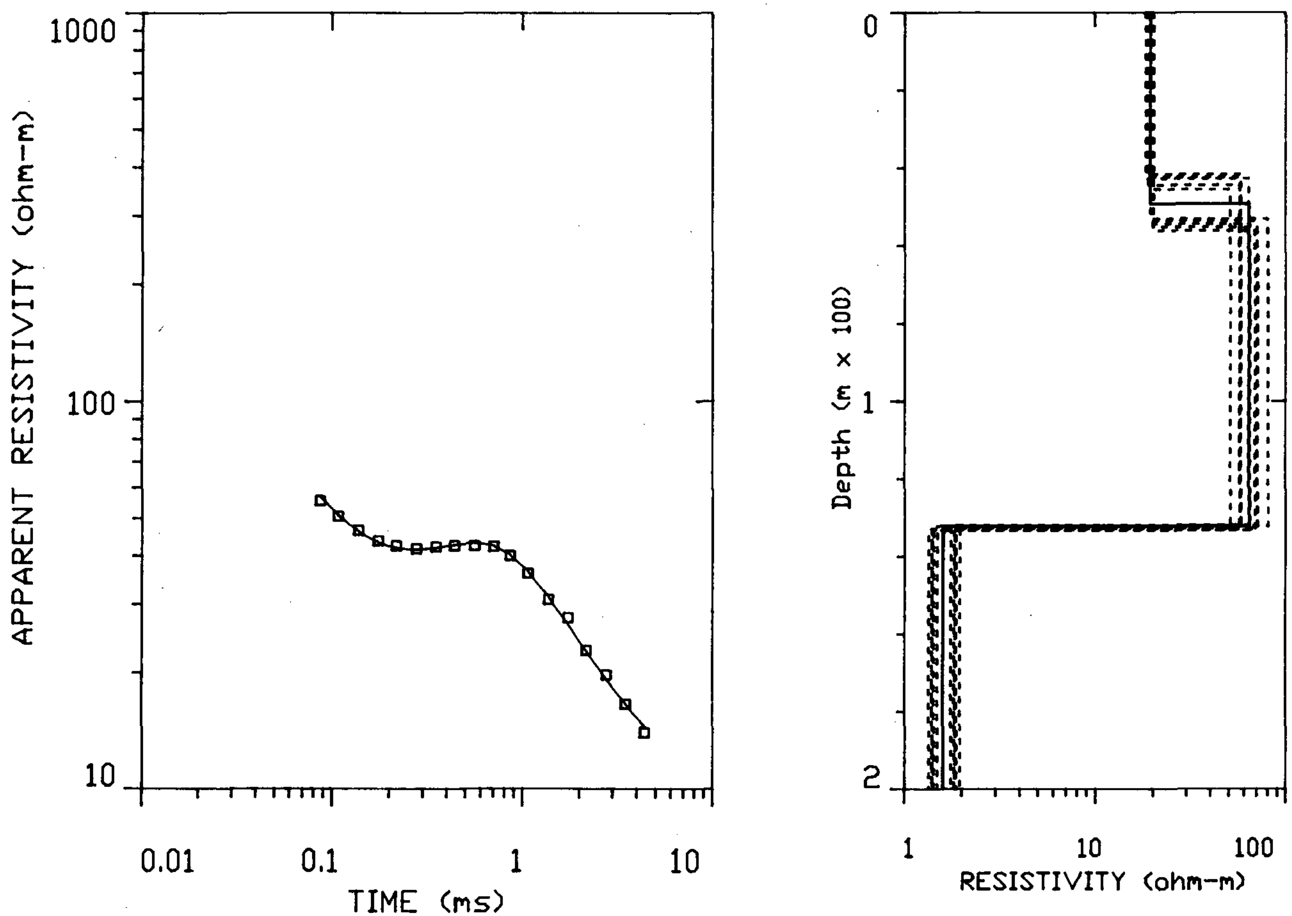
Figure 5.4-3 is the equivalence analysis at this site and the inversion table (Table 5.4-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ±1 m (3 ft) which is less than 1% of the total depth. The resistivity of this layer has a range from 1.3 to 2.0 ohm-m, which approximately corresponds to a chloride concentration in excess of 15,000 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 2 is from 51 to 81 ohm-m which corresponds to a chloride concentration above and below 250 mg/l. The results of the TDEM study are not in agreement with Rutledge (1985) who mapped a chloride concentration below 250 mg/l in this area. The chloride-to-sulfate ratio at the site is 5:1 (Table 5.1-4). Accordingly, equation (4) is valid. The discrepancy in the water quality results between the TDEM survey and Rutledge (1985) is probably due to the averaging of water quality in the Floridan aquifer by TDEM. There is not a sufficient resistivity contrast to locate the 250 mg/l isochlor at this site. As a consequence, TDEM yields an average resistivity for Layer 2.

5.4.6 Summary of TDEM Sounding at Riviera Country Club (Site 3)

- The depth to occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 433 ft (-428 ft msl) and occur near the base of the Upper Floridan aquifer.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration above 250 mg/l. The 250 mg/l isochlor is not interpreted to be present within the Floridan aquifer. This conclusion is not consistent with chloride concentration mapped in Rutledge (1985) for this area.



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 3 - RIVIERA COUNTRY CLUB
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-3	5.4-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 3

CLIENT:	SJRWMD	DATE:	04-MAY-95
LOCATION:	RIVIERA COUNTRY CLUB	SOUNDING:	1
COUNTY:	VOLUSIA COUNTY	ELEVATION:	1.50 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM

LOOP SIZE: 170.000 m by 47.000 m AZIMUTH:
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 2.745 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			1.50	
1	19.49	49.19	-47.69	2.52
2	64.31	83.02	-130.7	1.29
3	1.59			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	18.470	19.490	20.250
	2	51.009	64.310	80.603
	3	1.340	1.590	1.955
THICK	1	41.603	-1.722	56.137
	2	76.895	1.000	90.718
DEPTH	1	41.603	49.198	56.137
	2	131.953	132.218	133.326

CURRENT: 25.20 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz GAIN: 3 RAMP TIME: 125.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	134189.0	129363.8	3.59
2	0.108	88963.5	88388.8	0.646
3	0.138	54612.5	55407.1	-1.45

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 3 – RIVIERA COUNTRY CLUB
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.4–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.175	33130.9	33725.6	-1.79
5	0.218	20025.1	20484.4	-2.29
6	0.278	11181.9	11331.5	-1.33
7	0.351	6134.2	6210.7	-1.24
8	0.438	3494.1	3468.4	0.735
9	0.558	1907.9	1856.1	2.71
10	0.702	1080.5	1071.3	0.848
11	0.858	710.0	704.9	0.725
12	1.06	483.4	473.0	2.15
13	1.37	326.4	318.8	2.32
14	1.74	210.7	224.1	-6.33
15	2.17	162.3	163.5	-0.768
16	2.77	109.8	114.1	-3.86
17	3.50	79.32	79.57	-0.312
18	4.37	58.78	55.54	5.50

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.99				
P 2	0.00	0.74			
P 3	0.03	0.15	0.73		
T 1	-0.04	-0.09	0.14	0.86	
T 2	0.02	0.06	-0.07	0.08	0.96
	P 1	P 2	P 3	T 1	T 2

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE
DETECTION
INVESTIGATIONS
INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 3 – RIVIERA COUNTRY CLUB
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.4–1

5.5 TDEM Site 4 - NSB-West

5.5.1 Location Description and Geoelectrical Section

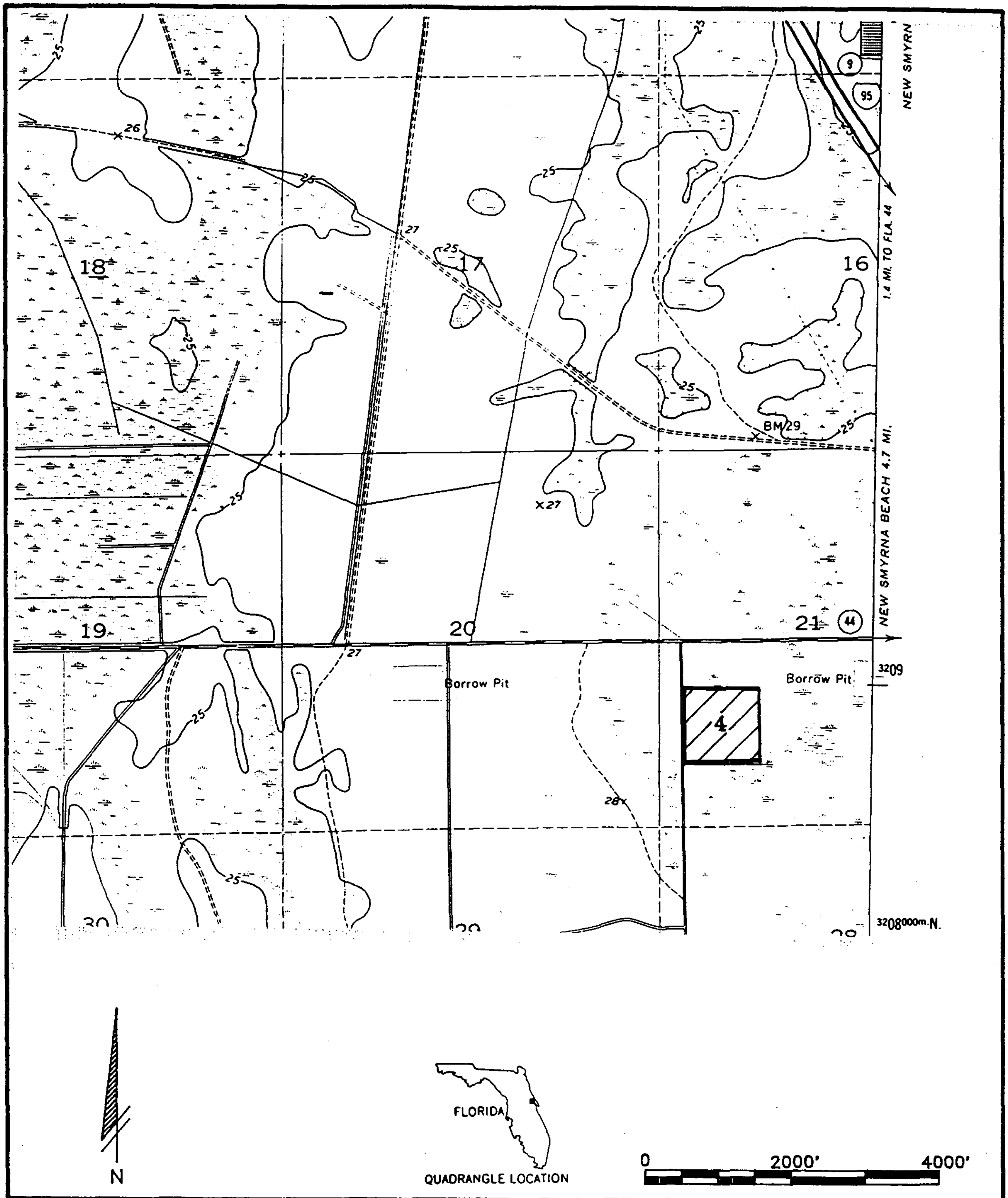
The site is located in east-central Volusia County, Florida (Figure 5.5-1). The site is located within a forested area. A possible interference source (powerlines) existed 500 ft north of the Tx loop. QA soundings were performed 100 ft north and 100 ft west of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 70 ft bmsl or 95 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at approximately 2,250 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 300 ft and the depth to the top of the Lower Floridan aquifer is approximately 765 ft bls (Miller, 1986). Chloride concentration in the upper portion of the Floridan aquifer ranges from 0 to 50 mg/l in this area (Rutledge, 1985).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.5-2. The interpreted geoelectrical section consists of a three-layer subsurface.

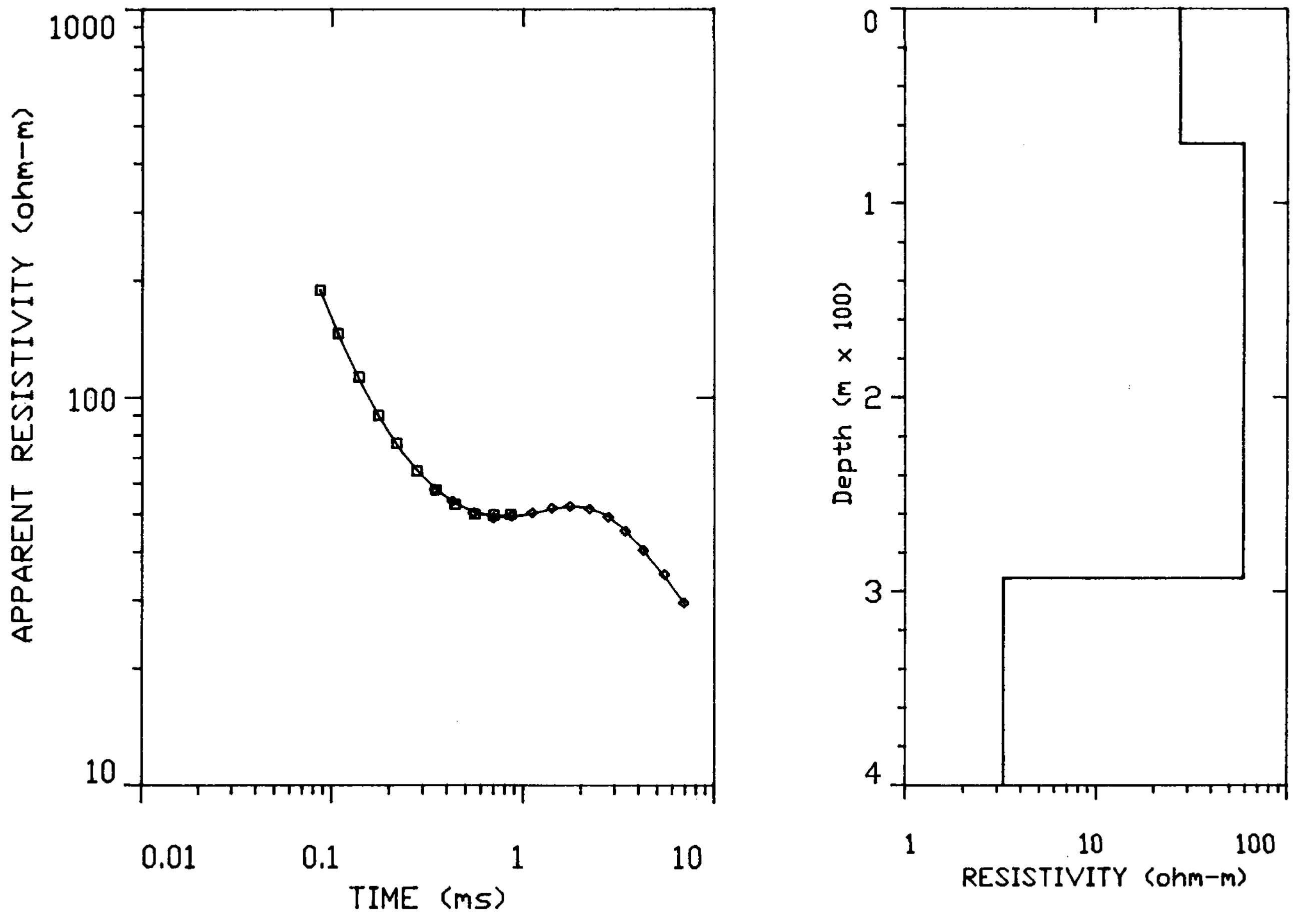
5.5.2 Geological Interpretation of Geoelectrical Model

There is a sufficient electrical resistivity contrast to distinguish two geological layers above a third saltwater saturated layer. The first layer occurs at a depth of 70 m (230 ft) and not at the hydrostratigraphic contact (95 ft bls) between the Holocene to Miocene deposits and the Floridan Aquifer System. The first layer has a low resistivity (27 ohm-m) and is considered to be the combined Holocene to Miocene deposits and the upper portion of the Floridan aquifer. The second layer also has a low resistivity (59 ohm-m) which, because it is less than 80 ohm-m, suggests the Floridan aquifer at this site contains brackish water. The



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 4 – NSB – WEST VOLUSIA COUNTY, FLORIDA

DESIGNED BY: JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY: MJW	DRAWING NO.:	LOC–4	5.5–1
DRAWN BY: RBT	DATE:	07/05/94	



BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 4 – NSB-WEST
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-4	5.5-2
DRAWN BY:	SAB	DATE:	07/26/95	

thickness of the brackish section is 224 m (735 ft), placing the depth to the low resistivity (saltwater) layer at 293 m (961 ft) below ground surface. The resistivity of the saltwater saturated layer is 3.2 ohm-m.

5.5.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 3.2 ohm-m, is interpreted to represent salt water. It occurs at a depth of 961 ft (-936 ft msl). Because the resistivity of Layer 2 (59 ohm-m) is interpreted to represent brackish water within the Floridan aquifer (is less than 80 ohm-m), the interpreted depth to the 5,000 mg/l isochlor is equal to the depth of the geoelectrical interface, or at 961 ft depth (-936 ft msl). The resistivity of Layer 3 (3.2 ohm-m) corresponds to a chloride content of 9,898 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

5.5.4 Depth of Occurrence of the 250 mg/l Isochlor

The resistivity of Layer 2, 59 ohm-m, corresponds to a chloride concentration above 250 mg/l, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. As the interpreted chloride concentration exceeds 250 mg/l, the 250 mg/l isochlor does not occur within the Floridan aquifer at this site. This conclusion does not agree with Rutledge (1985) who estimated a maximum thickness of approximately 300 ft for water with a chloride concentration below 250 mg/l in this area.

5.5.5 Accuracy of Measurement and Interpretation

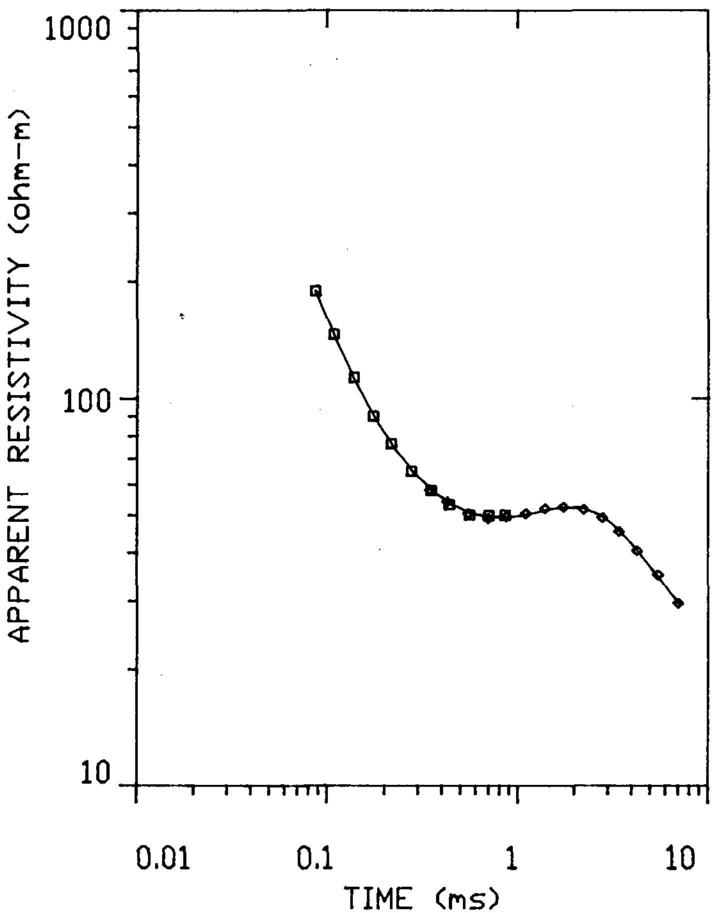
Figure 5.5-3 is the equivalence analysis at this site and the inversion table (Table 5.5-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

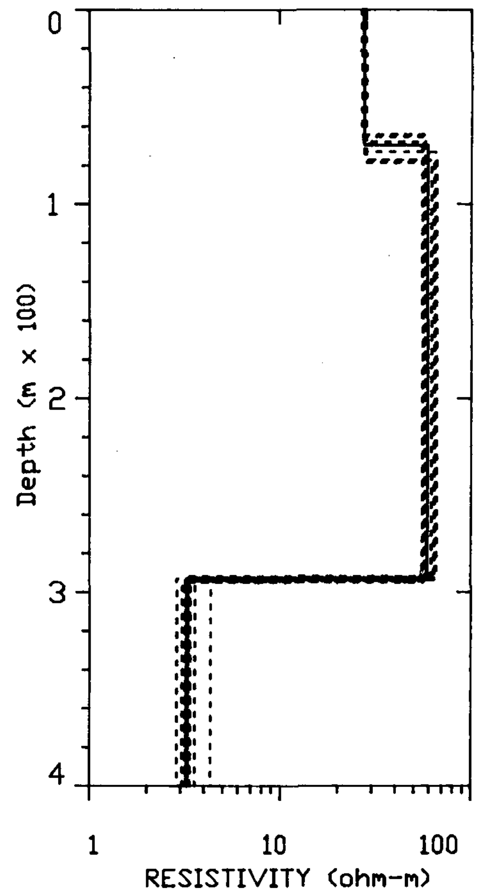
The range of equivalence in determining the depth to the low resistivity layer is about ±2 m (7 ft) which is 1% of the total depth. The resistivity of this layer has a range from 2.9 to 4.3 ohm-m. This corresponds to a range in interpreted chloride concentration of 10,938 to 7,327 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 2 is from 56 to 66 ohm-m which corresponds to a chloride concentration above 250 mg/l. The results of the TDEM study are not in agreement with the results from Rutledge (1985). The chloride-to-sulfate ratio at the site is 5:1 (Table 5.1-4). Accordingly, equation (4) is valid. The discrepancy in the water quality results between the TDEM survey and Rutledge (1985) is probably due to the averaging of water quality in the Floridan aquifer by TDEM. There is not a sufficient resistivity contrast to locate the 250 mg/l isochlor at this site. As a consequence, TDEM yields an average resistivity for Layer 2. Rutledge (1985) estimated a maximum thickness of approximately 300 ft for water with a chloride concentration below 250 mg/l in this area. However, the thickness of Layer 2 is 735 ft.

5.5.6 Summary of TDEM Sounding at NSB-West (Site 4)

- The depth to occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 961 ft (-936 ft msl) and occur within the Lower Floridan aquifer.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration above 250 mg/l. The 250 mg/l isochlor is not interpreted to be present within the Floridan aquifer.
- The results of the TDEM study are not in agreement with Rutledge (1985) who estimated a maximum thickness of approximately 300 ft for water with a chloride concentration below 250 mg/l in this area.





—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION SITE 4 – NSB-WEST VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-4	5.5-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 4

CLIENT:	SJRWMD	DATE:	04-MAY-95
LOCATION:	NSB-WEST	SOUNDING:	1
COUNTY:	VOLUSIA COUNTY	ELEVATION:	7.60 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	305.000 m by 305.000 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		
SOUNDING COORDINATES:	E: 0.0000	N:	0.0000

FITTING ERROR: 1.058 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			7.60	
1	27.46	69.57	-61.97	2.53
2	59.08	223.6	-285.6	3.78
3	3.24			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	26.919	27.470	28.268
	2	55.516	59.083	65.743
	3	2.869	3.244	4.331
THICK	1	64.263	-2.537	78.641
	2	213.091	1.000	230.596
DEPTH	1	64.263	69.579	78.641
	2	291.732	293.206	294.963

CURRENT:	20.10 AMPS	EM-57		COIL AREA:	100.00 sq m.
FREQUENCY:	30.00 Hz	GAIN:	3	RAMP TIME:	192.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	162808.7	162789.5	0.0117
2	0.108	137947.8	139353.6	-1.01
3	0.138	109983.9	111727.8	-1.58

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 4 - NSB-WEST
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.5-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.175	85543.8	85626.8	-0.0969
5	0.218	63244.5	63856.3	-0.967
6	0.278	43996.4	43819.9	0.401
7	0.351	29152.6	29056.0	0.331
8	0.438	19047.3	18818.1	1.20
9	0.558	11363.3	11182.7	1.58
10	0.702	6443.1	6532.3	-1.38
11	0.858	3883.3	3948.9	-1.68

CURRENT: 20.10 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 5 RAMP TIME: 192.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
12	0.346	30182.9	29878.7	1.00
13	0.427	19772.6	19859.0	-0.436
14	0.550	11674.6	11586.5	0.755
15	0.698	6715.4	6658.8	0.843
16	0.869	3816.5	3855.4	-1.01
17	1.10	2023.3	2045.4	-1.09
18	1.40	1072.8	1085.9	-1.21
19	1.75	608.4	608.2	0.0334
20	2.22	343.9	339.7	1.24
21	2.79	208.7	206.5	1.04
22	3.42	142.1	140.8	0.927
23	4.26	97.34	96.85	0.511
24	5.49	64.08	65.42	-2.08
25	6.96	45.58	45.59	-0.0241

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.99				
P 2	-0.02	0.80			
P 3	-0.01	-0.18	0.42		
T 1	-0.05	-0.20	-0.10	0.69	
T 2	0.02	0.07	0.03	0.11	0.96
	P 1	P 2	P 3	T 1	T 2

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 4 – NSB–WEST
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.5–1

5.6 TDEM Site 5 - Port Orange

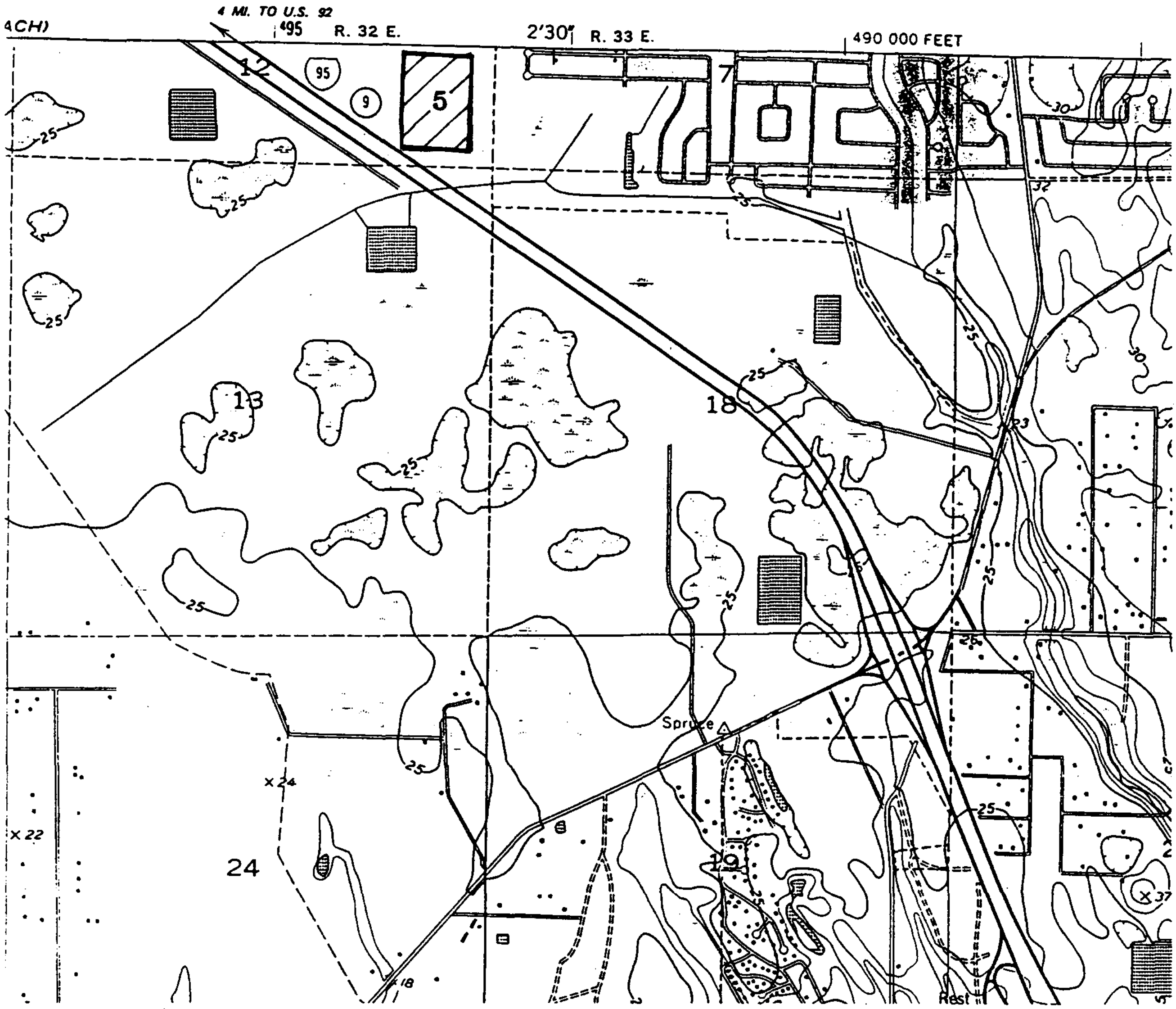
5.6.1 Location Description and Geoelectrical Section

The site is located in east-central Volusia County near Port Orange, Florida (Figure 5.6-1). The site is located within a pasture. No possible sources of interference were observed in the vicinity of the site. QA soundings were performed 110 ft north and 80 ft east of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 60 ft bmsl or 85 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at an approximate depth of 2,200 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 300 ft and the depth to the top of the Lower Floridan aquifer is approximately 750 ft bls (Miller, 1986). Chloride concentration in the upper portion of the Floridan aquifer ranges from 0 to 50 mg/l in this area (Rutledge, 1985). The resistivity sounding data and best-fit model inversion are presented on Figure 5.6-2. The interpreted geoelectrical section consists of a two-layer subsurface.

5.6.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the Holocene to Miocene deposits and the underlying Floridan aquifer to distinguish the two. Fixing the thickness of the upper layer does not resolve this dilemma; therefore, it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (207 m = 679 ft) surface layer of intermediate resistivity (40 ohm-m) overlying a low resistivity layer (9.6 ohm-m). The Holocene to Miocene deposits and part of the Floridan aquifer system exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater saturated Floridan aquifer at a depth of 679 ft bls. The saltwater interface at this site occurs near the top of the Lower Floridan aquifer.

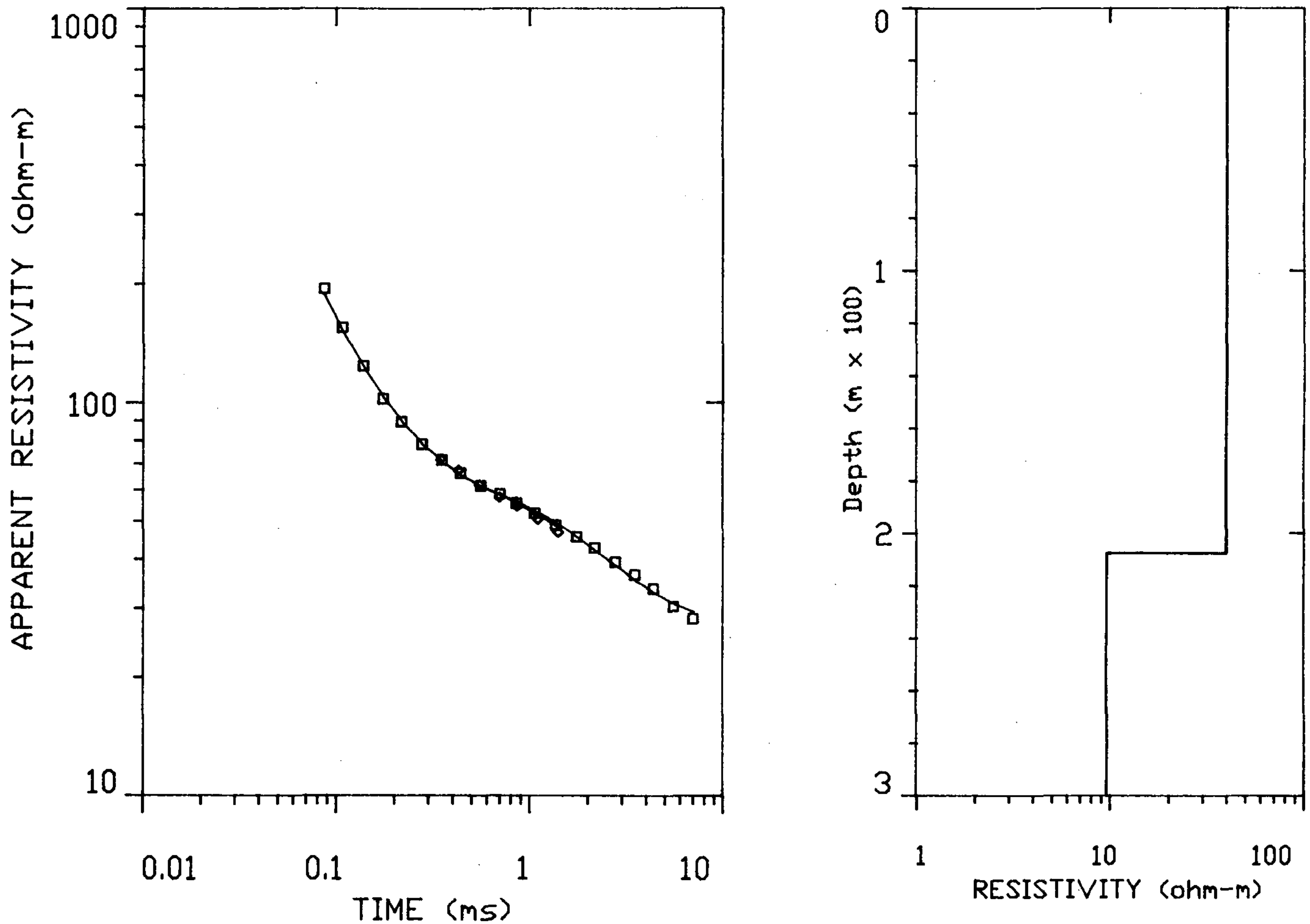


N

QUADRANGLE LOCATION

0 2000' 4000'

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 5 – PORT ORANGE VOLUSIA COUNTY, FLORIDA	
		DESIGNED BY: JEB CHECKED BY: MJW DRAWN BY: RBT	PROJECT NO.: 95706 DRAWING NO.: LOC–5 DATE: 06/21/95
		FIGURE	5.6–1



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 5 – PORT ORANGE
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-5	5.6-2
DRAWN BY:	SAB	DATE:	07/26/95	

5.6.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 9.6 ohm-m, is interpreted to represent salt water. It occurs at a depth of 679 ft (-654 ft msl), near the top of the Lower Floridan aquifer. Because the resistivity of Layer 1 (40 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken at the depth of the geoelectrical interface, or at 679 ft depth (-654 ft msl). The resistivity of Layer 2 (9.6 ohm-m) corresponds to a chloride concentration of 3,197 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

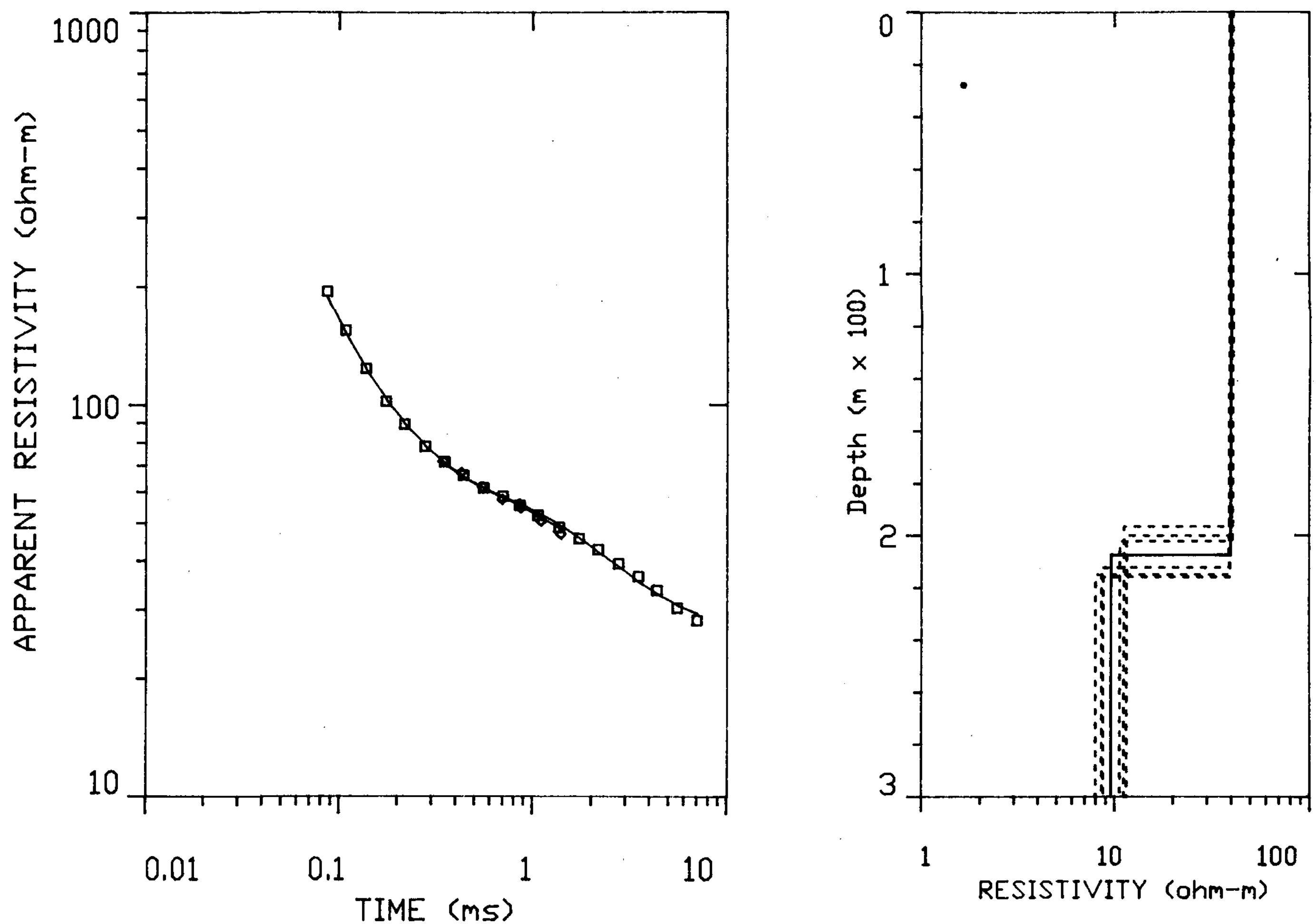
5.6.4 Depth of Occurrence of the 250 mg/l Isochlor

Because of the inability to segregate the Floridan aquifer from the overlying Holocene to Miocene deposits, the effective chloride concentration of Layer 1 cannot be calculated.

5.6.5 Accuracy of Measurement and Interpretation

Figure 5.6-3 is the equivalence analysis at this site and the inversion table (Table 5.6-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. The range of equivalence in determining the depth to the low resistivity layer is about ±10 m (33 ft) which is 5% of the total depth. The resistivity of this layer has a range from 8.0 to 11.5 ohm-m. This corresponds to a range in interpreted chloride concentration of from 3,867 to 2,644 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 1 is from 39 to 41 ohm-m. A corresponding chloride concentration cannot be determined because Layer 1 is in part comprised of Holocene to Miocene deposits. Accordingly, equation (4) may not be valid.



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 5 – PORT ORANGE
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-5	5.6-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 5

CLIENT:	SJRWMD	DATE:	05-MAY-95
LOCATION:	PORT ORANGE	SOUNDING:	1
COUNTY:	VOLUSIA COUNTY	ELEVATION:	7.60 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	244.000 m by 352.000 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		

SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 2.596 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			7.60	
1	39.77	207.4	-199.8	5.21
2	9.57			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	39.073	39.776	40.575
	2	7.959	9.575	11.539
THICK	1	196.477	1.000	215.858
DEPTH	1	196.477	207.441	215.858

CURRENT:	15.50 AMPS	EM-57	COIL AREA:	100.00 sq m.
FREQUENCY:	30.00 Hz	GAIN: 3	RAMP TIME:	150.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	112891.0	118647.7	-5.09
2	0.108	91805.4	94220.0	-2.63
3	0.138	69718.0	70063.5	-0.495
4	0.175	51461.1	50568.2	1.73
5	0.218	36300.3	36150.5	0.412
6	0.278	24049.9	24007.2	0.177
7	0.351	15380.2	15633.2	-1.64

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 5 – PORT ORANGE
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706

TABLE: 5.6–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	0.438	9945.4	10094.2	-1.49
9	0.558	6067.6	6085.3	-0.290
10	0.702	3676.8	3702.4	-0.696
11	0.858	2415.4	2392.3	0.954
12	1.06	1530.5	1502.0	1.86
13	1.37	908.9	889.7	2.11
14	1.74	553.1	551.4	0.301
15	2.17	351.2	358.4	-2.04
16	2.77	215.6	222.8	-3.34
17	3.50	134.5	141.2	-4.95
18	4.37	87.27	90.23	-3.39
19	5.56	55.93	54.62	2.33
20	7.03	34.63	32.71	5.55

CURRENT: 15.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 6 RAMP TIME: 150.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
21	0.346	15886.0	16098.8	-1.33
22	0.427	10347.1	10659.8	-3.02
23	0.550	6240.2	6306.1	-1.05
24	0.698	3843.2	3778.0	1.69
25	0.869	2395.6	2355.5	1.67
26	1.10	1465.5	1411.0	3.72
27	1.40	911.5	872.6	4.27

CURRENT: 15.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 6 RAMP TIME: 150.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
28	0.857	2401.0	2428.2	-1.13
29	1.06	1546.0	1530.6	0.995

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	1.00		
P 2	-0.01	0.81	
T 1	0.00	0.04	0.99
	P 1	P 2	T 1

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 5 - PORT ORANGE
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.6-1

5.6.6 Summary of TDEM Sounding at Port Orange (Site 5)

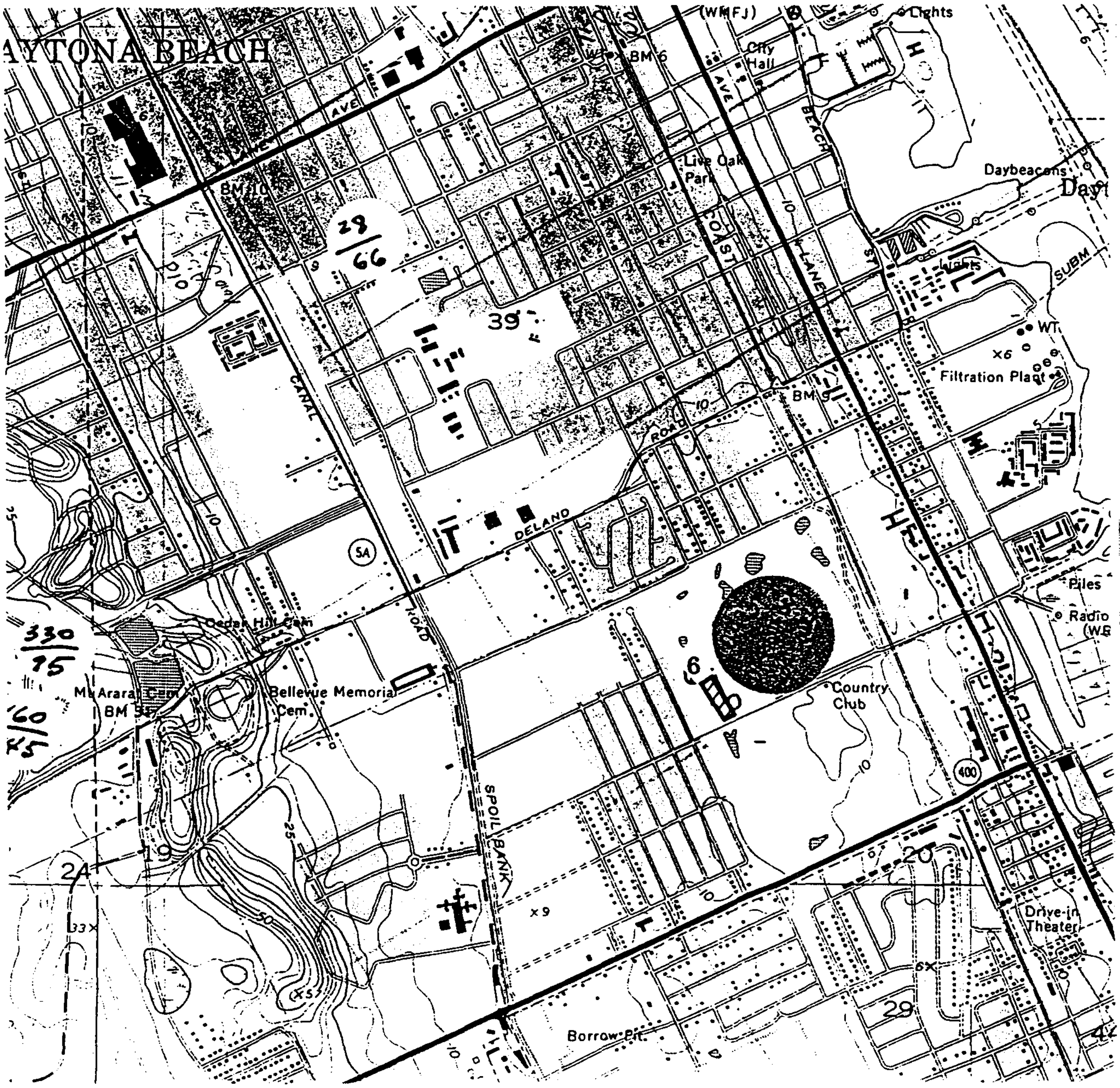
- The depth of occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 679 ft (-654 ft msl) and occur near the top of the Lower Floridan aquifer.
- The quality of ground water within the Floridan aquifer at this site cannot be interpreted because the analysis of the TDEM data does not allow the Holocene to Miocene deposits to be distinguished from the Floridan Aquifer System.

5.7 TDEM Site 6 - Daytona Beach Country Club

5.7.1 Location Description and Geoelectrical Section

The site is located in north-eastern Volusia County in Daytona Beach, Florida (Figure 5.7-1). The site is located within a wooded area between the 3N and 8N fairways of the Daytona Beach Country Club. Possible sources of interference included suspected underground piping at the golf course. QA soundings were performed 56 ft west and southeast of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 80 ft bmsl or 90 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at an approximate depth of 2,200 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 350 ft and the depth to the top of the Lower Floridan aquifer is approximately 800 ft bls (Miller, 1986). Chloride concentration in the Upper Floridan aquifer is above 250 mg/l in this area (Tibbals, 1990).



0 2000' 4000'

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 6 DAYTONA BEACH COUNTRY CLUB VOLUSIA COUNTY, FLORIDA	
		DESIGNED BY: JEB CHECKED BY: MJW DRAWN BY: RBT	PROJECT NO.: 95706 DRAWING NO.: LOC-6 DATE: 06/21/95	FIGURE 5.7-1

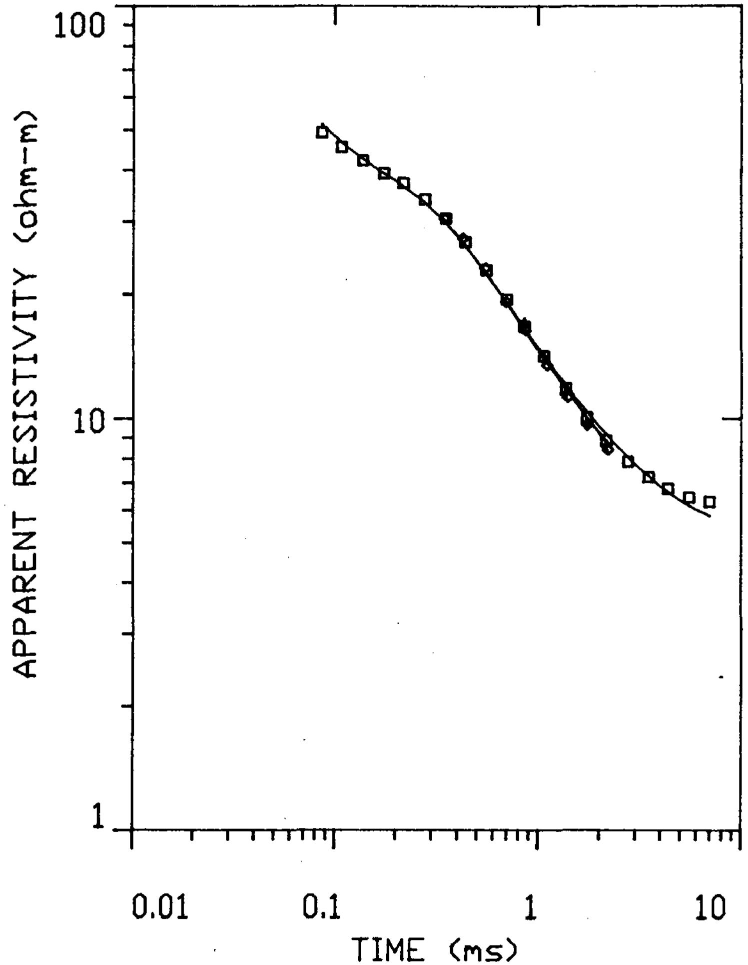
The resistivity sounding data and best-fit model inversion are presented on Figure 5.7-2. The interpreted geoelectrical section consists of a two-layer subsurface.

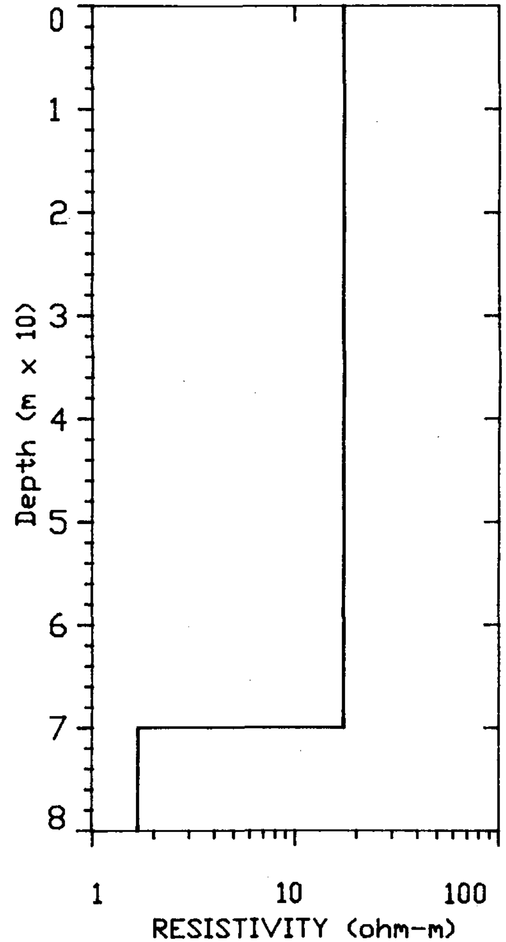
5.7.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the Holocene to Miocene deposits and the underlying Floridan aquifer to distinguish the two. Fixing the thickness of the upper layer does not resolve this dilemma; therefore, it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (70 m = 230 ft) surface layer of intermediate resistivity (17 ohm-m) overlying a low resistivity layer (1.7 ohm-m). The Holocene to Miocene deposits and part of the Upper Floridan aquifer exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater saturated Floridan aquifer at a depth of 230 ft bls.

5.7.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 1.7 ohm-m, is interpreted to represent salt water. It occurs at a depth of 230 ft (-220 ft msl). Because the resistivity of Layer 1 (17 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken at the depth of the geoelectrical interface, or at 230 ft depth (-220 ft msl). The resistivity of Layer 2 (1.7 ohm-m) corresponds to a chloride concentration of 18,767 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.





—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 6 – DAYTONA BEACH COUNTRY CLUB
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-6	5.7-2
DRAWN BY:	SAB	DATE:	07/26/95	

5.7.4 Depth of Occurrence of the 250 mg/l Isochlor

Because the resistivity of Layer 1 is below 20 ohm-m and because Layer 1 contains a portion of the Floridan aquifer, the 250 mg/l isochlor is not present in the Floridan aquifer at this site. Brackish water is present in the aquifer.

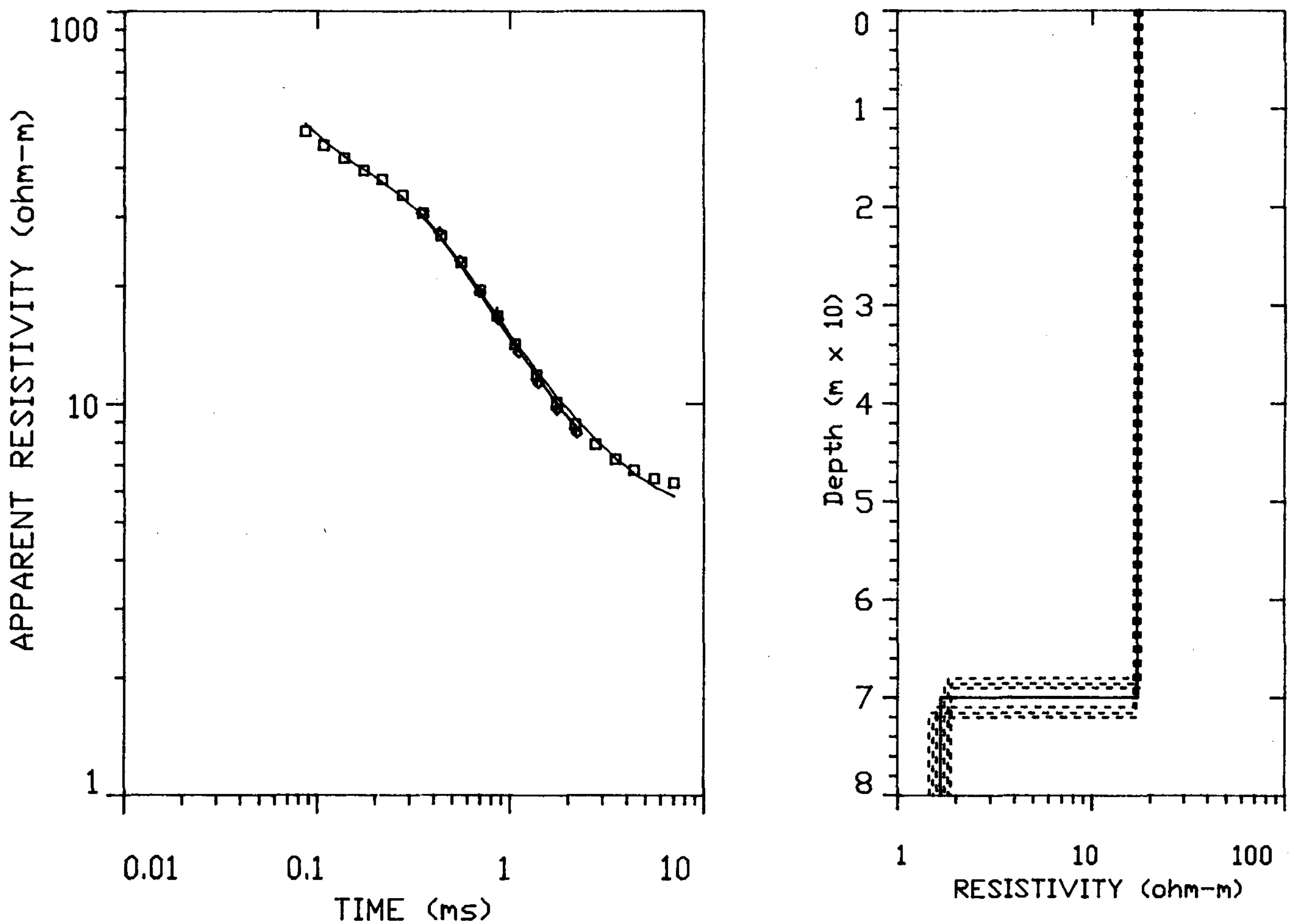
5.7.5 Accuracy of Measurement and Interpretation

Figure 5.7-3 is the equivalence analysis at this site and the inversion table (Table 5.7-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. The range of equivalence in determining the depth to the low resistivity layer is about ±2 m (7 ft) which is 3% of the total depth. The resistivity of this layer has a range from 1.5 to 1.9 ohm-m. This corresponds to an interpreted chloride concentration of 16,775 to over 20,000 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 1 is from 17 to 18 ohm-m. A corresponding chloride concentration cannot be determined because Layer 1 is in part comprised of Holocene to Miocene deposits. Accordingly, equation (4) may not be valid.

5.7.6 Summary of TDEM Sounding at Daytona Beach Country Club (Site 6)

- The depth of occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 230 ft (-220 ft msl) and occur within the Upper Floridan aquifer.
- The 250 mg/l isochlor is not present in the Floridan aquifer at this site. Water within the aquifer is brackish.



— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 6 – DAYTONA BEACH COUNTRY CLUB
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-6	5.7-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 6

CLIENT:	SJRWMD	DATE:	05-MAY-95
LOCATION:	DAYTONA BEACH COUNTRY CLUB	SOUNDING:	1
COUNTY:	VOLUSIA COUNTY	ELEVATION:	3.00 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	42.000 m by 173.000 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		

SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 4.097 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			3.00	
1	17.30	69.97	-66.97	4.04
2	1.66			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	16.619	17.302	17.986
	2	1.455	1.669	1.887
THICK	1	67.997	1.000	72.006
DEPTH	1	67.997	69.971	72.006

CURRENT:	23.50 AMPS EM-57	COIL AREA:	100.00 sq m.
FREQUENCY:	30.00 Hz GAIN: 3	RAMP TIME:	100.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	140912.9	131684.2	6.54
2	0.108	91806.6	88350.8	3.76
3	0.138	55538.6	54942.7	1.07
4	0.175	34193.8	34083.9	0.321
5	0.218	21405.9	21918.6	-2.39
6	0.278	13372.7	13698.4	-2.43
7	0.351	8750.8	9008.4	-2.94

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PALATKA, FLORIDA

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INVESTIGATIONS
INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 6 – DAYTONA BEACH COUNTRY CLUB
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.7-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	0.438	6138.7	6275.4	-2.22
9	0.558	4235.5	4342.3	-2.52
10	0.702	3046.1	3107.8	-2.02
11	0.858	2308.6	2335.3	-1.15
12	1.06	1719.6	1702.6	0.988
13	1.37	1209.4	1170.6	3.20
14	1.74	845.3	806.9	4.54
15	2.17	590.9	562.2	4.84
16	2.77	383.1	370.4	3.32
17	3.50	242.9	241.9	0.396
18	4.37	153.5	158.5	-3.24
19	5.56	90.72	97.32	-7.27
20	7.03	52.30	58.91	-12.63

CURRENT: 23.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 7 RAMP TIME: 100.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
21	0.346	9067.8	9289.8	-2.44
22	0.427	6351.1	6587.2	-3.71
23	0.550	4324.1	4491.1	-3.86
24	0.698	3153.6	3185.9	-1.02
25	0.869	2313.6	2343.8	-1.30
26	1.10	1688.6	1656.0	1.92
27	1.40	1224.2	1174.6	4.05
28	1.75	888.6	841.7	5.27
29	2.22	604.8	579.7	4.15

CURRENT: 23.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 100.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
30	0.857	2259.8	2393.1	-5.89
31	1.06	1729.0	1754.1	-1.45
32	1.37	1253.5	1219.1	2.74
33	1.74	895.6	852.0	4.86
34	2.17	620.4	603.8	2.66

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.99		
P 2	-0.01	0.94	
T 1	0.00	0.01	1.00
	P 1	P 2	T 1

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WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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DETECTION
INVESTIGATIONS
INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 6 – DAYTONA BEACH COUNTRY CLUB
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.7-1

5.8 TDEM Site 7 - Tiger Bay WMA

5.8.1 Location Description and Geoelectrical Section

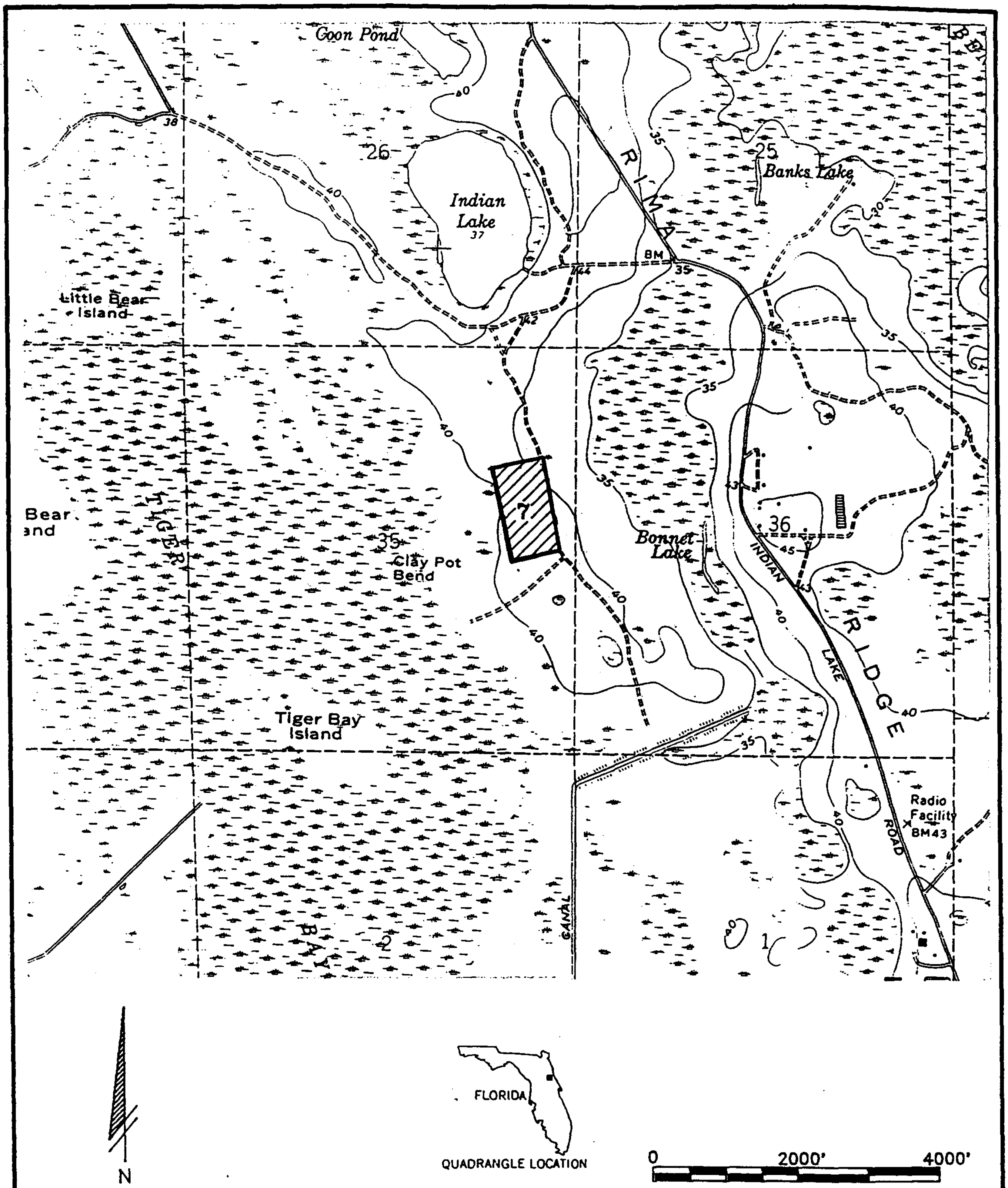
The site is located in north-central Volusia County, Florida (Figure 5.8-1). The site is located within a cleared tree farm. No sources of interference were observed within the proximity of the site. QA soundings were performed 130 ft north and south and 70 ft east of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 50 ft bmsl or 90 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The bottom of the Floridan aquifer occurs at an approximate depth of 2150 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 350 ft and the depth to the top of the Lower Floridan aquifer is approximately 820 ft bls (Miller, 1986). Chloride concentration in the upper portion of the Floridan aquifer ranges from 0 to 50 mg/l in this area and the maximum thickness of the freshwater-saturated Floridan aquifer is 1,000 ft (Rutledge, 1985).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.8-2. The interpreted geoelectrical section consists of a two-layer subsurface.

5.8.2 Geological Interpretation of Geoelectrical Model

The first layer occurs at 337 m (1,106 ft) bls and not at the hydrostratigraphic contact between the Holocene to Miocene deposits (90 ft bls) and the Floridan Aquifer System. Therefore, it can be interpreted that there exists a two-layer geoelectrical section with a 1,106 ft thick surface layer with a resistivity of 94 ohm-m overlying a low resistivity layer (1.4 ohm-m). The Holocene to Miocene deposits and the upper part of the Floridan aquifer system exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater-saturated Floridan aquifer at a depth of 1,106 ft bls.

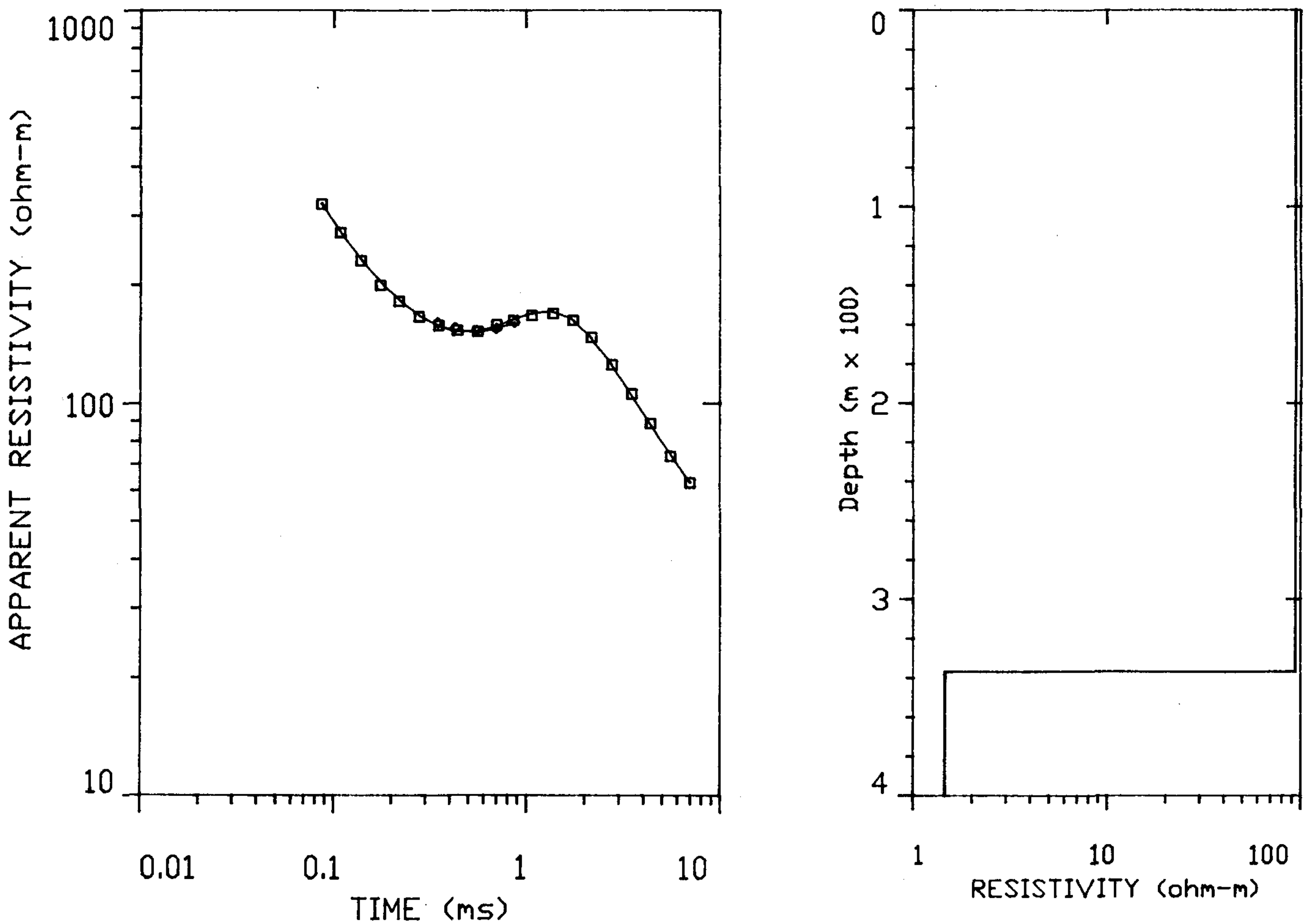


ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SURVEY LOCATION MAP
SOUNDING 7 – TIGER BAY WMA
VOLUSIA COUNTY, FLORIDA

DESIGNED BY: JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY: MJW	DRAWING NO.:	LOC-7	5.8-1
DRAWN BY: RBT	DATE:	06/20/95	



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 7 – TIGER BAY WMA
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-7	5.8-2
DRAWN BY:	SAB	DATE:	07/26/95	

5.8.3 Depth to Occurrence of Salt Water

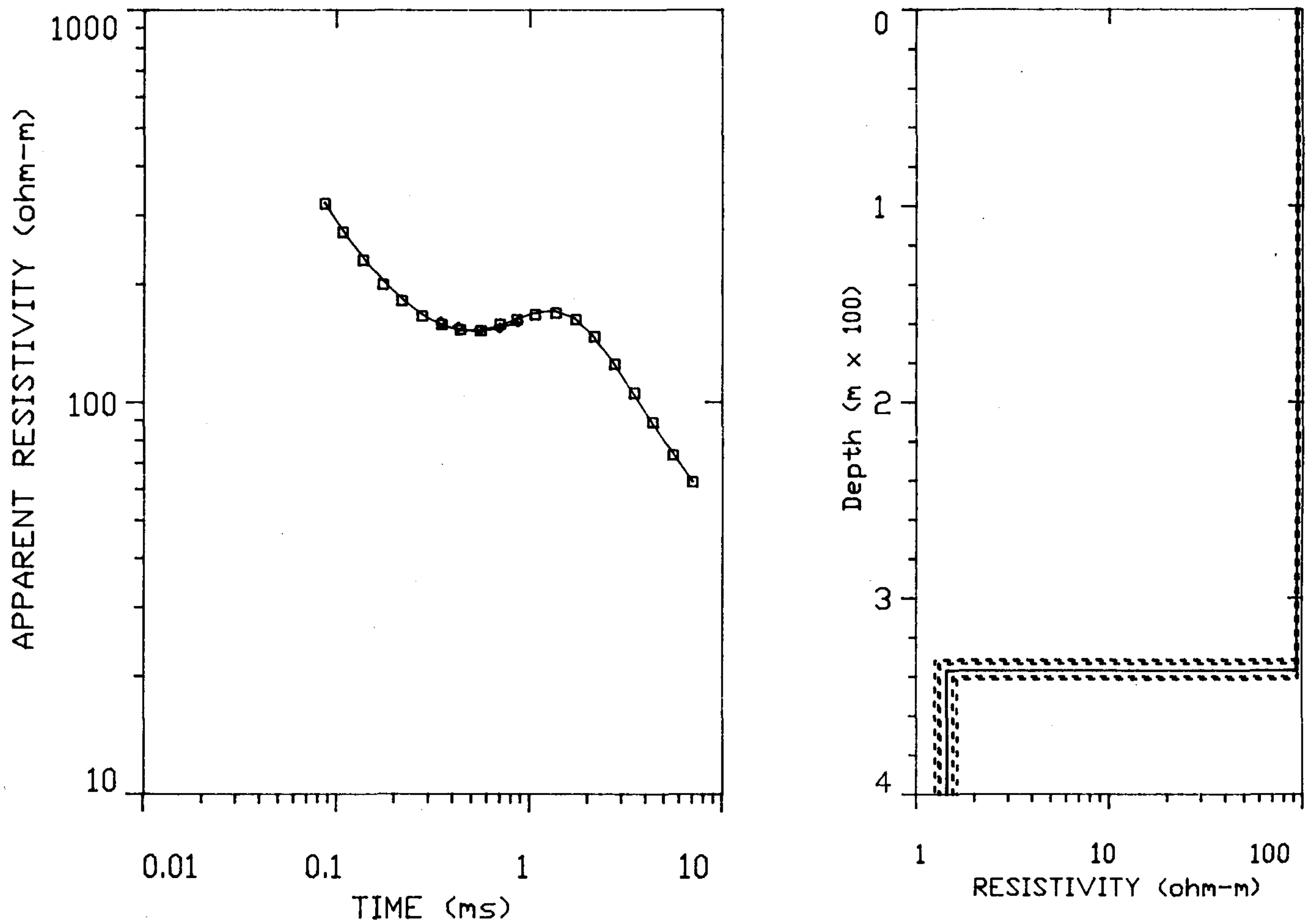
The bottom (second) layer of the geoelectrical model, with a resistivity of 1.4 ohm-m, is interpreted to represent salt water. It occurs at a depth of 1,106 ft (-1,066 ft msl). Because the resistivity of Layer 1 (94 ohm-m) is greater than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken as 50 ft greater than the depth of the geoelectrical interface, or at a depth of 1,156 ft (-1,116 ft msl). The resistivity of Layer 2 (1.4 ohm-m) corresponds to a chloride concentration of greater than 20,000 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

5.8.4 Depth of Occurrence of the 250 mg/l Isochlor

Since the resistivity (94 ohm-m) of Layer 1 is greater than 80 ohm-m, the chloride concentration in the Upper Floridan aquifer is less than 250 mg/l, even though Layer 1 contains Holocene to Miocene deposits. Since the resistivity of Layer 1 (94 ohm-m) is greater than 80 ohm-m, the 250 mg/l isochlor is interpreted to occur 50 ft above the boundary between Layer 1 and Layer 2. That depth is 1,056 ft. For comparison, Rutledge (1985) estimated a maximum thickness of approximately 1,000 ft for water with a chloride concentration less than 250 mg/l in the Floridan aquifer at this site. The top of the Floridan aquifer occurs at an approximate depth of 50 ft bmsl or 90 ft bls at this site (SJRWMD, personal communication).

5.8.5 Accuracy of Measurement and Interpretation

Figure 5.8-3 is the equivalence analysis at this site and the inversion table (Table 5.8-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. The range of equivalence in determining the depth to the low resistivity layer is about ±5 m (16



—— BEST–FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1–D INVERSION
SITE 7 – TIGER BAY WMA
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU–7	5.8–3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 7

CLIENT: SJRWMD
LOCATION: TIGER BAY
COUNTY: VOLUSIA COUNTY
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 396.000 m by 218.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 06-MAY-95
SOUNDING: 1
ELEVATION: 12.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 1.540 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			12.00	
1	94.15	336.9	-324.9	3.57
2	1.44			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	92.952	94.151	95.244
	2	1.254	1.446	1.636
THICK	1	331.393	1.000	341.413
DEPTH	1	331.393	336.945	341.413

CURRENT: 16.20 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz GAIN: 4 RAMP TIME: 165.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	57580.9	57345.6	0.408
2	0.108	42652.3	42142.7	1.19
3	0.138	29587.9	29014.5	1.93
4	0.175	20279.5	19612.0	3.29
5	0.218	13499.8	13270.8	1.69
6	0.278	8420.4	8310.6	1.30
7	0.351	5065.5	5091.5	-0.513

ST. JOHNS RIVER
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PALATKA, FLORIDA

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TDEM SOUNDING DATA TABLE
SITE 7 – TIGER BAY WMA
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.8–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	0.438	3050.4	3066.7	-0.535
9	0.558	1679.6	1678.7	0.0531
10	0.702	893.2	907.0	-1.54
11	0.858	519.9	517.8	0.408
12	1.06	289.2	284.3	1.71
13	1.37	152.1	148.8	2.12
14	1.74	88.65	88.02	0.711
15	2.17	59.32	59.74	-0.714
16	2.77	41.07	41.13	-0.154
17	3.50	29.54	29.91	-1.27
18	4.37	21.96	22.22	-1.17
19	5.56	16.04	15.84	1.22
20	7.03	11.30	11.30	0.0490

CURRENT: 16.20 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 8 RAMP TIME: 165.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
21	0.346	5125.9	5270.9	-2.82
22	0.427	3173.8	3274.4	-3.16
23	0.550	1729.8	1759.0	-1.68
24	0.698	936.4	937.5	-0.118
25	0.869	511.6	515.4	-0.733

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

	P 1	P 2	T 1
P 1	1.00		
P 2	-0.03	0.67	
T 1	0.00	-0.03	0.99

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 7 – TIGER BAY WMA
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.8–1

ft) which is 1% of the total depth. The resistivity of this layer has a range of from 1.3 to 1.6 ohm-m. This corresponds to an interpreted chloride concentration exceeding 20,000 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 1 is from 93 to 95 ohm-m. Since the resistivity is greater than 80 ohm-m, the chloride concentration in the upper part of the Floridan aquifer is less than 250 mg/l even though Layer 1 is in part comprised of both the upper portion of the Floridan aquifer and Holocene to Miocene deposits.

5.8.6 Summary of TDEM Sounding at Tiger Bay (Site 7)

- The depth of occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 1,156 ft (-1,116 ft msl) and occur within the Lower Floridan aquifer.
- The 250 mg/l isochlor is interpreted to occur at 1,056 ft bls. The thickness of freshwater (<250 mg/l chloride) in the Floridan aquifer at this site is interpreted to be 966 ft.
- The results of the TDEM study are in agreement with the thickness estimates for freshwater (<250 mg/l chloride) from Rutledge (1985) who indicated that the maximum thickness of freshwater (<250 mg/l chloride) in the Floridan aquifer in this area to be approximately 1,000 ft.

5.9 TDEM Site 8 - Reed Canal

5.9.1 Location Description and Geoelectrical Section

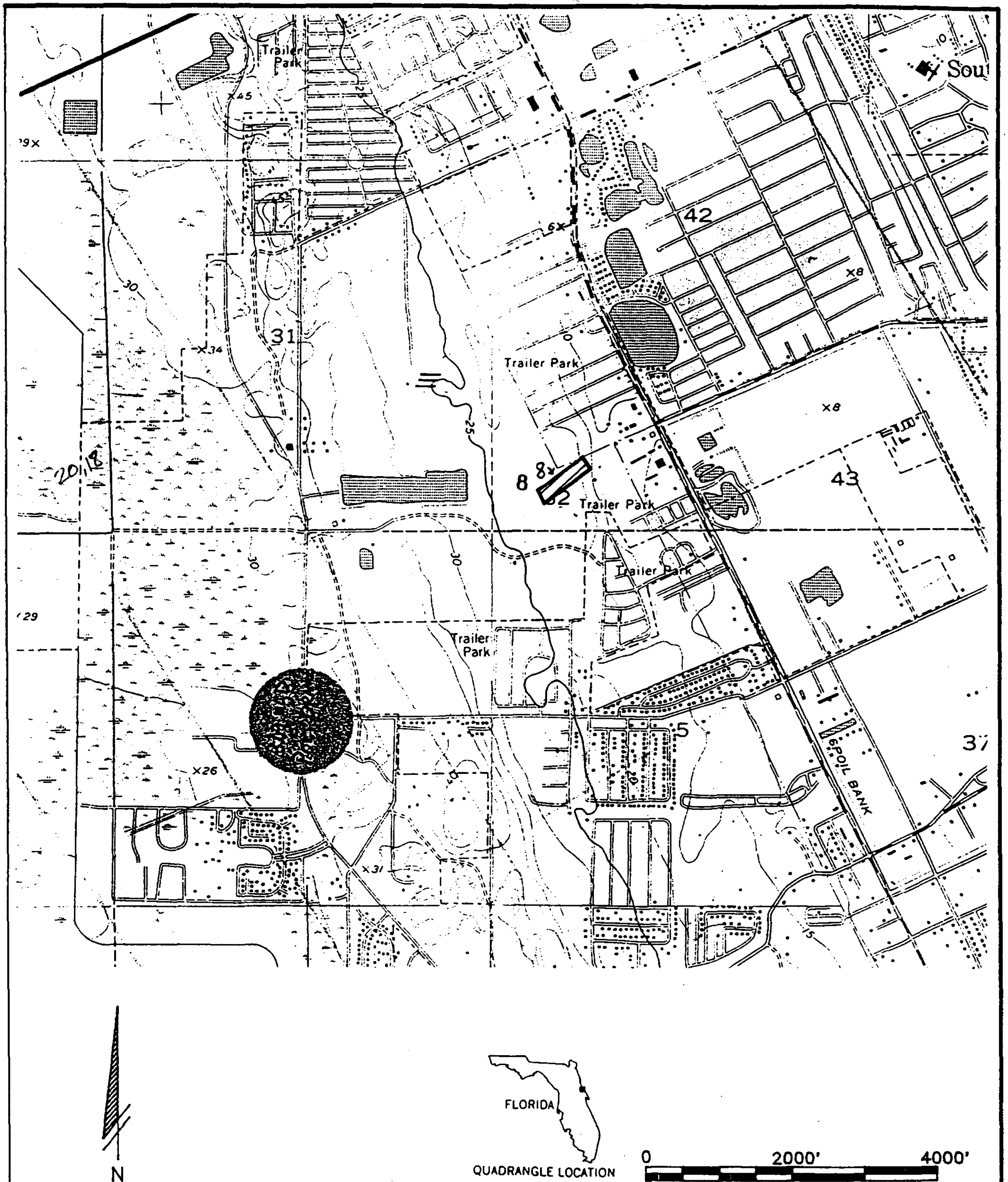
The site is located in east-central Volusia County in South Daytona, Florida (Figure 5.9-1). The site is located within a wooded area. Scattered pieces of metallic debris were present in several areas near the transmitter loop. This debris could be a possible source of interference. QA soundings were performed 70 ft west and 24 ft south of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 70 ft bmsl or 90 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at approximately 2,200 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 350 ft and the depth to the top of the Lower Floridan aquifer is approximately 800 ft bls (Miller, 1986). Chloride concentration in the Upper Floridan aquifer is above 250 mg/l in this area (Tibbals, 1990).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.9-2. The interpreted geoelectrical section consists of a two-layer subsurface.

5.9.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the Holocene to Miocene deposits and the underlying Floridan aquifer to distinguish the two. Fixing the thickness of the upper layer does not resolve this dilemma; therefore, it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (193 m = 633 ft) surface layer of intermediate resistivity (49 ohm-m) overlying a low resistivity layer (2.1 ohm-m). The Holocene to Miocene deposits and part of the Floridan aquifer system exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater saturated Floridan aquifer at a depth of 633 ft bls.

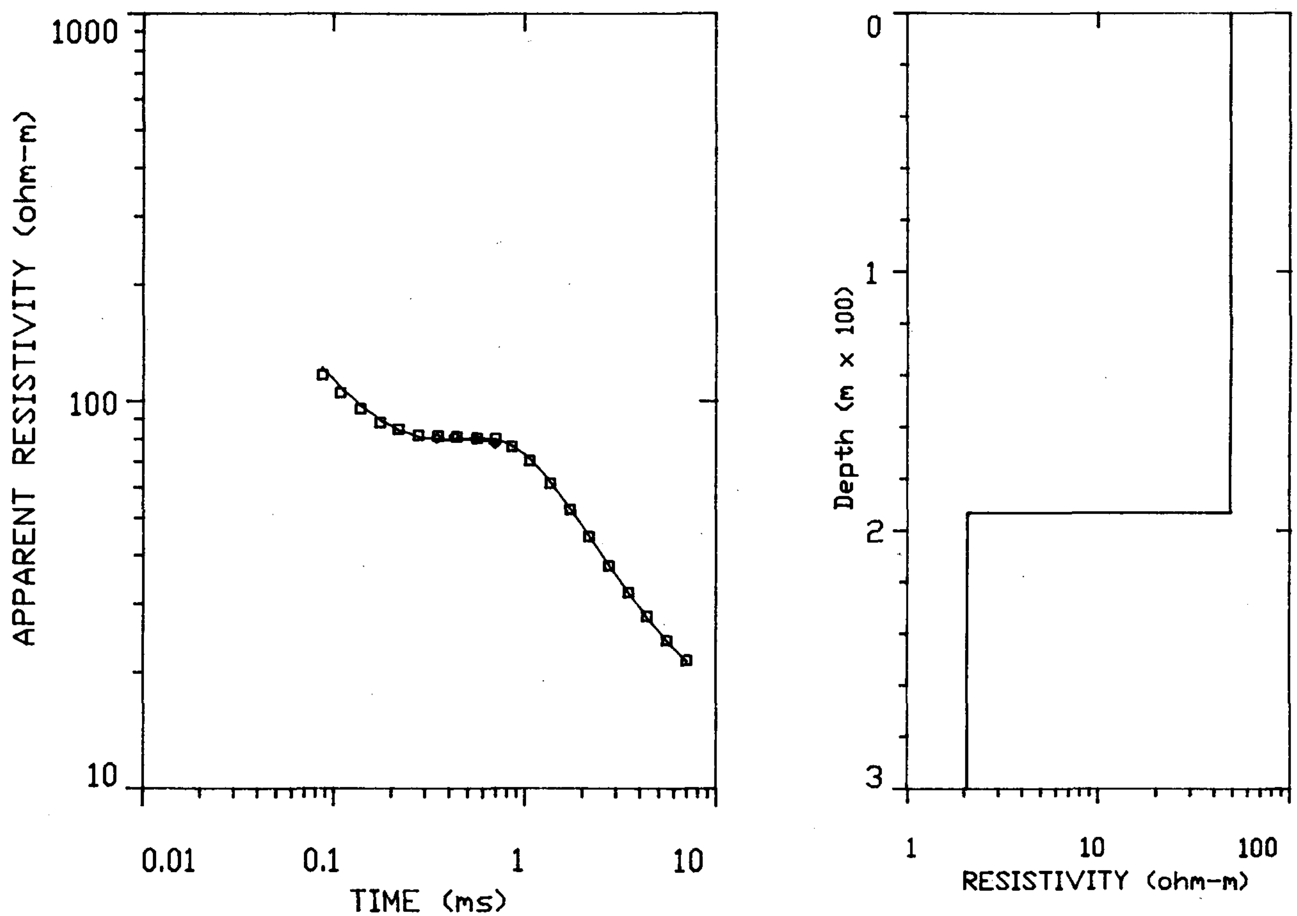


ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SURVEY LOCATION MAP
SOUNDING 8 – REED CANAL
VOLUSIA COUNTY, FLORIDA

DESIGNED BY: JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY: MJW	DRAWING NO.:	LOC-8	5.9-1
DRAWN BY: RBT	DATE:	06/21/95	



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER
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PALATKA, FLORIDA

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MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 8 – REED CANAL
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-8	5.9-2
DRAWN BY:	SAB	DATE:	07/26/95	

5.9.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 2.1 ohm-m, is interpreted to represent salt water. It occurs at a depth of 633 ft (-613 ft msl). Because the resistivity of Layer 1 (49 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken at the depth of the geoelectrical interface, or at 633 ft depth (-613 ft msl). The resistivity of Layer 2 (2.1 ohm-m) corresponds to a chloride concentration of 15,163 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

5.9.4 Depth of Occurrence of the 250 mg/l Isochlor

Because of the inability to segregate the Floridan aquifer from the overlying Holocene to Miocene deposits, the effective chloride concentration of Layer 1 cannot be calculated.

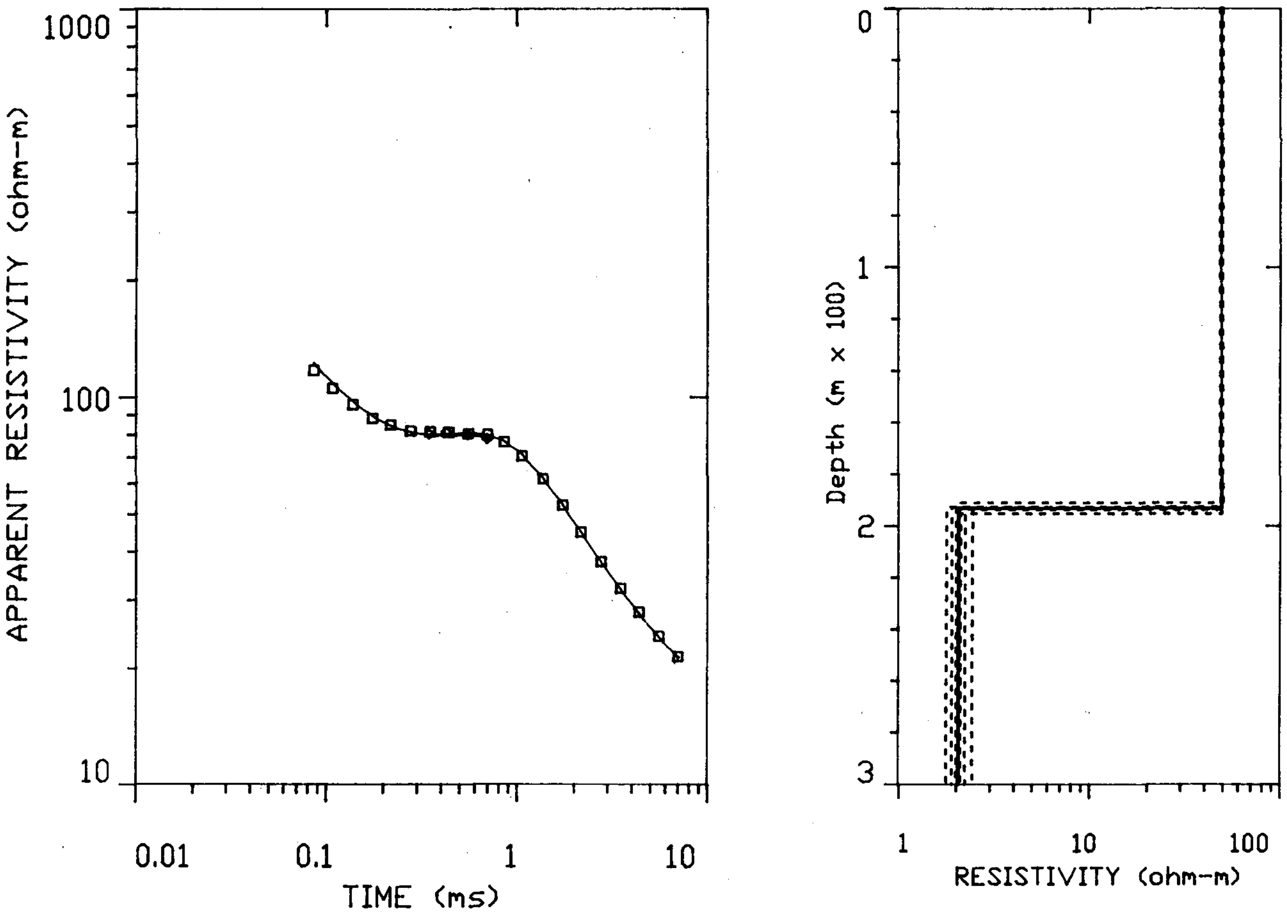
5.9.5 Accuracy of Measurement and Interpretation

Figure 5.9-3 is the equivalence analysis at this site and the inversion table (Table 5.9-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. The range of equivalence in determining the depth to the low resistivity layer is about ±2 m (7 ft) which is 1% of the total depth. The resistivity of this layer has a range from 1.8 to 2.4 ohm-m. This corresponds to a range in interpreted chloride concentration of from 17,716 to 13,248 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 1 is from 48 to 50 ohm-m. A corresponding chloride concentration cannot be determined because Layer 1 is in part comprised of Holocene to Miocene deposits. Accordingly, equation (4) may not be valid.

5.9.6 Summary of TDEM Sounding at Reed Canal (Site 8)

- The depth of occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 633 ft (-613 ft msl).
- The quality of ground water within the Floridan aquifer at this site cannot be interpreted because the analysis of the TDEM data does not allow the Holocene to Miocene deposits to be distinguished from the Floridan Aquifer System.



——— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 8 – REED CANAL
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-8	5.9-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE8

CLIENT:	SJRWMD	DATE:	06-MAY-95
LOCATION:	REED CANAL	SOUNDING:	1
COUNTY:	VOLUSIA COUNTY	ELEVATION:	6.00 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	231.000 m by 75.000 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		
SOUNDING COORDINATES:	E: 0.0000 N: 0.0000		

FITTING ERROR: 2.248 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			6.00	
1	48.90	193.1	-187.1	3.94
2	2.05			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	48.195	48.909	49.634
	2	1.772	2.050	2.436
THICK	1	190.993	1.000	195.247
DEPTH	1	190.993	193.140	195.247

CURRENT:	20.00 AMPS	EM-57	COIL AREA:	100.00 sq m.
FREQUENCY:	30.00 Hz	GAIN: 3	RAMP TIME:	100.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	72066.3	67706.0	6.05
2	0.108	48802.7	46514.0	4.68
3	0.138	30559.6	29730.2	2.71
4	0.175	19071.1	18687.8	2.01
5	0.218	11685.1	11785.8	-0.861
6	0.278	6714.4	6816.7	-1.52
7	0.351	3769.3	3892.4	-3.26

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 8 – REED CANAL
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.9–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	0.438	2179.6	2228.4	-2.24
9	0.558	1204.9	1201.8	0.252
10	0.702	684.6	687.6	-0.447
11	0.858	443.0	439.5	0.784
12	1.06	291.7	286.6	1.75
13	1.37	190.8	189.1	0.877
14	1.74	132.5	132.2	0.239
15	2.17	97.08	96.99	0.0996
16	2.77	68.57	68.82	-0.362
17	3.50	48.48	48.82	-0.693
18	4.37	34.34	34.86	-1.50
19	5.56	23.35	23.54	-0.823
20	7.03	15.53	15.70	-1.11

CURRENT: 20.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 8 RAMP TIME: 100.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
21	0.346	3976.4	4051.3	-1.88
22	0.427	2316.2	2396.4	-3.46
23	0.550	1254.5	1264.6	-0.799
24	0.698	722.8	714.6	1.13

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

	P 1	P 2	T 1
P 1	1.00		
P 2	-0.02	0.72	
T 1	0.00	0.00	1.00

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE
DETECTION
INVESTIGATIONS
INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 8 – REED CANAL
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.9-1

5.10 TDEM Site 9 - Samsula

5.10.1 Location Description and Geoelectrical Section

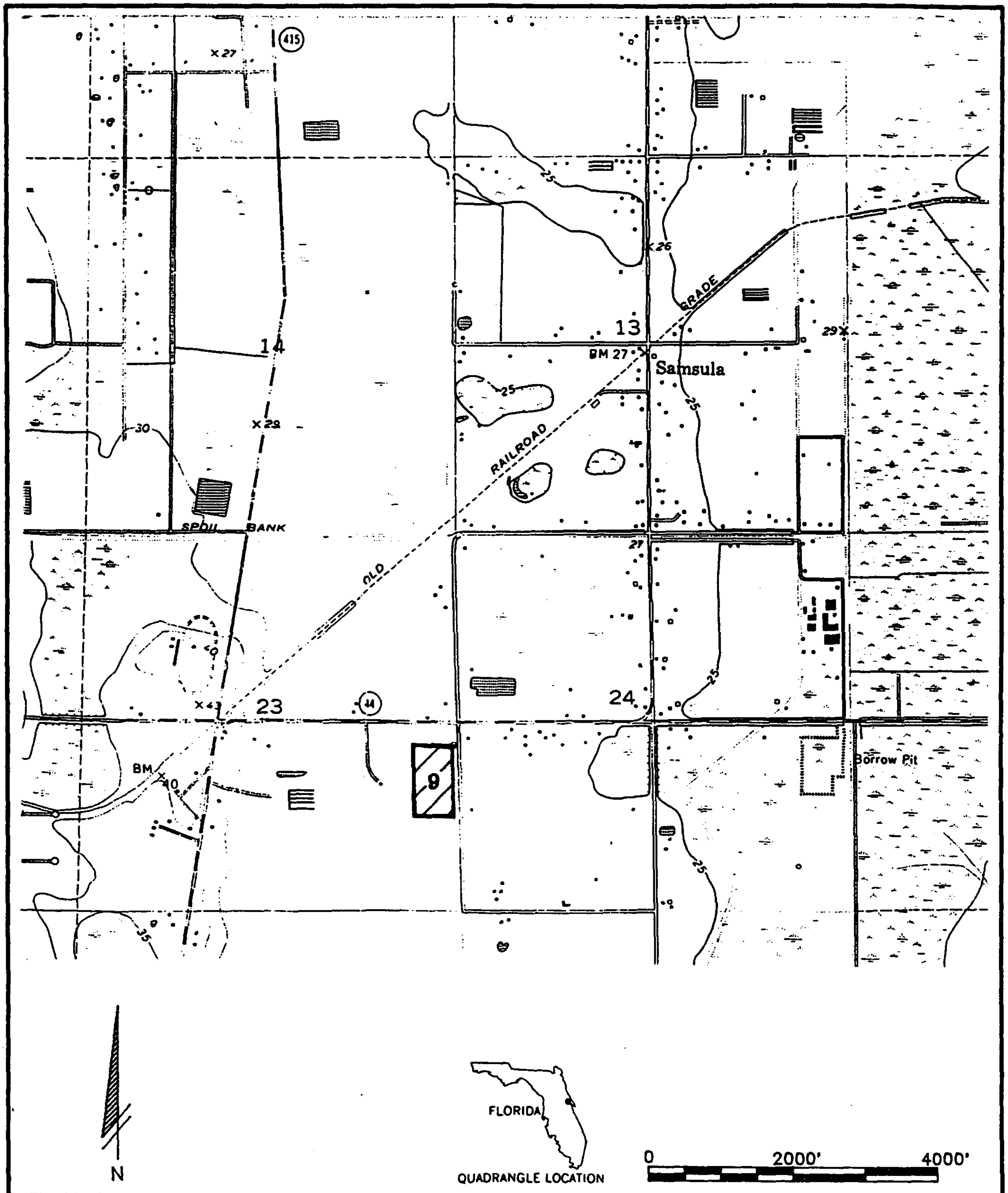
The site is located in east-central Volusia County, Florida (Figure 5.10-1). The site is located within a pasture. A possible interference source (powerlines) existed 200 ft north of the Tx loop. QA soundings were performed 100 ft north, south and east of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 60 ft bmsl or 85 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at approximately 2,250 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 300 ft and the depth to the top of the Lower Floridan aquifer is approximately 750 ft bls (Miller, 1986). Chloride concentration in the upper portion of the Floridan aquifer ranges from 0 to 50 mg/l and the maximum thickness of the freshwater-saturated Floridan aquifer is 600 ft in this area (Rutledge, 1985).

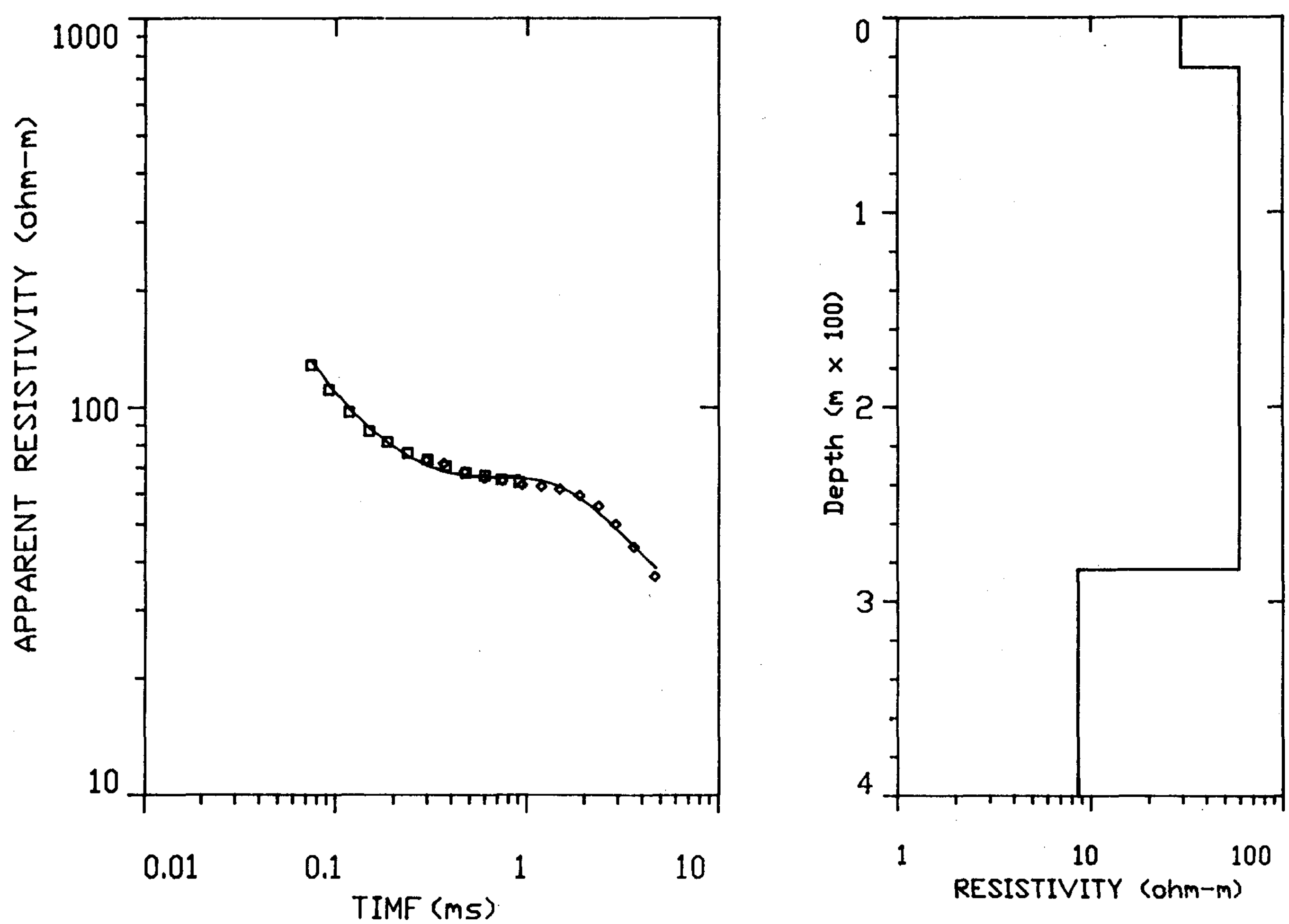
The resistivity sounding data and best-fit model inversion are presented on Figure 5.10-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.10.2 Geological Interpretation of Geoelectrical Model

The three-layered geoelectrical section consists of a low resistivity (29 ohm-m) upper layer which is considered to be Holocene to Miocene deposits above the Floridan aquifer. The thickness of Layer 1 was fixed at 25.9 m (85 ft, SJRWMD, personal communication). The second layer has only intermediate resistivity (60 ohm-m) which, because it is less than 80 ohm-m, suggests the Floridan aquifer at this site contains brackish water. The thickness of the brackish section is 258 m (846 ft), placing the depth to the low resistivity (saltwater) layer at 284 m (932 ft) below ground surface. The resistivity of the saltwater saturated layer is 8.6



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 9 – SAMSULA VOLUSIA COUNTY, FLORIDA		
		DESIGNED BY: JEB CHECKED BY: MJW DRAWN BY: RBT	PROJECT NO.: 95706 DRAWING NO.: LOC-9 DATE: 06/21/95	FIGURE 5.10-1



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION SITE 9 - SAMSULA VOLUSIA COUNTY, FLORIDA	
		DESIGNED BY: JEB CHECKED BY: MJW DRAWN BY: SAB	PROJECT NO.: 95706 DRAWING NO.: MDL-9 DATE: 07/26/95
		FIGURE 5.10-2	

ohm-m. Layer 1 is considered to be the Holocene to Miocene deposits above the Floridan aquifer, Layer 2 to be the Floridan aquifer (brackish), and Layer 3 to be the salt water within the Lower Floridan aquifer.

5.10.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 8.6 ohm-m, is interpreted to represent salt water. It occurs at a depth of 932 ft (-907 ft msl). Because the resistivity of Layer 2 (60 ohm-m) is interpreted to represent brackish water within the Floridan aquifer (is less than 80 ohm-m), the interpreted depth to the 5,000 mg/l isochlor is equal to the depth of the geoelectrical interface, or at 932 ft depth (-907 ft msl). The resistivity of Layer 3 (8.6 ohm-m) corresponds to a chloride concentration of 3,587 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

5.10.4 Depth of Occurrence of the 250 mg/l Isochlor

The resistivity of Layer 2, 60 ohm-m, corresponds to a chloride concentration above 250 mg/l, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. As the interpreted chloride concentration exceeds 250 mg/l, the 250 mg/l isochlor does not occur within the Floridan aquifer at this site. This conclusion does not agree with Rutledge (1985) who estimated a maximum thickness of approximately 600 ft for water with a chloride concentration less than 250 mg/l in the Floridan aquifer in this area. The top of the Floridan aquifer occurs at an approximate depth of 60 ft bmsl or 85 ft bls at this site (SJRWMD, personal communication).

5.10.5 Accuracy of Measurement and Interpretation

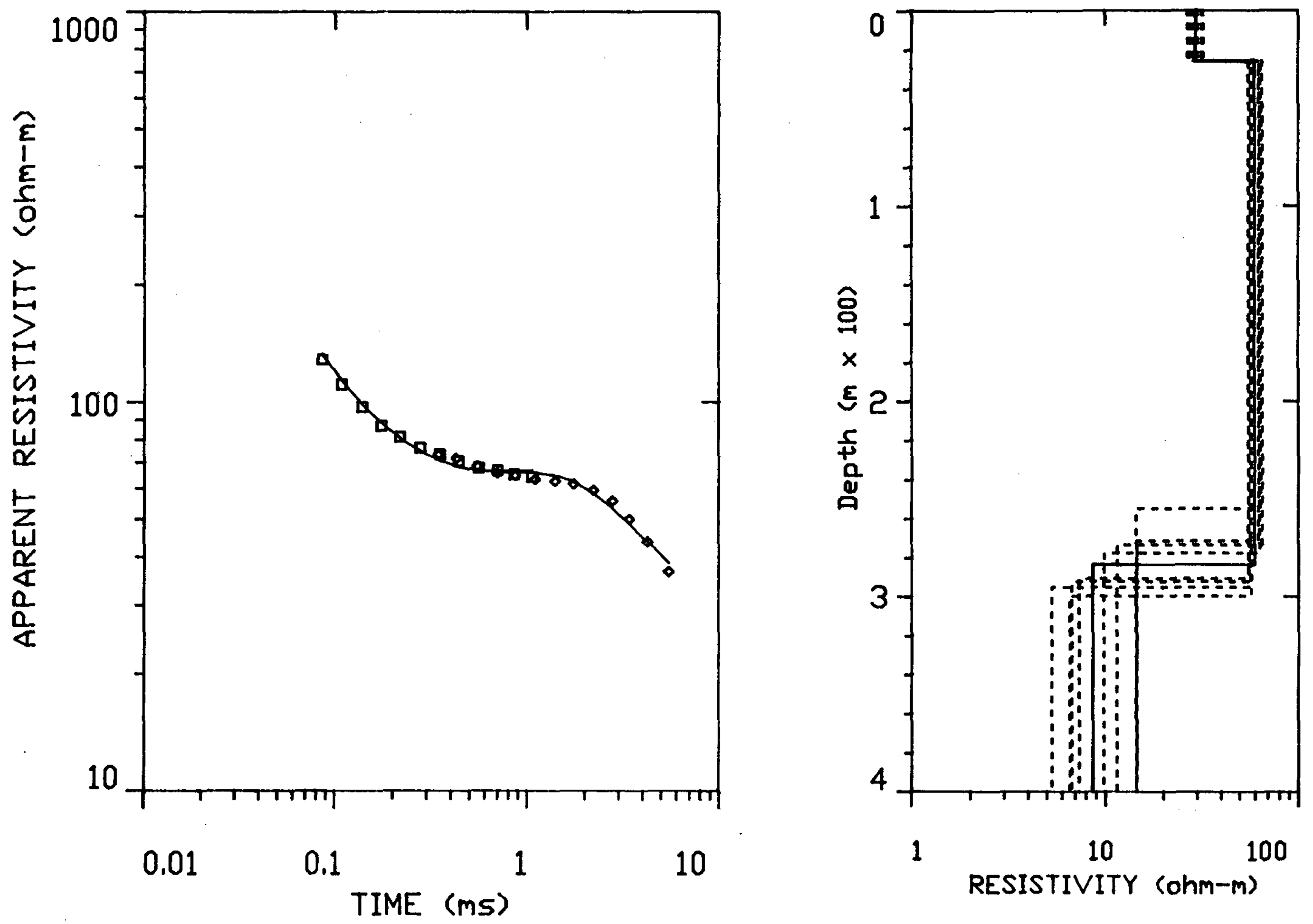
Figure 5.10-3 is the equivalence analysis at this site and Table 5.10-1 lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ±22 m (72 ft) which is 8% of the total depth. The resistivity of this layer has a range from 5.3 to 14.5 ohm-m. This corresponds to a range in interpreted chloride concentration from 5,916 to 2,065 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 2 is from 55 to 65 which corresponds to a chloride concentration above 250 mg/l. The results of the TDEM study are not in agreement with Rutledge (1985). The chloride-to-sulfate ratio at the site is 5:1 (Table 5.1-4). Accordingly, equation (4) is valid. The discrepancy in the water quality results between the TDEM survey and Rutledge (1985) is probably due to the averaging of water quality in the Floridan aquifer by TDEM. There is not a sufficient resistivity contrast to locate the 250 mg/l isochlor at this site. As a consequence, TDEM yields an average resistivity for Layer 2. Rutledge (1985) estimated a maximum thickness of approximately 600 ft for water with a chloride concentration below 250 mg/l in this area. However, the thickness of Layer 2 is 846 ft.

5.10.6 Summary of TDEM Sounding at Samsula (Site 9)

- The depth to occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 932 ft (-907 ft msl) and occur within the Lower Floridan aquifer.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration above 250 mg/l. The 250 mg/l isochlor is not interpreted to be present within the Floridan aquifer.
- The results of the TDEM study are not in agreement with Rutledge (1985) who estimated a maximum thickness of approximately 600 ft for water with a chloride concentration below 250 mg/l in the Floridan aquifer in this area.



—— BEST–FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1–D INVERSION
SITE 9 – SAMSULA
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU–9	5.10–3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 9

CLIENT: SJRWMD
LOCATION: SAMSULA
COUNTY: VOLUSIA COUNTY
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 305.000 m by 152.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 05-MAY-95
SOUNDING: 1
ELEVATION: 7.60 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 4.338 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)		ELEVATION (meters)	CONDUCTANCE (Siemens)
				7.60	
1	29.28	25.90	*	-18.30	0.884
2	59.67	257.6		-275.9	4.31
3	8.60				

"*" INDICATES FIXED PARAMETER

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	26.764	29.282	32.250
	2	55.246	59.674	65.369
	3	5.298	8.602	14.505
THICK	1	25.900	0.000	25.900
	2	228.897	1.000	273.718
DEPTH	1	25.900	25.900	25.900
	2	254.797	283.501	299.618

CURRENT: 20.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz GAIN: 3 RAMP TIME: 150.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	153139.3	146034.1	4.63
2	0.108	109990.4	105370.6	4.20
3	0.138	72819.0	70595.0	3.05

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 9 – SAMSULA
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.10–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.175	47545.5	46302.8	2.61
5	0.218	30281.9	30502.2	-0.727
6	0.278	18172.0	18671.9	-2.75
7	0.351	10747.0	11347.9	-5.59
8	0.438	6553.8	6892.3	-5.16
9	0.558	3802.1	3896.0	-2.46
10	0.702	2192.5	2213.4	-0.950
11	0.858	1376.6	1338.0	2.80
12	1.06	818.7	775.1	5.32

CURRENT: 20.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 6 RAMP TIME: 150.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
13	0.346	11170.6	11725.1	-4.96
14	0.427	6817.8	7321.5	-7.38
15	0.550	3891.4	4047.9	-4.02
16	0.698	2275.9	2258.8	0.751
17	0.869	1343.5	1309.1	2.56
18	1.10	760.0	715.6	5.84
19	1.40	427.7	406.6	4.93
20	1.75	252.6	247.0	2.23
21	2.22	147.4	150.6	-2.20
22	2.79	91.43	97.41	-6.54
23	3.42	64.67	67.12	-3.78
24	4.26	45.76	45.68	0.182
25	5.49	31.59	29.19	7.60

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.99				
P 2	0.01	0.99			
P 3	0.02	-0.04	0.61		
F 1	0.00	0.00	0.00	0.00	
T 2	0.00	0.00	0.04	0.00	0.99
	P 1	P 2	P 3	F 1	T 2

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE
DETECTION
INVESTIGATIONS
INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 9 – SAMSULA
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.10-1

5.11 TDEM Site 10 - Oak Hill

5.11.1 Location Description and Geoelectrical Section

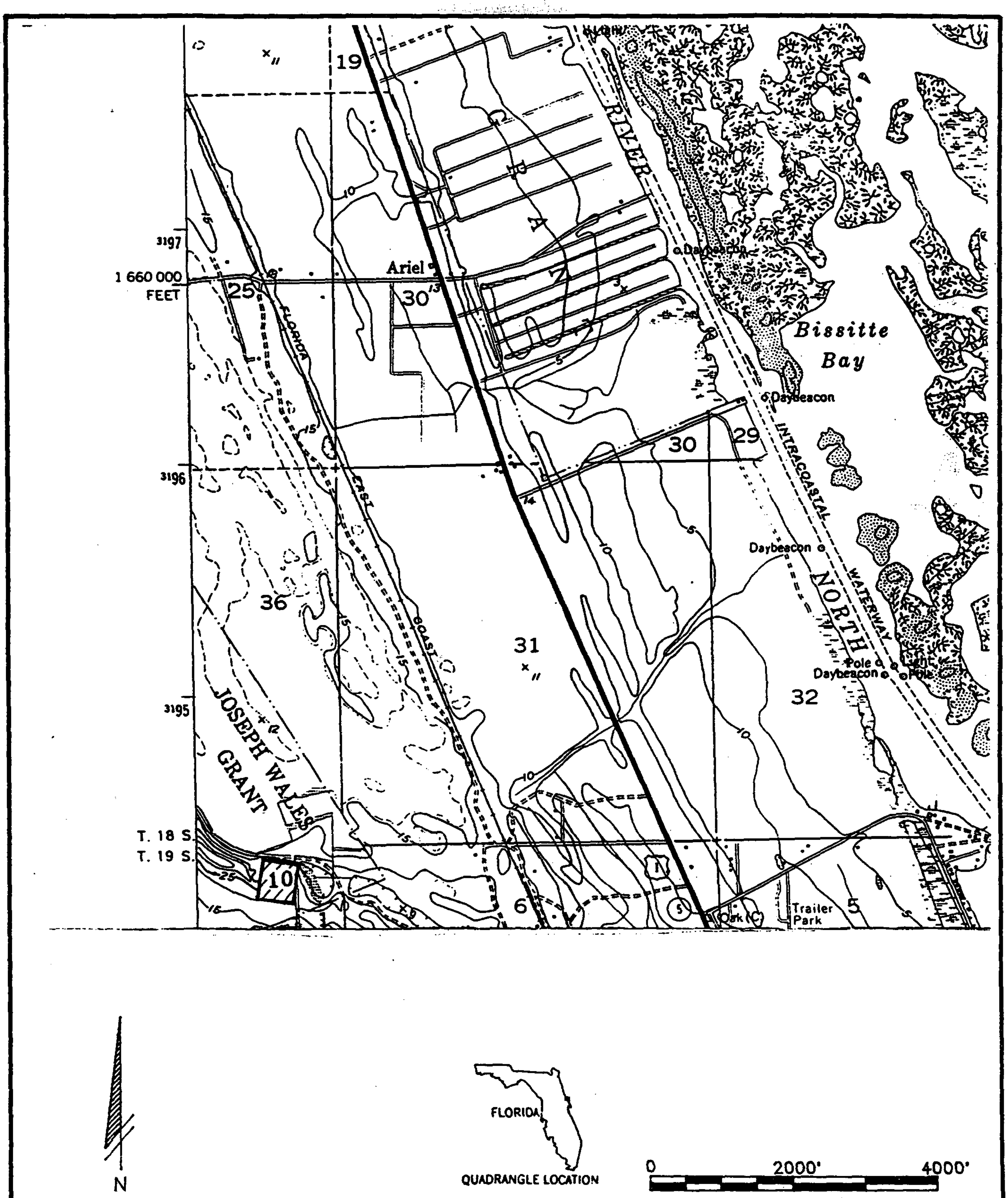
The site is located in south-eastern Volusia County near Oak Hill, Florida (Figure 5.11-1). The site is located within an orange grove. A possible source of interference (a powerline) existed 300 ft south of the Tx loop. QA soundings were performed 54 ft east and south of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 120 ft bmsl or 145 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at an approximate depth of 2,350 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 375 ft and the depth to the top of the Lower Floridan aquifer is approximately 875 ft bls (Miller, 1986). The chloride concentration in the Floridan aquifer at this site is between 250 and 1,000 mg/l (Rutledge, 1985). The resistivity sounding data and best-fit model inversion are presented on Figure 5.11-2.

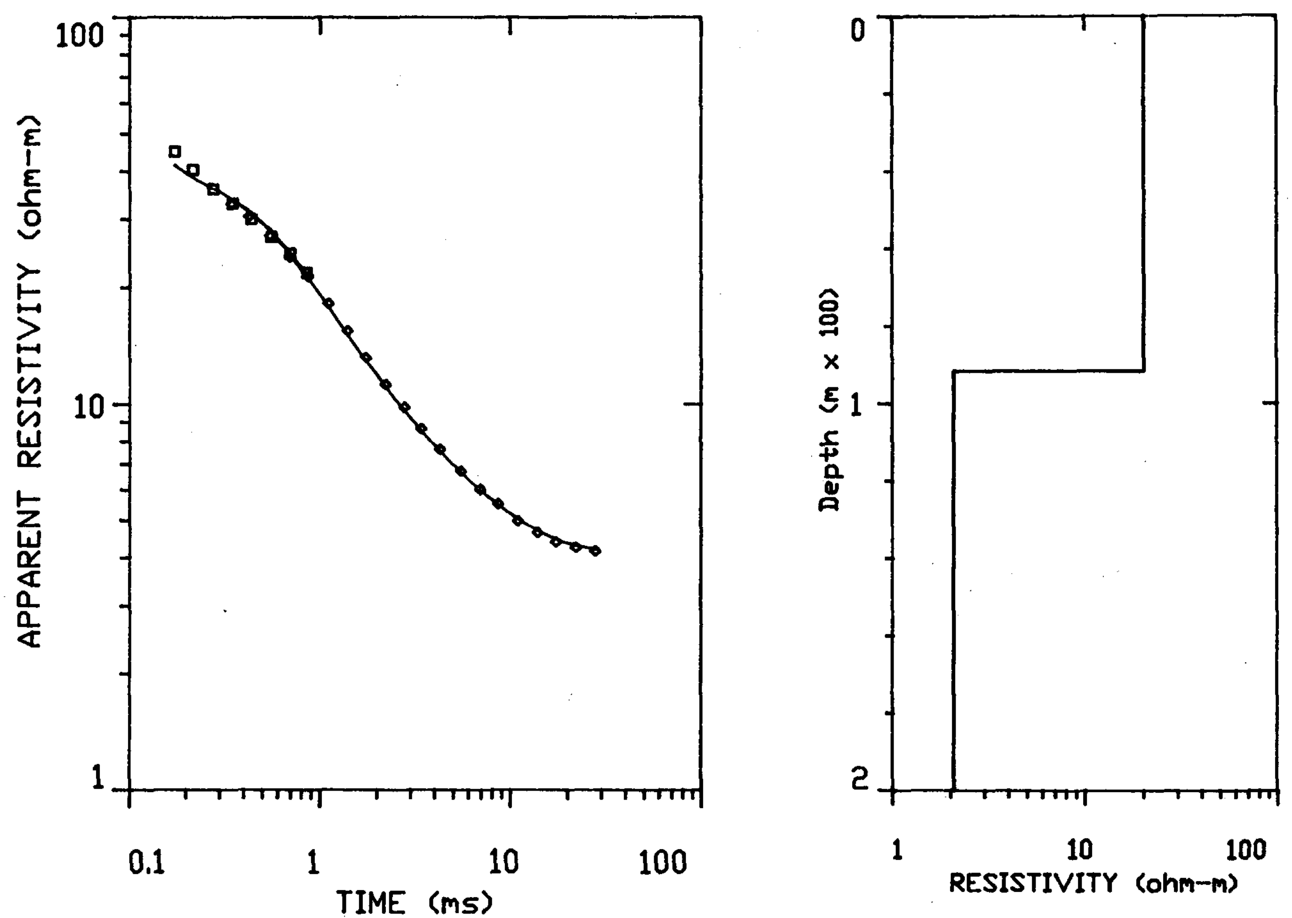
The interpreted geoelectrical section consists of a two-layer subsurface.

5.11.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the Holocene to Miocene deposits and the underlying Floridan aquifer to distinguish the two. Fixing the thickness of the upper layer does not resolve this dilemma; therefore, it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (92 m = 302 ft) surface layer of intermediate resistivity (20 ohm-m) overlying a low resistivity layer (2.1 ohm-m). The Holocene to Miocene deposits and part of the Floridan aquifer system exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater saturated Floridan aquifer at a depth of 302 ft bls.



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 10 – OAK HILL VOLUSIA COUNTY, FLORIDA		
		DESIGNED BY: JEB CHECKED BY: MJW DRAWN BY: RBT	PROJECT NO.: 95706 DRAWING NO.: LOC-10 DATE: 06/21/95	FIGURE 5.11-1



— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 10 - OAK HILL
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-10	5.11-2
DRAWN BY:	SAB	DATE:	07/26/95	

5.11.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 2.1 ohm-m, is interpreted to represent salt water. It occurs at a depth of 302 ft (-277 ft msl). Because the resistivity of Layer 1 (20 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken at the depth of the geoelectrical interface, or at 302 ft depth (-277 ft msl). The resistivity of Layer 2 (2.1 ohm-m) corresponds to a chloride concentration of 15,163 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

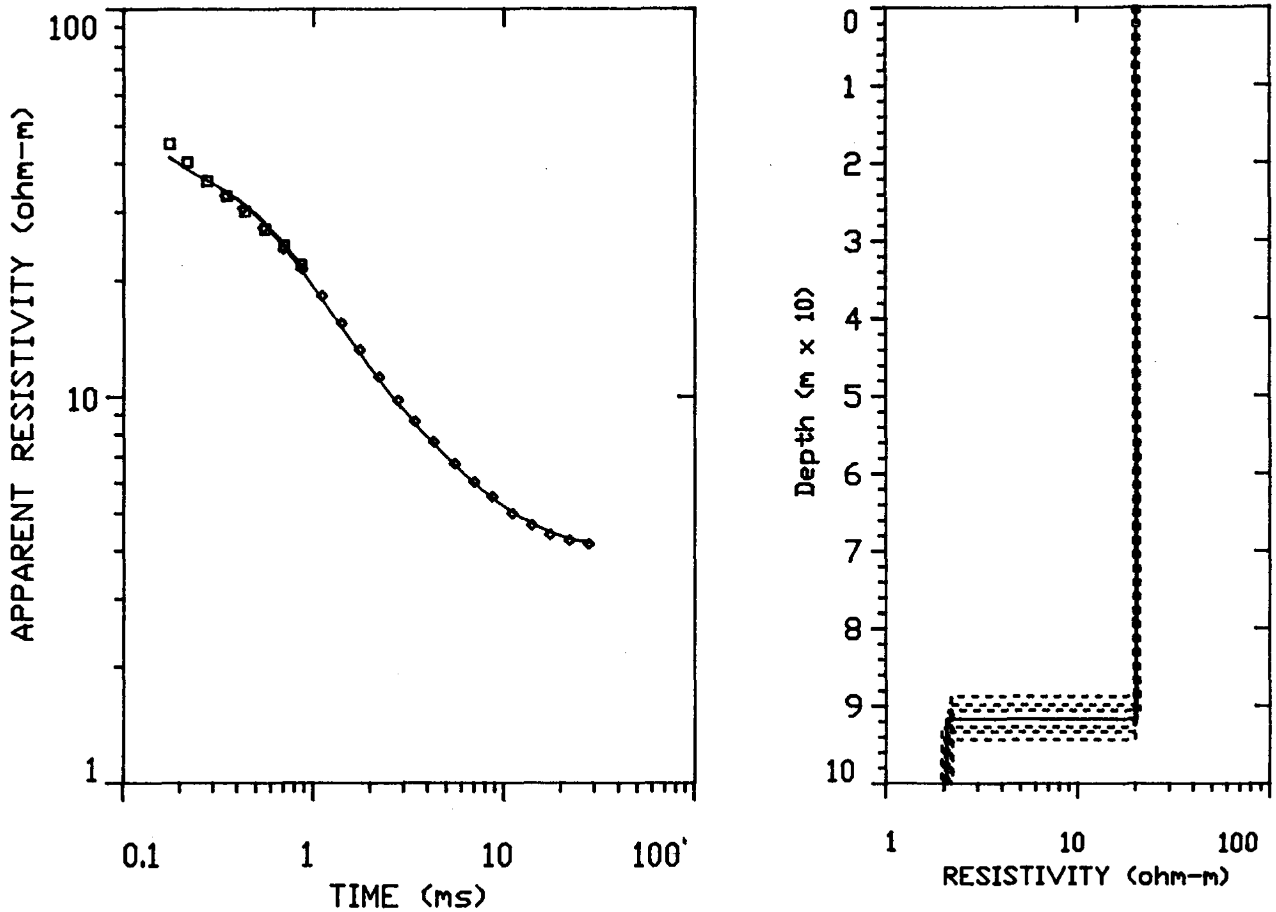
5.11.4 Depth of Occurrence of the 250 mg/l Isochlor

Because of the inability to segregate the Floridan Aquifer from the overlying Holocene to Miocene deposits, the effective chloride concentration of Layer 1 cannot be calculated.

5.11.5 Accuracy of Measurement and Interpretation

Figure 5.11-3 is the equivalence analysis at this site and the inversion table (Table 5.11-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. The range of equivalence in determining the depth to the low resistivity layer is about ±3 m (10 ft) which is 3% of the total depth. The resistivity of this layer has a range from 1.9 to 2.2 ohm-m. This corresponds to a range in interpreted chloride concentration of from 16,775 to 14,467 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 1 is from 20 to 21 ohm-m. A corresponding chloride concentration cannot be determined because Layer 1 is in part comprised of Holocene to Miocene deposits. Accordingly, equation (4) may not be valid.



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 10 – OAK HILL
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-10	5.11-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE10

CLIENT:	SJRWMD	DATE:	05-MAY-95
LOCATION:	OAK HILL	SOUNDING:	1
COUNTY:	VOLUSIA COUNTY	ELEVATION:	7.60 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	137.000 m by 164.000 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		
SOUNDING COORDINATES:	E: 1.0000 N: -0.1000		

FITTING ERROR: 3.735 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			7.60	
1	20.35	91.67	-84.07	4.50
2	2.07			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	19.720	20.359	21.061
	2	1.944	2.072	2.225
THICK	1	88.746	1.000	94.346
DEPTH	1	88.746	91.680	94.346

CURRENT:	20.20 AMPS	EM-57	COIL AREA:	100.00 sq m.
FREQUENCY:	30.00 Hz	GAIN: 3	RAMP TIME:	105.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.175	59178.2	66859.5	-12.97
2	0.218	40173.9	42952.6	-6.91
3	0.278	25922.7	25829.5	0.359
4	0.351	16528.3	15935.5	3.58
5	0.438	10893.1	10277.3	5.65
6	0.558	6963.4	6601.1	5.20
7	0.702	4554.0	4521.8	0.706

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PALATKA, FLORIDA

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TDEM SOUNDING DATA TABLE
SITE 10 – OAK HILL
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.11-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	0.858	3271.5	3305.6	-1.04

CURRENT: 20.20 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 5 RAMP TIME: 105.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
9	0.346	17155.7	16498.9	3.82
10	0.427	11313.2	10882.0	3.81
11	0.550	7155.4	6855.5	4.19
12	0.698	4767.8	4647.4	2.52
13	0.869	3285.7	3322.8	-1.12
14	1.10	2273.9	2330.0	-2.46
15	1.40	1608.2	1659.1	-3.16
16	1.75	1173.2	1197.9	-2.10
17	2.22	825.3	838.9	-1.64
18	2.79	573.4	586.8	-2.34
19	3.42	416.7	422.6	-1.41
20	4.26	289.6	292.7	-1.06
21	5.49	186.6	187.8	-0.635
22	6.96	121.3	122.0	-0.561
23	8.66	80.04	80.56	-0.652
24	11.06	50.56	49.73	1.63
25	14.00	31.13	30.57	1.79
26	17.47	19.45	18.99	2.36
27	22.23	11.22	11.03	1.69
28	28.10	6.44	6.35	1.38

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	1.00		
P 2	0.00	0.98	
T 1	0.00	0.00	1.00
	P 1	P 2	T 1

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TDEM SOUNDING DATA TABLE
SITE 10 – OAK HILL
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.11-1

5.11.6 Summary of TDEM Sounding at Oak Hill (Site 10)

- The depth of occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 302 ft (-277 ft msl) and occur within the Upper Floridan aquifer.
- The quality of ground water within the Floridan aquifer at this site cannot be interpreted because the analysis of the TDEM data does not allow the Holocene to Miocene deposits to be distinguished from the Floridan Aquifer System.

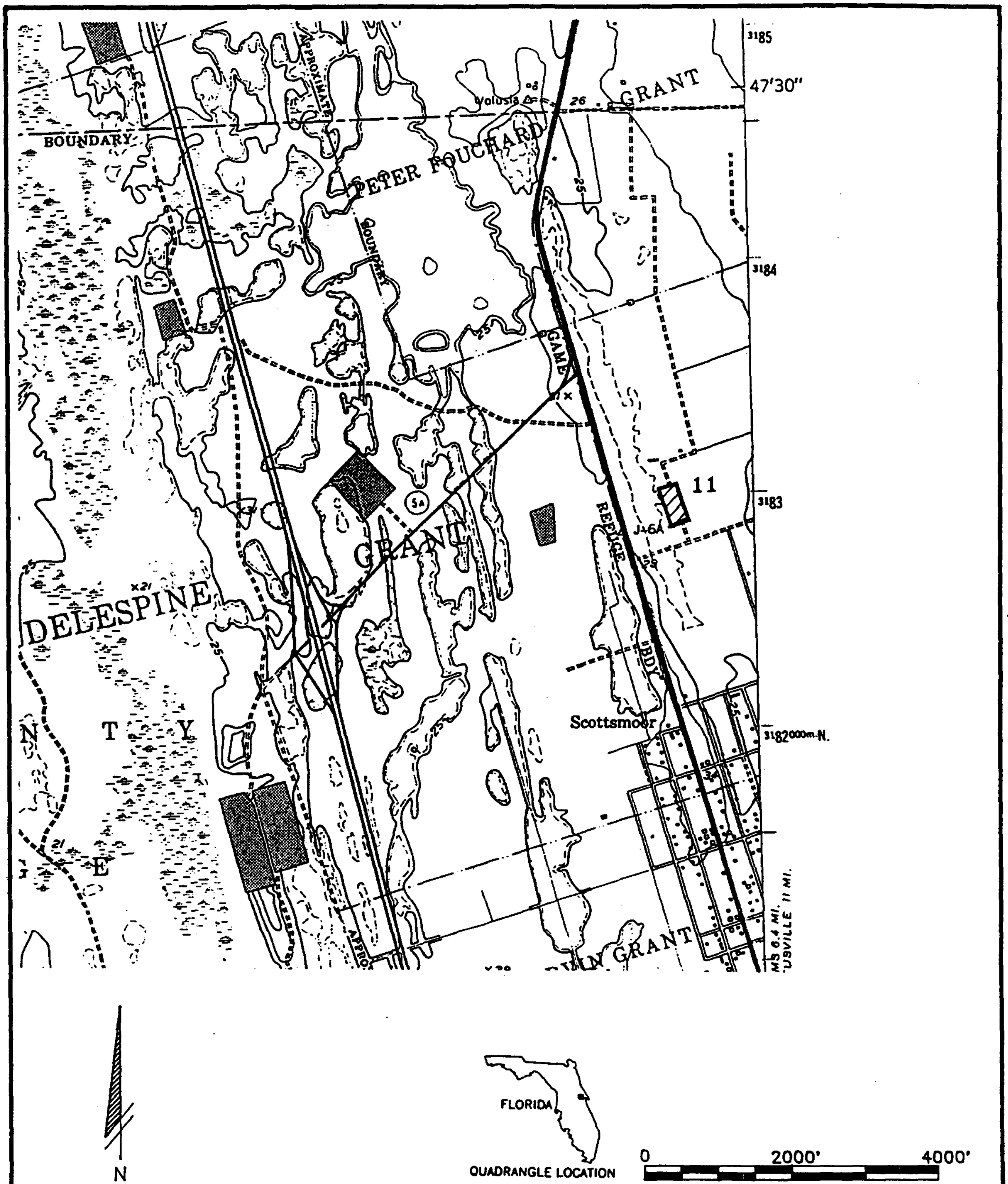
5.12 TDEM Site 11 - Scottsmoor

5.12.1 Location Description and Geoelectrical Section

The site is located in northeast Brevard County near Scottsmoor, Florida (Figure 5.12-1). The site is located within a pasture. Possible sources of interference (powerlines) existed 200 ft south and east and 300 ft west of the Tx loop. QA soundings were performed 55 ft south and 30 ft west of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 95 ft bmsl or 115 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at an approximate depth of 2,400 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 380 ft and the depth to the top of the Lower Floridan aquifer is approximately 940 ft bls (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.12-2. The interpreted geoelectrical section consists of a two-layer subsurface.



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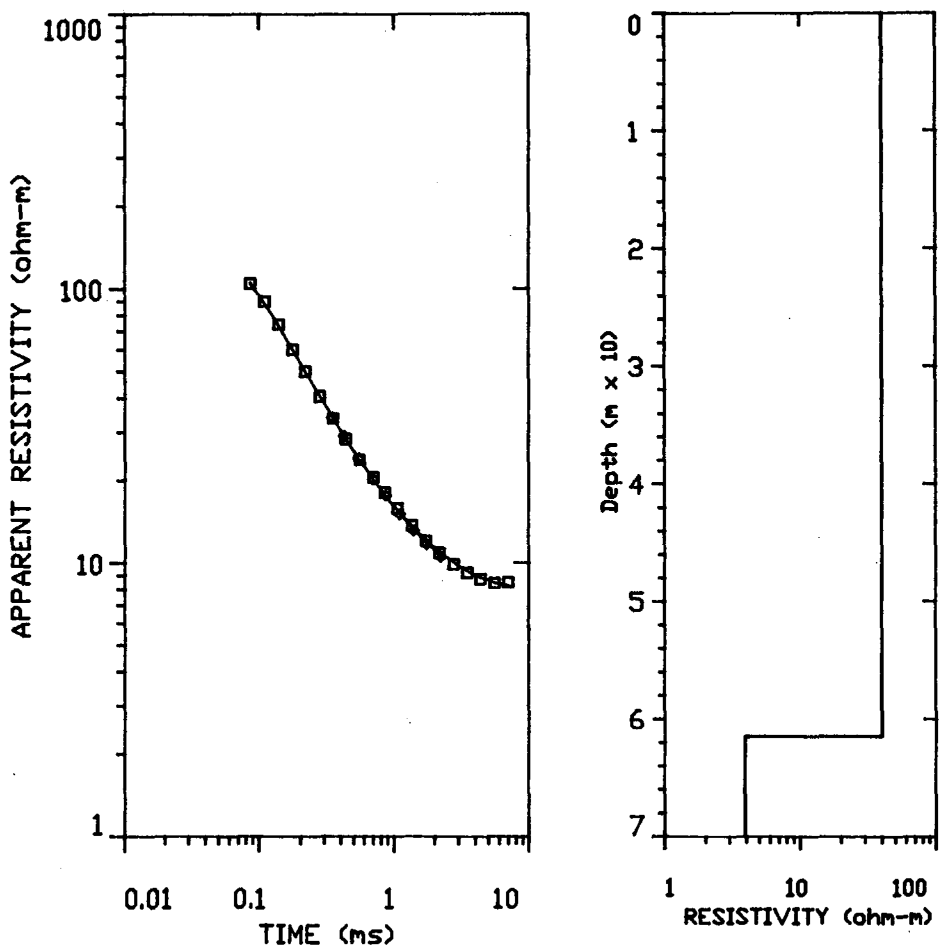
TDEM SURVEY LOCATION MAP
SOUNDING 11 – SCOTTSMOOR
BREVARD COUNTY, FLORIDA

DESIGNED BY: JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY: MJW	DRAWING NO.:	LOC-11	5.12-1
DRAWN BY: RBT	DATE:	06/21/95	



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

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PALATKA, FLORIDA

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MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 11 – SCOTTSMOOR
BREVARD COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-11	5.12-2
DRAWN BY:	SAB	DATE:	07/26/95	

5.12.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the Holocene to Miocene deposits and the underlying Floridan aquifer to distinguish the two. Fixing the thickness of the upper layer does not resolve this dilemma; therefore, it can be interpreted that there exists a two-layer geoelectrical section with a 61 m (200 ft) thick surface layer of intermediate resistivity (40 ohm-m) overlying a low resistivity layer (3.9 ohm-m). It can be interpreted that the Holocene to Miocene deposits and the upper part of the Floridan aquifer system exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater-saturated Upper Floridan aquifer at a depth of 200 ft bls.

5.12.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 3.9 ohm-m, is interpreted to represent salt water. It occurs at a depth of 200 ft (-180 ft msl). Because the resistivity of Layer 1 (40 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is the depth of the geoelectrical interface, or 200 ft (-180 ft msl). The resistivity of Layer 2 (3.9 ohm-m) corresponds to a chloride concentration of 8,094 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

5.12.4 Depth of Occurrence of the 250 mg/l Isochlor

Because of the inability to segregate the Floridan aquifer from the overlying Holocene to Miocene deposits, the effective chloride concentration of Layer 1 cannot be calculated.

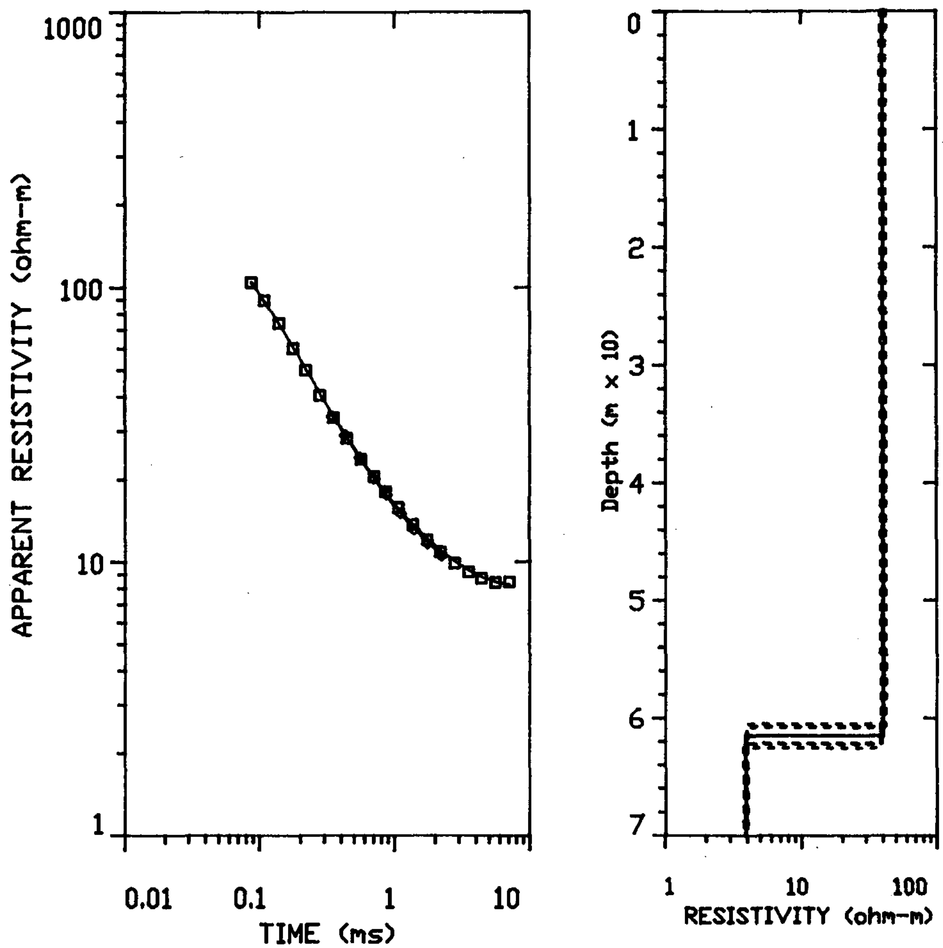
5.12.5 Accuracy of Measurement and Interpretation

Figure 5.12-3 is the equivalence analysis at this site and the inversion table (Table 5.12-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. The range of equivalence in determining the depth to the low resistivity layer is about ±1 m (3 ft) which is 2% of the total depth. The resistivity of this layer has a range from 3.8 to 4.0 ohm-m. This corresponds to a range in interpreted chloride concentration of from 8,311 to 7,888 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 1 is from 39 to 42 ohm-m. A corresponding chloride concentration cannot be determined because Layer 1 is in part comprised of the Holocene to Miocene deposits. Accordingly, equation (4) may not be valid.

5.12.6 Summary of TDEM Sounding at Scottsmoor (Site 11)

- The depth of occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 200 ft (-180 ft msl) and occur within the Upper Floridan aquifer.
- The quality of ground water within the Floridan aquifer at this site cannot be interpreted because the analysis of the TDEM data does not allow the Holocene to Miocene deposits to be distinguished from the Floridan Aquifer System.



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—— BEST–FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

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MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1–D INVERSION
SITE 11 – SCOTTSMOOR
BREVARD COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU–11	5.12–3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 11

CLIENT: SJRWMD
LOCATION: SCOTTSMOOR
COUNTY: BREVARD COUNTY
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 168.000 m by 91.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 07-MAY-95
SOUNDING: 1
ELEVATION: 6.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 1.536 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			6.00	
1	40.18	61.48	-55.48	1.52
2	3.91			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	38.723	40.190	42.011
	2	3.797	3.913	4.026
THICK	1	60.496	1.000	62.536
DEPTH	1	60.496	61.488	62.536

CURRENT: 22.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz GAIN: 4 RAMP TIME: 100.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	74826.6	74683.1	0.191
2	0.108	54155.4	54633.3	-0.882
3	0.138	39076.2	39421.8	-0.884
4	0.175	29585.5	29234.8	1.18
5	0.218	22526.3	22327.7	0.881
6	0.278	16833.4	16557.5	1.63
7	0.351	12422.4	12297.6	1.00

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TDEM SOUNDING DATA TABLE
SITE 11 – SCOTTSMOOR
BREVARD COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.12-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	0.438	9256.3	9192.7	0.687
9	0.558	6574.7	6573.0	0.0259
10	0.702	4601.8	4703.6	-2.21
11	0.858	3369.9	3466.3	-2.86
12	1.06	2392.8	2448.7	-2.33
13	1.37	1589.6	1608.6	-1.19
14	1.74	1060.5	1054.2	0.596
15	2.17	711.7	701.1	1.49
16	2.77	446.4	436.6	2.19
17	3.50	276.8	271.4	1.93
18	4.37	172.2	169.2	1.73
19	5.56	99.47	98.95	0.521
20	7.03	54.88	57.15	-4.13

CURRENT: 22.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 6 RAMP TIME: 100.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
21	0.346	12747.8	12578.7	1.32
22	0.427	9497.8	9561.0	-0.665
23	0.550	6697.6	6758.2	-0.904
24	0.698	4783.4	4790.4	-0.145
25	0.869	3381.8	3442.7	-1.80
26	1.10	2339.3	2340.9	-0.0683
27	1.40	1598.1	1583.7	0.904
28	1.75	1093.9	1080.0	1.26
29	2.22	706.4	704.7	0.240

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.97		
P 2	-0.01	0.98	
T 1	0.01	0.01	0.99
	P 1	P 2	T 1

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TDEM SOUNDING DATA TABLE
SITE 11 – SCOTTSMOOR
BREVARD COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.12-1

5.13 TDEM Site 12 - Osteen

5.13.1 Location Description and Geoelectrical Section

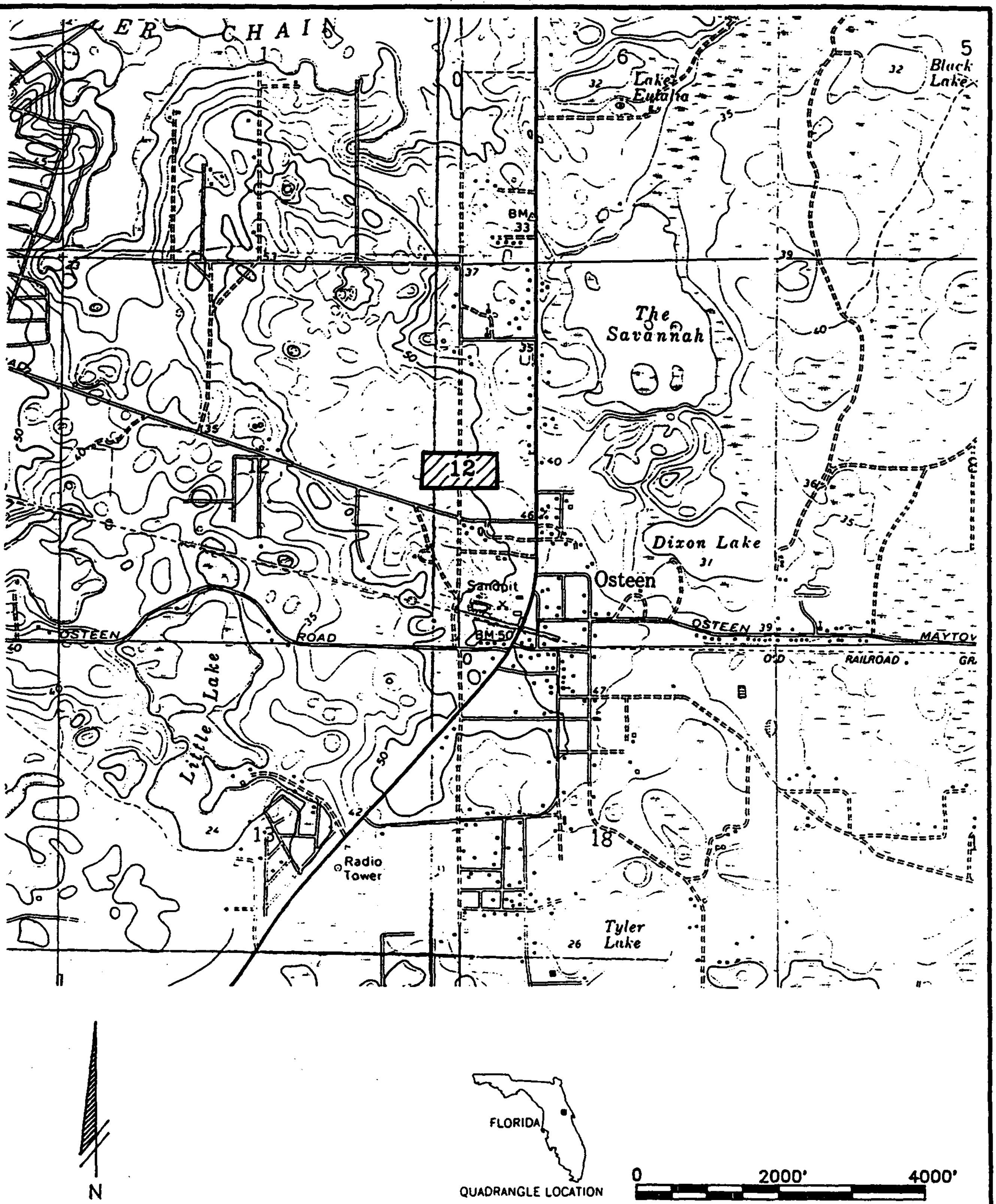
The site is located in southern Volusia County in Osteen, Florida (Figure 5.13-1). The site is located within a pasture. A possible source of interference (powerline) existed 250 ft east of the Tx loop. QA soundings were performed 100 ft east and 50 ft south of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 40 ft bmsl or 90 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at an approximate depth of 2,250 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 275 ft and the depth to the top of the Lower Floridan aquifer is approximately 800 ft bls (Miller, 1986). Chloride concentration in the upper portion of the Floridan aquifer is below 250 mg/l in this area and the maximum thickness of the fresh-water saturated Floridan aquifer is approximately 150 ft (Rutledge, 1985).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.13-2. The interpreted geoelectrical section consists of a two-layer subsurface.

5.13.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the Holocene to Miocene deposits and the underlying Floridan aquifer to distinguish the two. Fixing the thickness of the upper layer does not resolve this dilemma; therefore, it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (108 m = 354 ft) surface layer of intermediate resistivity (47 ohm-m) overlying a low resistivity layer (7.7 ohm-m). It can be



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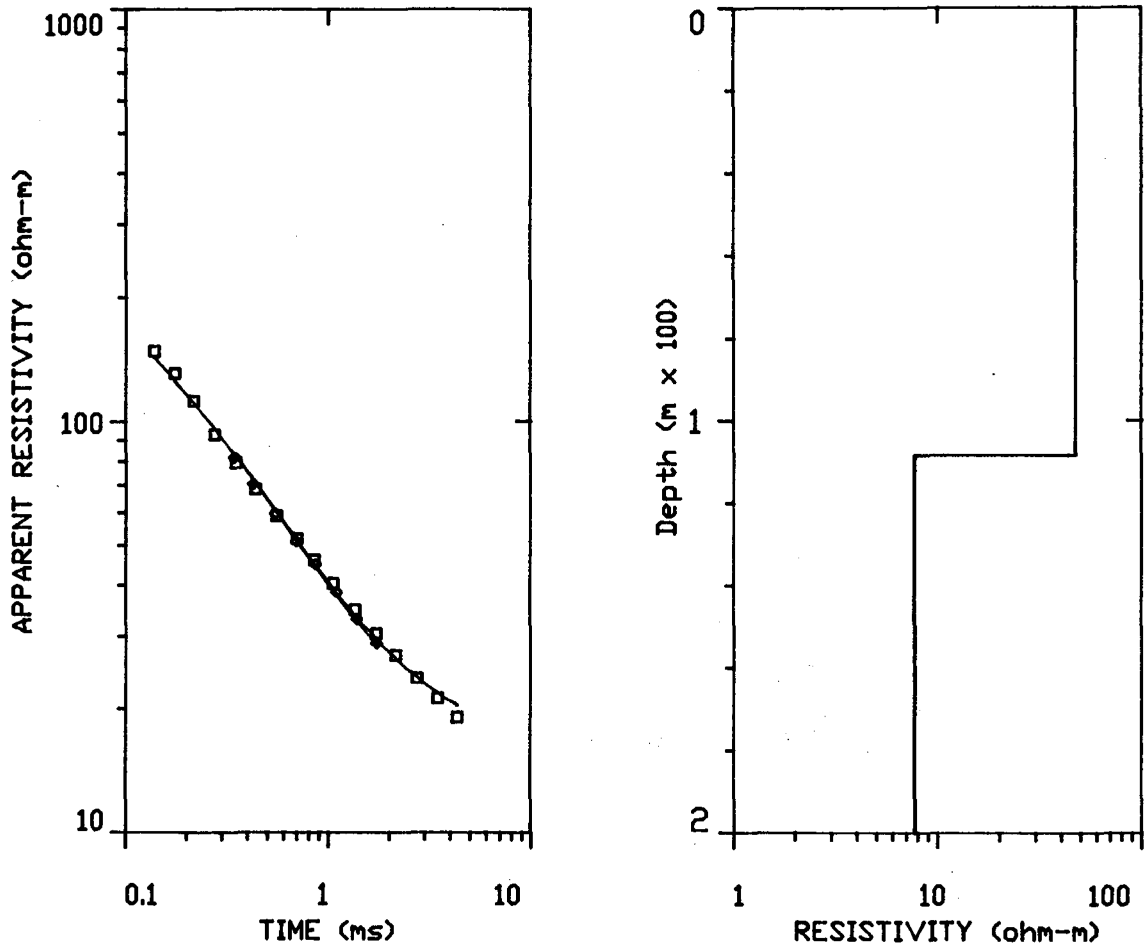
TDEM SURVEY LOCATION MAP
SOUNDING 12 – OSTEEN
VOLUSIA COUNTY, FLORIDA

DESIGNED BY: JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY: MJW	DRAWING NO.:	LOC-12	5.13-1
DRAWN BY: RBT	DATE:	06/21/95	



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
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MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 12 – OSTEEN
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-12	5.13-2
DRAWN BY:	SAB	DATE:	07/26/95	

interpreted that the Holocene to Miocene deposits and the upper part of the Floridan aquifer system exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater-saturated Floridan aquifer at a depth of 354 ft bls.

5.13.3 Depth to Occurrence of Salt Water

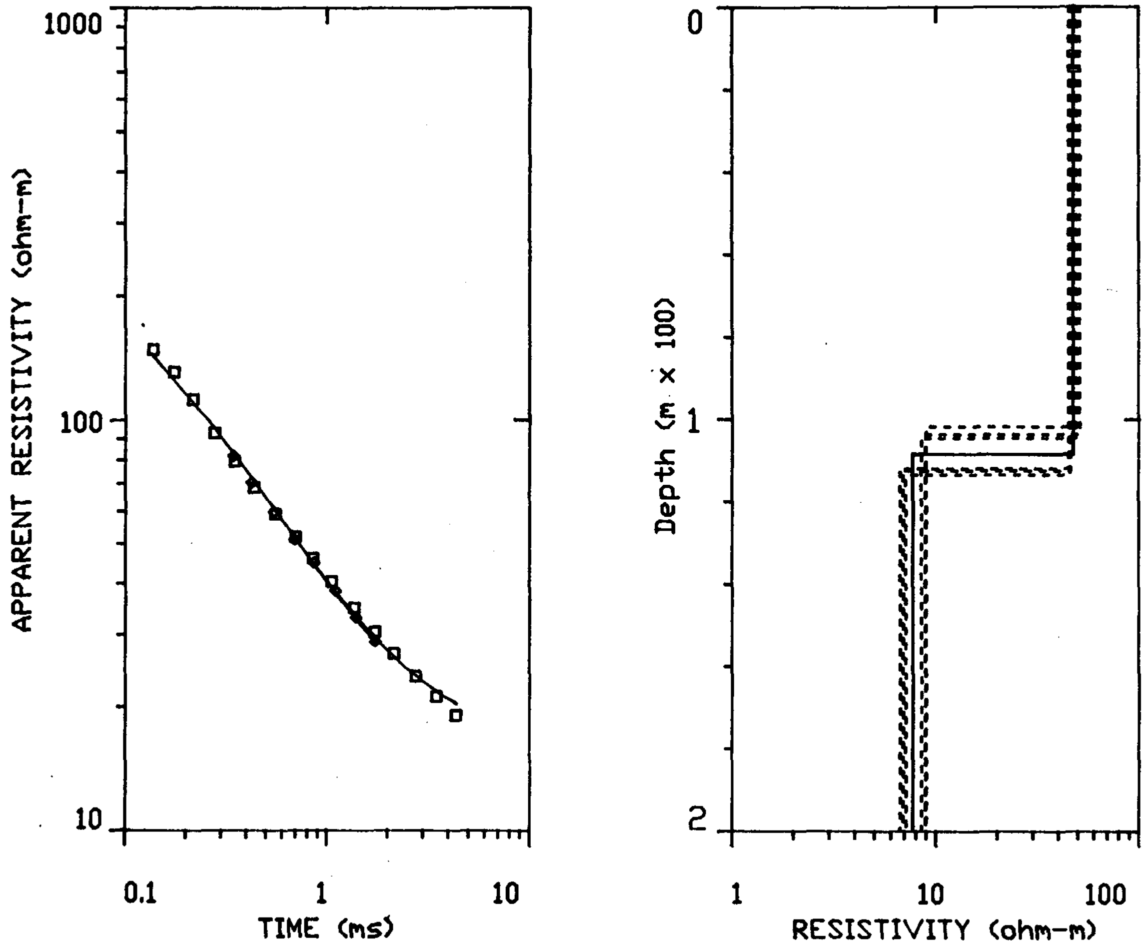
The bottom (second) layer of the geoelectrical model, with a resistivity of 7.7 ohm-m, is interpreted to represent salt water. It occurs at a depth of 354 ft (-304 ft msl) near the base of the Upper Floridan aquifer. Because the resistivity of Layer 1 (47 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken at the depth of the geoelectrical interface, or at 354 ft depth (-304 ft msl). The resistivity of Layer 2 (7.7 ohm-m) corresponds to a chloride concentration of 4,024 mg/l, assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

5.13.4 Depth of Occurrence of the 250 mg/l Isochlor

Because of the inability to segregate the Floridan aquifer from the overlying Holocene to Miocene deposits, the effective chloride concentration of Layer 1 cannot be calculated.

5.13.5 Accuracy of Measurement and Interpretation

Figure 5.13-3 is the equivalence analysis at this site and the inversion table (Table 5.13-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. The range of equivalence in determining the depth to the low resistivity layer is about ±6 m (20 ft) which is 6% of the total depth. The resistivity of this layer has a range from 6.6 to 8.9 ohm-m. This corresponds to a range in interpreted chloride concentration of from 4,720 to 3,461 mg/l, again subject to the same assumptions of porosity and validity of equation (4).



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

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MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 12 - OSTEEN
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-12	5.13-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 12

CLIENT: SJRWMD
LOCATION: OSTEEN
COUNTY: VOLUSIA COUNTY
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 352.000 m by 152.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 07-MAY-95
SOUNDING: 1
ELEVATION: 15.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 4.378 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			15.00	
1	47.32	108.4	-93.42	2.29
2	7.67			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	44.823	47.325	51.012
	2	6.639	7.673	8.933
THICK	1	101.762	1.000	113.509
DEPTH	1	101.762	108.426	113.509

CURRENT: 19.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz GAIN: 3 RAMP TIME: 160.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.138	43441.7	45646.4	-5.07
2	0.175	28963.5	30916.7	-6.74
3	0.218	21070.0	21512.8	-2.10
4	0.278	15216.5	14528.6	4.52
5	0.351	10787.5	10127.0	6.12
6	0.438	7724.0	7268.6	5.89
7	0.558	5271.4	5090.9	3.42

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TDEM SOUNDING DATA TABLE
SITE 12 – OSTEEN
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.13–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	0.702	3596.4	3641.8	-1.26
9	0.858	2607.4	2696.7	-3.42
10	1.06	1844.1	1931.3	-4.72
11	1.37	1227.4	1295.1	-5.51
12	1.74	828.5	866.5	-4.57
13	2.17	572.0	588.9	-2.93
14	2.77	376.0	374.8	0.318
15	3.50	248.1	238.1	3.99
16	4.37	167.5	151.3	9.66

CURRENT: 19.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 7 RAMP TIME: 160.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
17	0.346	10689.3	10398.9	2.71
18	0.427	7896.1	7596.5	3.79
19	0.550	5377.2	5246.0	2.44
20	0.698	3743.3	3717.5	0.688
21	0.869	2621.9	2688.2	-2.52
22	1.10	1811.1	1859.7	-2.68
23	1.40	1258.1	1283.8	-2.04
24	1.75	886.2	893.6	-0.830

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.99		
P 2	-0.01	0.95	
T 1	0.00	0.01	0.99
	P 1	P 2	T 1

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TDEM SOUNDING DATA TABLE
SITE 12 - OSTEEN
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.13-1

The equivalence range of the resistivity of Layer 1 is from 45 to 51 ohm-m. A corresponding chloride concentration cannot be determined because Layer 1 is in part comprised of the Holocene to Miocene deposits. Accordingly, equation (4) may not be valid.

5.13.6 Summary of TDEM Sounding at Osteen (Site 12)

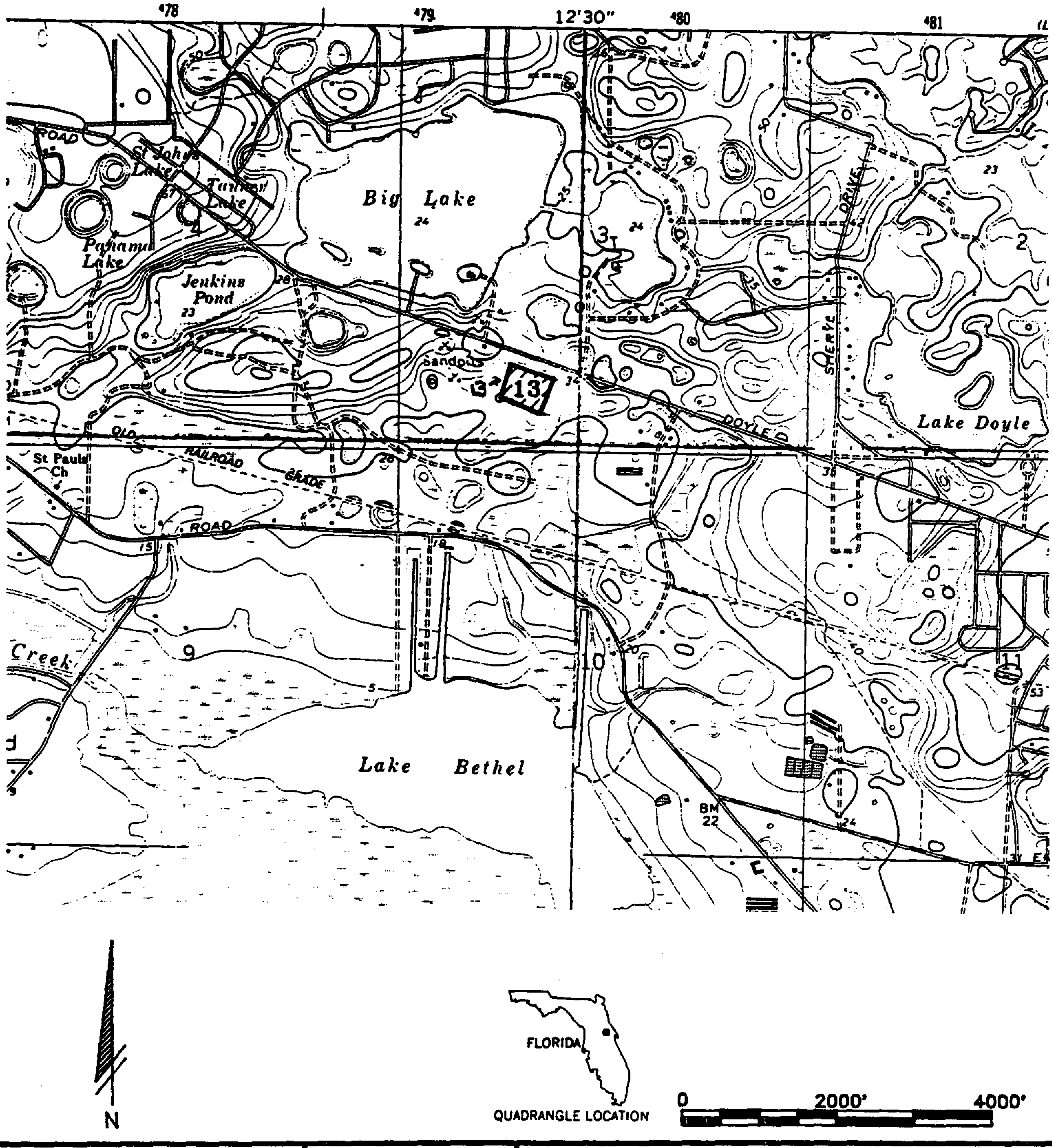
- The depth of occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 354 ft (-304 ft msl) and occur near the base of the Upper Floridan aquifer.
- The quality of ground water within the Floridan aquifer at this site cannot be interpreted because the analysis of the TDEM data does not allow the Holocene to Miocene deposits to be distinguished from the Floridan Aquifer System.

5.14 TDEM Site 13 - Big Lake

5.14.1 Location Description and Geoelectrical Section

The site is located in southern Volusia County, Florida (Figure 5.14-1). The site is located within a tree farm. No sources of interference were observed in the vicinity of the site. QA soundings were performed 50 ft east and south of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 40 ft bmsl or 75 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The bottom of the Floridan aquifer occurs at an approximate depth of 2,200 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 280 ft and the depth to the top of the Lower Floridan aquifer is approximately 750 ft bls (Miller, 1986). Chloride concentration in the upper portion of the Floridan aquifer ranges from 50 to 250 mg/l in this area and the maximum thickness of the freshwater-saturated Floridan aquifer is approximately 150 ft (Rutledge, 1985).



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TDEM SURVEY LOCATION MAP
SOUNDING 13 – BIG LAKE
VOLUSIA COUNTY, FLORIDA

DESIGNED BY: JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY: MJW	DRAWING NO.:	LOC-13	5.14-1
DRAWN BY: RBT	DATE:	06/21/95	

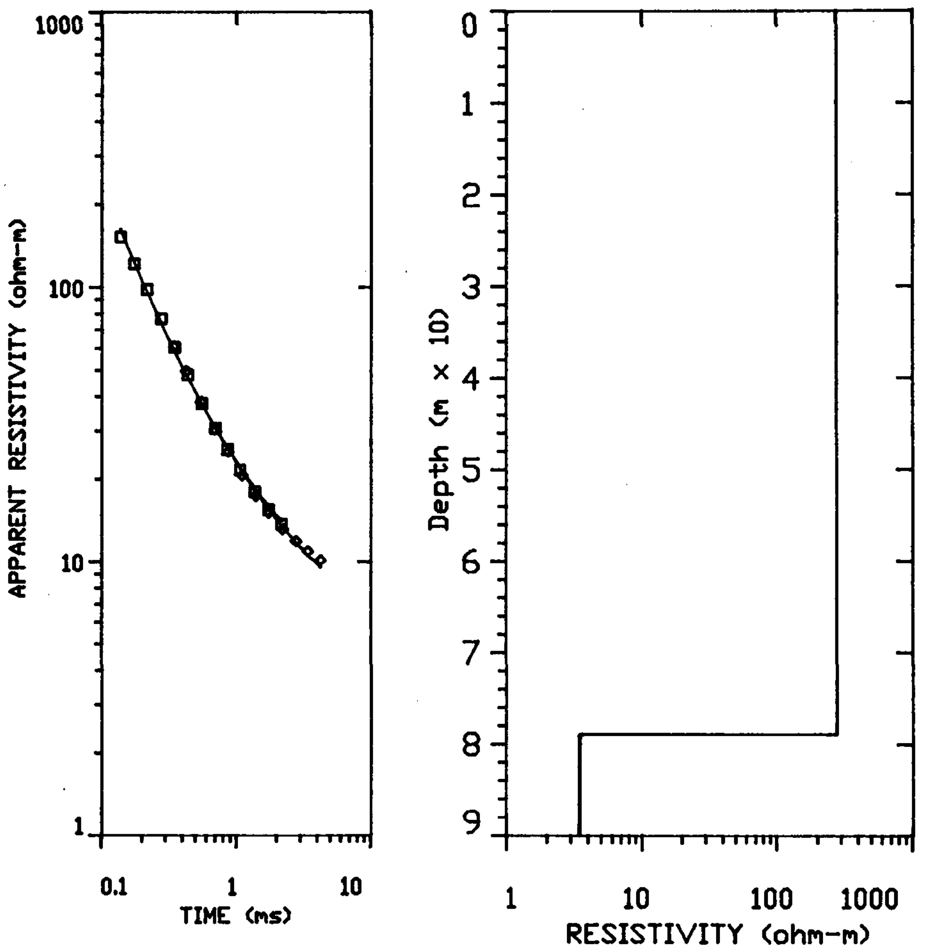
The resistivity sounding data and best-fit model inversion are presented on Figure 5.14-2. The interpreted geoelectrical section consists of a two-layer subsurface.

5.14.2 Geological Interpretation of Geoelectrical Model

The first layer occurs at 79 m (259 ft) bls and not at the hydrostratigraphic contact between the Holocene and Miocene deposits (75 ft bls) and the Floridan Aquifer System. Therefore, it can be interpreted that there exists a two-layer geoelectrical section with a 259 ft thick surface layer with a resistivity of 278 ohm-m overlying a low-resistivity layer (3.5 ohm-m). The Holocene to Miocene deposits and the upper part of the Floridan aquifer system exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater-saturated Upper Floridan aquifer at a depth of 259 ft bls.

5.14.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 3.5 ohm-m, is interpreted to represent salt water. It occurs at a depth of 259 ft (-224 ft msl). Because the resistivity of Layer 1 (278 ohm-m) is greater than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken as 50 ft greater than the depth of the geoelectrical interface, or at a depth of 309 ft (-274 ft msl). The resistivity of Layer 2 (3.5 ohm-m) corresponds to a chloride concentration of 9,037 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.



— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 13 - BIG LAKE
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-13	5.14-2
DRAWN BY:	SAB	DATE:	07/26/95	

5.14.4 Depth of Occurrence of the 250 mg/l Isochlor

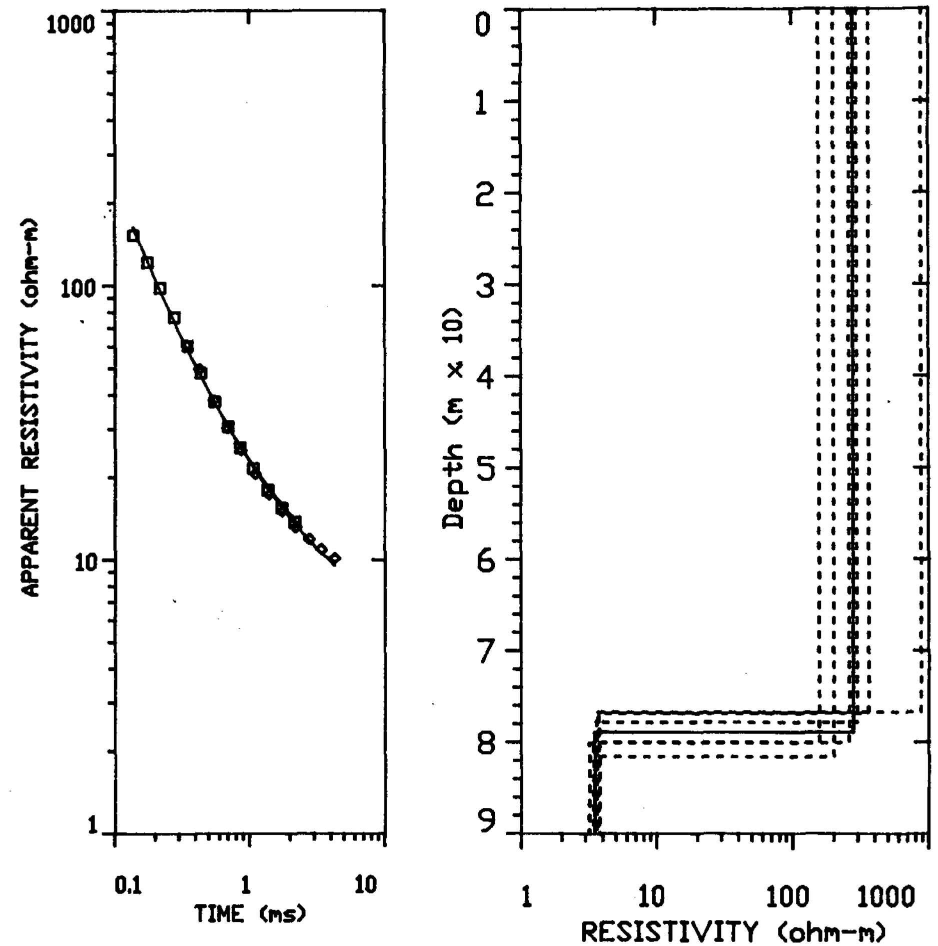
Since the resistivity (278 ohm-m) of Layer 1 is greater than 80 ohm-m, the chloride concentration in the Upper Floridan aquifer is less than 250 mg/l, even though Layer 1 contains Holocene to Miocene deposits. Since the resistivity of Layer 1 (278 ohm-m) is greater than 80 ohm-m, the 250 mg/l isochlor is interpreted to occur 50 ft above the boundary between Layer 1 and Layer 2. That depth is 209 ft and the thickness for water with a chloride concentration less than 250 mg/l is 134 ft (209 - 75). For comparison, Rutledge (1985) estimated a maximum thickness of approximately 150 ft for water with a chloride concentration less than 250 mg/l in the Floridan aquifer at this site. The top of the Floridan aquifer occurs at an approximate depth of 40 ft bmsl or 75 ft bls at this site (SJRWMD, personal communication).

5.14.5 Accuracy of Measurement and Interpretation

Figure 5.14-3 is the equivalence analysis at this site and the inversion table (Table 5.14-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. The range of equivalence in determining the depth to the low resistivity layer is about ±2 m (7 ft) which is 3% of the total depth.

The resistivity of this layer has a range of from 3.2 to 3.8 ohm-m. This corresponds to a range in interpreted chloride concentration of from 9,898 to 8,311 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range for the resistivity of Layer 1 is from 157 to 881 ohm-m. Since the resistivity is greater than 80 ohm-m, the chloride concentration in the upper part of the Floridan aquifer is less than 250 mg/l even though Layer 1 is in part comprised of Holocene to Miocene deposits.



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 13 - BIG LAKE
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-13	5.14-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 13

CLIENT:	SJRWMD	DATE:	08-MAY-95
LOCATION:	BIG LAKE	SOUNDING:	1
COUNTY:	VOLUSIA COUNTY	ELEVATION:	10.70 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	152.000 m by 152.000 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		

SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 4.409 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			10.70	
1	278.4	78.91	-68.21	0.283
2	3.49			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	156.584	278.450	880.537
	2	3.189	3.494	3.810
THICK	1	76.724	1.000	81.611
DEPTH	1	76.724	78.918	81.611

CURRENT:	21.50 AMPS	EM-57	COIL AREA:	100.00 sq m.
FREQUENCY:	30.00 Hz	GAIN: 4	RAMP TIME:	110.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.138	18719.4	17090.8	8.70
2	0.175	14458.3	14251.8	1.42
3	0.218	11510.9	11886.5	-3.26
4	0.278	9077.0	9573.8	-5.47
5	0.351	7257.8	7648.9	-5.38
6	0.438	5894.9	6082.0	-3.17
7	0.558	4614.4	4645.8	-0.680

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 13 – BIG LAKE
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.14–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	0.702	3549.9	3529.9	0.564
9	0.858	2804.5	2733.2	2.54
10	1.06	2115.5	2037.1	3.70
11	1.37	1483.8	1417.6	4.46
12	1.74	1023.9	979.8	4.30
13	2.17	707.2	682.2	3.54

CURRENT: 21.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 7 RAMP TIME: 110.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
14	0.346	7425.3	7823.4	-5.36
15	0.427	5989.2	6312.4	-5.39
16	0.550	4693.6	4785.2	-1.95
17	0.698	3669.5	3614.2	1.50
18	0.869	2801.0	2745.0	1.99
19	1.10	2054.7	1983.8	3.45
20	1.40	1478.9	1418.8	4.06
21	1.75	1055.1	1018.2	3.49
22	2.22	712.5	699.4	1.84
23	2.79	467.4	478.7	-2.41
24	3.42	319.5	336.7	-5.36
25	4.26	206.7	226.8	-9.71

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

	P 1	P 2	T 1
P 1	0.01		
P 2	-0.03	0.96	
T 1	0.02	0.01	1.00

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 13 – BIG LAKE
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.14-1

5.14.6 Summary of TDEM Sounding at Big Lake (Site 13)

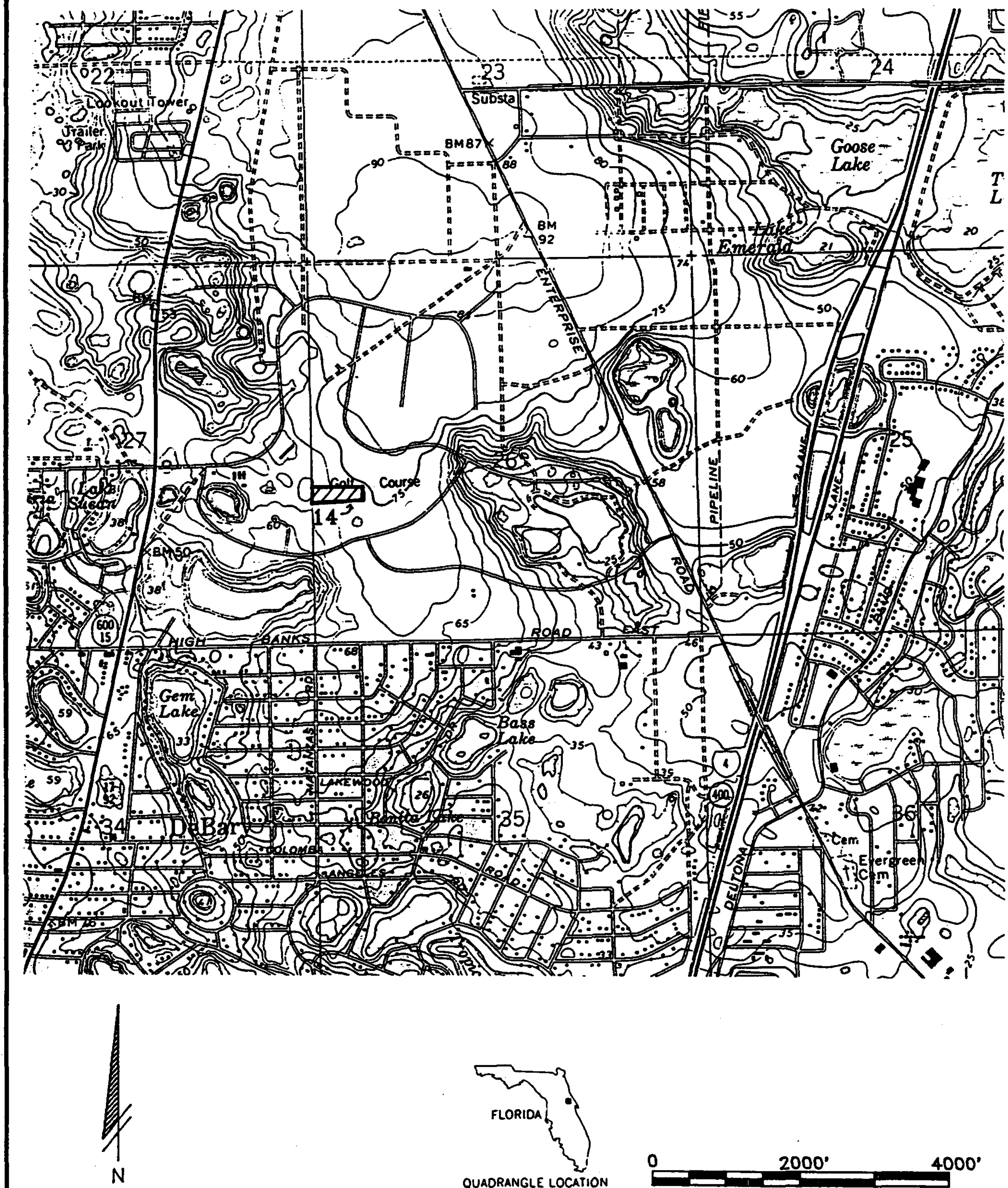
- The depth of occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 309 ft (-274 ft msl) and occur within the Upper Floridan aquifer.
- The 250 mg/l isochlor is interpreted to occur at 209 ft bls. The thickness of freshwater (<250 mg/l chloride) in the Upper Floridan aquifer at this site is interpreted to be 134 ft.
- The results of the TDEM study are in agreement with the thickness estimates for freshwater (<250 mg/l chloride) from Rutledge (1985) who indicated that the maximum thickness of freshwater (<250 mg/l chloride) in the Upper Floridan aquifer in this area to be approximately 150 ft.

5.15 TDEM Site 14 - Glen Abbey

5.15.1 Location Description and Geoelectrical Section

The site is located in south Volusia County near De Bary, Florida (Figure 5.15-1). The site is the driving range for the Glen Abbey golf course. Possible sources of interference included any underground pipelines at the site. QA soundings were performed 22 ft south and 70 ft west of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 20 ft bmsl or 90 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at an approximate depth of 2,200 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 300 ft and the depth to the top of the Lower Floridan aquifer is approximately 750 ft bls (Miller, 1986). Chloride concentration in the upper portion of the Floridan aquifer is below 250 mg/l in this area and the maximum thickness of the freshwater-saturated Floridan aquifer is approximately 100 ft (Rutledge, 1985).



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 14 – GLEN ABBEY VOLUSIA COUNTY, FLORIDA	
		DESIGNED BY: JEB CHECKED BY: MJW DRAWN BY: RBT	PROJECT NO.: 95706 DRAWING NO.: LOC-14 DATE: 06/21/95
		FIGURE	5.15-1

The resistivity sounding data and best-fit model inversion are presented on Figure 5.15-2. The interpreted geoelectrical section consists of a two-layer subsurface.

5.15.2 Geological Interpretation of Geoelectrical Model

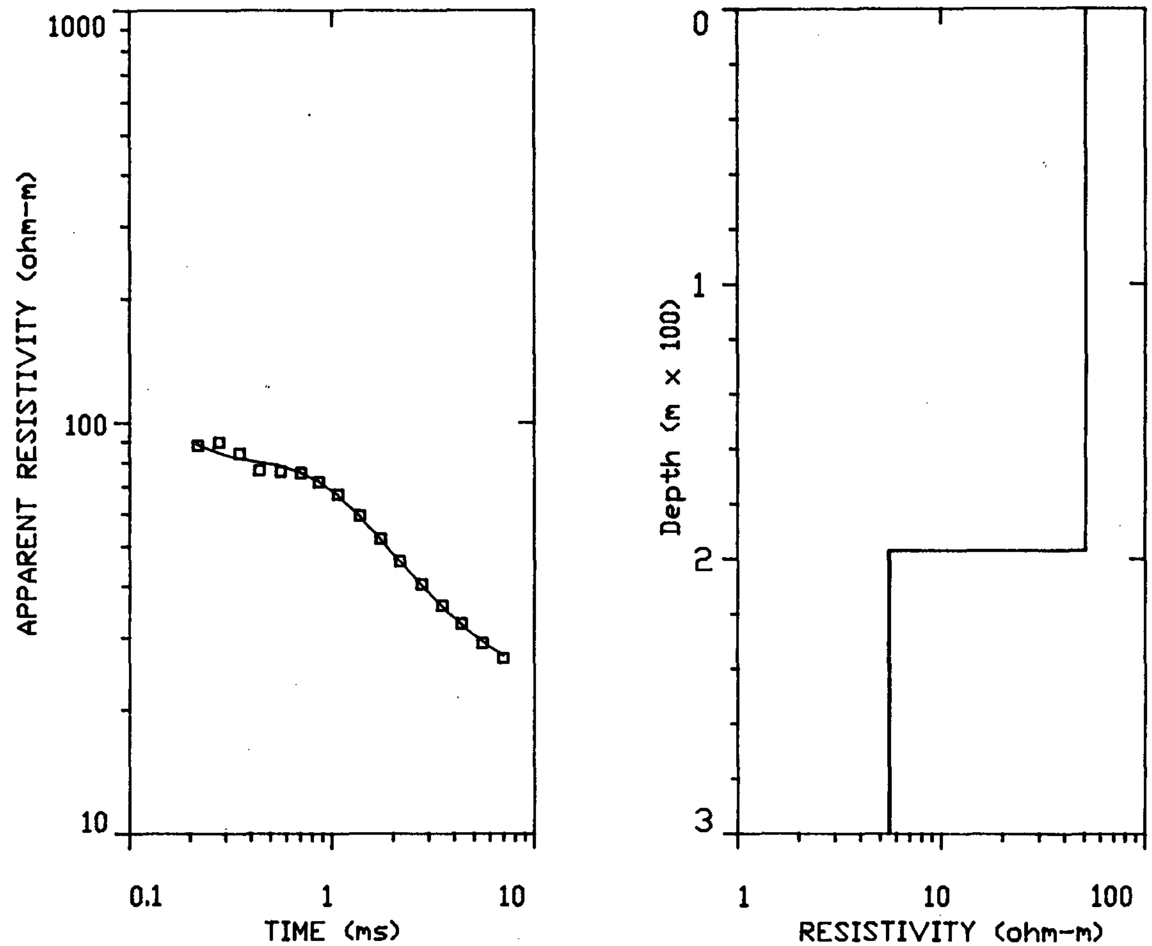
There is insufficient electrical resistivity contrast between the Holocene to Miocene deposits and the underlying Floridan aquifer to distinguish the two. Fixing the thickness of the upper layer does not resolve this dilemma; therefore, it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (197 m = 646 ft) surface layer of intermediate resistivity (51 ohm-m) overlying a low resistivity layer (5.5 ohm-m). The Holocene to Miocene deposits and the upper part of the Floridan aquifer system exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater saturated Floridan aquifer at a depth of 646 ft bls.

5.15.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 5.5 ohm-m, is interpreted to represent salt water. It occurs at a depth of 646 ft (-576 ft msl). Because the resistivity of Layer 1 (51 ohm-m) is less than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken at the depth of the geoelectrical interface, or at 646 ft depth (-576 ft msl). The resistivity of Layer 2 (5.5 ohm-m) corresponds to a chloride concentration of 5,695 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

5.15.4 Depth of Occurrence of the 250 mg/l Isochlor

Because of the inability to segregate the Floridan aquifer from the overlying Holocene to Miocene deposits, the effective chloride concentration of Layer 1 cannot be calculated.



—— BEST–FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

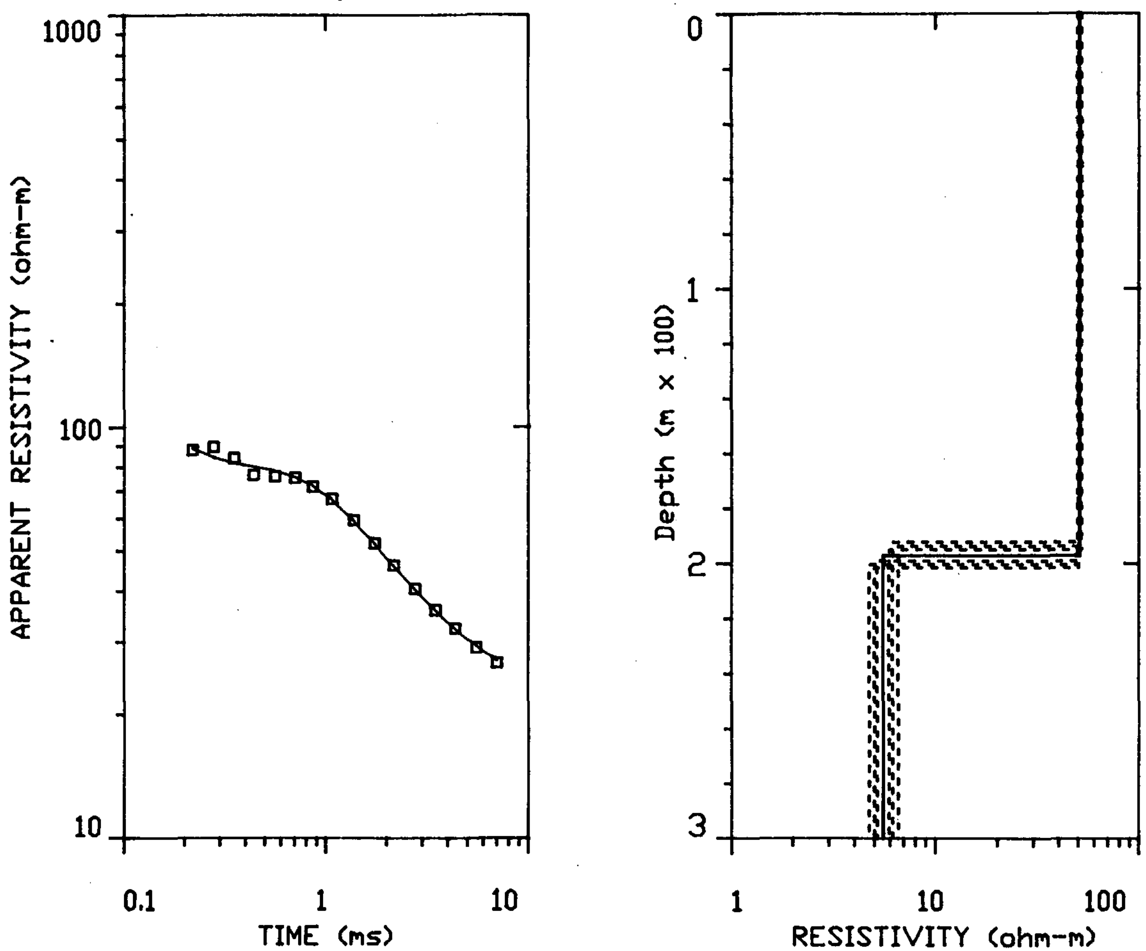
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII

SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1–D INVERSION
SITE 14 – GLEN ABBEY
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL–14	5.15–2
DRAWN BY:	SAB	DATE:	07/26/95	



— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 14 – GLENN ABBEY
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-14	5.15-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 14

CLIENT:	SJRWMD	DATE:	08-MAY-95
LOCATION:	GLEN ABBY	SOUNDING:	1
COUNTY:	VOLUSIA COUNTY	ELEVATION:	21.30 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	223.000 m by 64.000 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		

SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 3.404 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			21.30	
1	50.98	197.0	-175.7	3.86
2	5.51			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	49.916	50.990	52.197
	2	4.715	5.517	6.540
THICK	1	192.107	1.000	201.535
DEPTH	1	192.107	197.047	201.535

CURRENT:	21.20 AMPS EM-57	COIL AREA:	100.00 sq m.
FREQUENCY:	30.00 Hz GAIN: 4	RAMP TIME:	105.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.218	9960.8	9844.2	1.16
2	0.278	5285.4	5784.8	-9.45
3	0.351	3242.2	3382.8	-4.33
4	0.438	2147.4	2005.4	6.61
5	0.558	1184.8	1129.4	4.66
6	0.702	675.0	671.6	0.507
7	0.858	441.0	438.0	0.670

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 14 – GLEN ABBEY
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.15–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	1.06	284.5	285.7	-0.421
9	1.37	181.5	182.5	-0.510
10	1.74	121.3	121.5	-0.195
11	2.17	84.21	84.31	-0.124
12	2.77	55.64	56.05	-0.746
13	3.50	37.03	37.30	-0.717
14	4.37	24.79	25.03	-0.978
15	5.56	15.97	15.80	1.06
16	7.03	10.07	9.87	2.04

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	1.00		
P 2	-0.01	0.86	
T 1	0.00	0.02	1.00
	P 1	P 2	T 1

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE
DETECTION
INVESTIGATIONS
INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 14 – GLEN ABBEY
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.15–1

5.15.5 Accuracy of Measurement and Interpretation

Figure 5.15-3 is the equivalence analysis at this site and the inversion table (Table 5.15-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. The range of equivalence in determining the depth to the low resistivity layer is about ±5 m (16 ft) which is 3% of the total depth. The resistivity of this layer has a range from 4.7 to 6.5 ohm-m. This corresponds to a range in interpreted chloride concentration of from 6,690 to 4,795 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 1 is from 50 to 52 ohm-m. A corresponding chloride concentration cannot be determined because Layer 1 is in part comprised of the Holocene to Miocene deposits. Accordingly, equation (4) may not be valid.

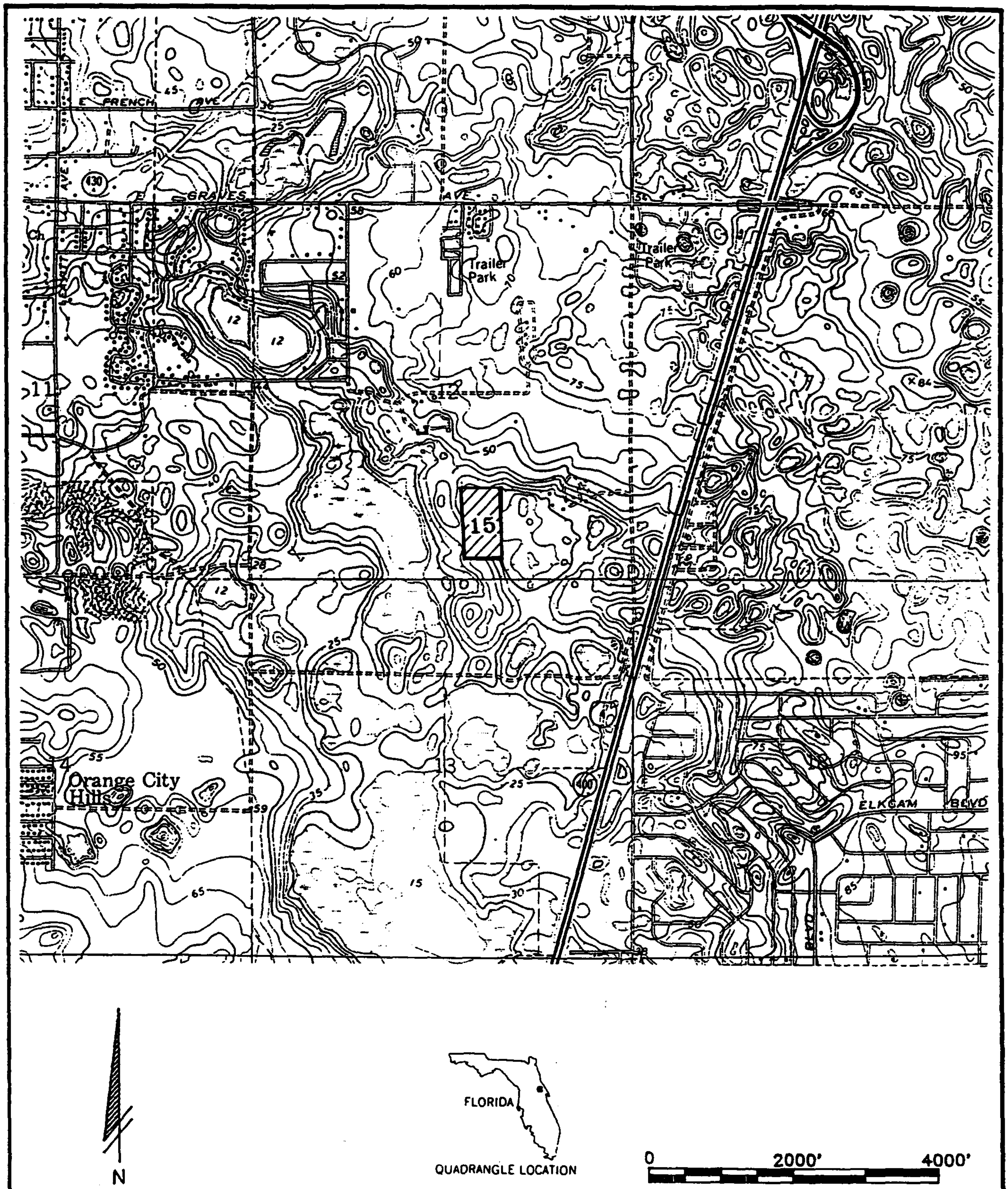
5.15.6 Summary of TDEM Sounding at Glen Abbey (Site 14)

- The depth of occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 646 ft (-576 ft msl) and occur within the Floridan aquifer.
- The quality of ground water within the Floridan aquifer at this site cannot be interpreted because the analysis of the TDEM data does not allow the Holocene to Miocene deposits to be distinguished from the Floridan Aquifer System.

5.16 TDEM Site 15 - Orange City-East

5.16.1 Location Description and Geoelectrical Section

The site is located in southern Volusia County near Orange City, Florida (Figure 5.16-1). The site is located within a wooded area next to a golf course. No visible sources of interference were observed in the area of the site. QA soundings were performed 50 ft to the east and 100 ft to the north of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 15 – ORANGE CITY – EAST VOLUSIA COUNTY, FLORIDA

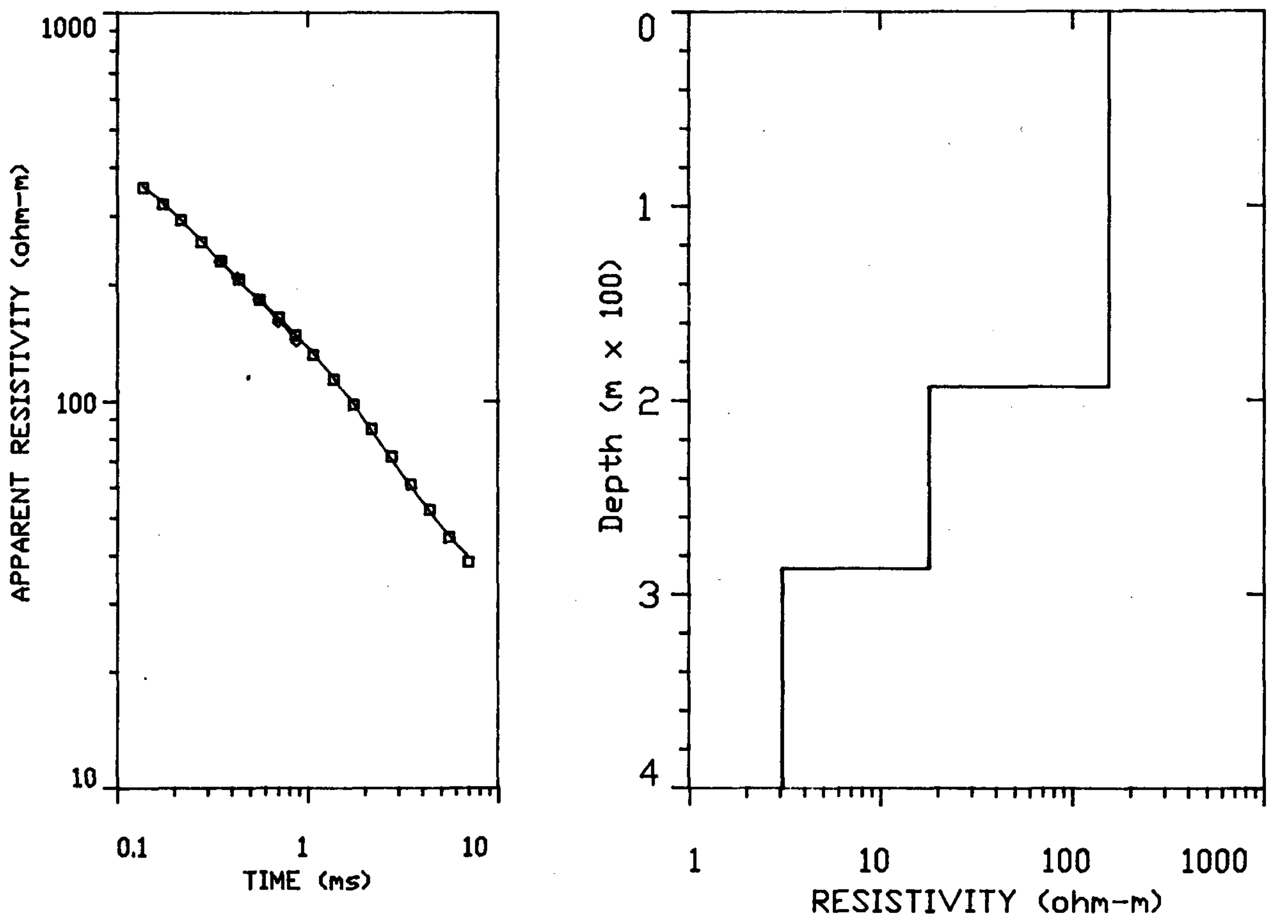
DESIGNED BY: JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY: MJW	DRAWING NO.:	LOC-15	5.16-1
DRAWN BY: RBT	DATE:	06/21/95	

The Floridan aquifer occurs at an approximate depth of 20 ft bmsl or 45 ft bls (SJRWMD, personal communication) and is overlain by the Holocene to Miocene deposits. The base of the Floridan aquifer occurs at approximately 2,150 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 300 ft and the depth to the top of the Lower Floridan aquifer is approximately 675 ft bls (Miller, 1986). Chloride concentration in the upper portion of the Floridan aquifer ranges from 0 to 50 mg/l in this area and the maximum thickness of the Freshwater saturated Floridan aquifer is 300 ft (Rutledge, 1985).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.16-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.16.2 Geological Interpretation of Geoelectrical Model

There is a sufficient electrical resistivity contrast to distinguish two geological layers above a third saltwater saturated layer. The first layer occurs at a depth of 193 m (633 ft) and not at the hydrostratigraphic contact (45 ft bls) between the Holocene to Miocene deposits and the Floridan Aquifer System. The first layer has a high resistivity (156 ohm-m) and is considered to represent the Holocene to Miocene deposits combined with the upper portion of the Floridan aquifer. The second layer has an intermediate resistivity (18 ohm-m) which, because it is less than 80 ohm-m, suggests the Floridan aquifer at this site contains brackish water. The third layer occurs at a depth of 287 m (942 ft). It has a resistivity of 3.1 ohm-m and is considered to represent a saltwater saturated Lower Floridan aquifer.



—— BEST–FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1–D INVERSION
SITE 15 – ORANGE CITY – EAST
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL–15	5.16–2
DRAWN BY:	SAB	DATE:	07/26/95	

5.16.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 3.1 ohm-m, is interpreted to represent salt water. It occurs at a depth of 942 ft. Because the resistivity of Layer 2 (18 ohm-m) is interpreted to represent brackish water within the Floridan aquifer (i.e., is less than 80 ohm-m), the interpretated depth to the 5,000 mg/l isochlor is equal to the geoelectric interface, or at 942 ft depth (-918 ft msl).

The resistivity of Layer 3 (3.1 ohm-m) corresponds to a chloride concentration of 10,222 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, the concentration of Layer 3 is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

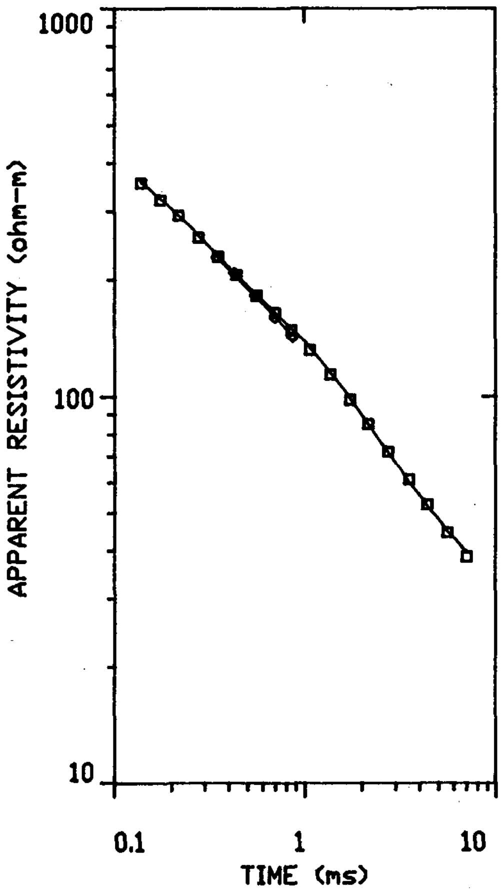
5.16.4 Depth of Occurrence of the 250 mg/l Isochlor

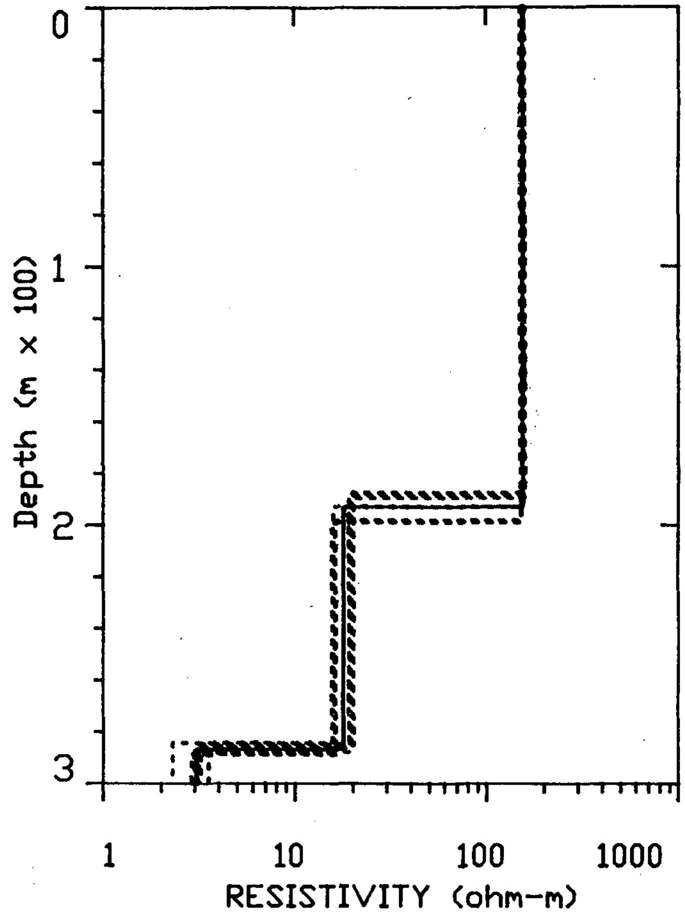
The resistivity of Layer 1 (156 ohm-m,) corresponds to a chloride concentration of less than 250 mg/l, even though Layer 1 is in part comprised of Holocene to Miocene deposits. The 250 mg/l isochlor is placed in the Floridan aquifer at a depth 50 ft above the Layer 2 interface or at 583 ft (-559 ft msl).

For comparison, Rutledge (1985) estimated a maximum thickness of approximately 300 ft for water with a chloride concentration less than 250 mg/l in the Floridan aquifer at this site. The top of the Floridan aquifer occurs at an approximate depth of 20 ft bmsl or 45 ft bls at this site (SJRWMD, personal communication).

5.16.5 Accuracy of Measurement and Interpretation

Figure 5.16-3 is the equivalence analysis at this site and the inversion table (Table 5.16-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.





—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 15 - ORANGE CITY - EAST
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-15	5.16-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE15

CLIENT: SJRWMD
LOCATION: ORANGE CITY-EAST
COUNTY: VOLUSIA COUNTY
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 305.000 m by 152.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 08-MAY-95
SOUNDING: 1
ELEVATION: 7.60 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 1.556 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			7.60	
1	155.5	193.0	-185.4	1.24
2	17.99	93.66	-279.1	5.20
3	3.06			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	150.719	155.600	158.411
	2	15.671	17.997	20.327
	3	2.296	3.069	3.553
THICK	1	187.417	-0.549	199.173
	2	89.237	1.000	97.640
DEPTH	1	187.417	193.035	199.173
	2	284.188	286.701	288.966

CURRENT: 19.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz GAIN: 5 RAMP TIME: 148.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.138	10184.4	10031.2	1.50
2	0.175	6534.9	6459.9	1.14
3	0.218	4338.4	4332.4	0.136

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 15 – ORANGE CITY – EAST
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.16–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.278	2868.5	2821.4	1.63
5	0.351	1890.5	1888.1	0.123
6	0.438	1279.8	1285.8	-0.470
7	0.558	839.2	836.1	0.373
8	0.702	553.0	555.2	-0.388
9	0.858	391.6	387.8	0.959
10	1.06	271.4	266.2	1.89
11	1.37	180.6	178.0	1.43
12	1.74	124.4	123.3	0.889
13	2.17	88.74	89.79	-1.18
14	2.77	61.72	63.13	-2.28
15	3.50	43.98	44.95	-2.19
16	4.37	31.69	32.18	-1.52
17	5.56	22.27	21.96	1.38
18	7.03	15.41	14.81	3.91

CURRENT: 19.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 8 RAMP TIME: 148.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
19	0.346	1975.4	1953.9	1.09
20	0.427	1339.9	1362.9	-1.71
21	0.550	871.1	875.9	-0.561
22	0.698	586.1	578.4	1.31
23	0.869	403.1	396.2	1.70

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.98				
P 2	-0.06	0.55			
P 3	-0.01	-0.21	0.51		
T 1	0.02	0.10	0.00	0.97	
T 2	-0.03	-0.15	-0.04	0.04	0.93
	P 1	P 2	P 3	T 1	T 2

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 15 – ORANGE CITY – EAST
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.16–1

The range of equivalence in determining the depth to the low-resistivity layer is about ±2 m (7 ft) which is 1% of the total depth. The resistivity of this layer has a range of from 2.6 to 3.6 ohm-m. This corresponds to a range in interpreted chloride concentration of from 12,218 to 8,781 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity for Layer 1 is from 151 to 158 ohm-m. Since the resistivity is greater than 80 ohm-m, the chloride concentration in the upper part of the Floridan aquifer is less than 250 mg/l even though Layer 1 is in part comprised of both the upper portion of the Floridan aquifer and Holocene to Miocene deposits. The results from the TDEM study agree with the results from Rutledge (1985).

5.16.6 Summary of TDEM Sounding at Orange City-East (Site 15)

- The depth to occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 942 ft (-918 ft msl) and occur within the Lower Floridan aquifer.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration of less than 250 mg/l. The 250 mg/l isochlor is interpreted to be present in the Floridan aquifer at a depth of 583 ft (-559 ft msl). For comparison, Rutledge (1985) estimated an approximate depth of 320 ft bls for the 250 mg/l isochlor.
- The results of the TDEM study agree with the water quality results of Rutledge (1985) who indicates that the chloride concentration in the Upper Floridan aquifer is less than 250 mg/l at this site.

5.17 TDEM Site 16 - Astor Park

5.17.1 Location Description and Geoelectrical Section

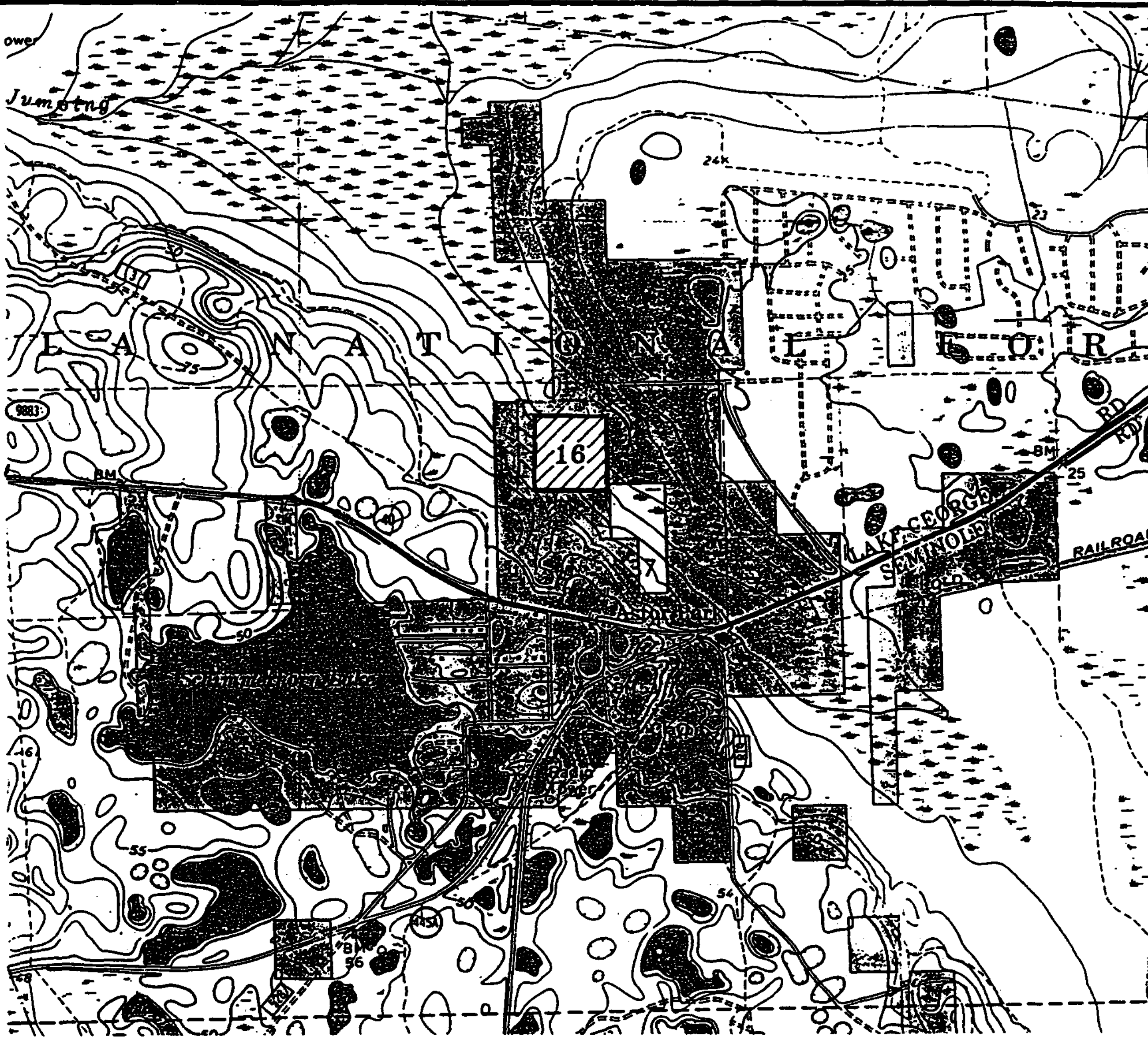
The site is located in northeast Lake County near Astor Park, Florida (Figure 5.17-1). The site is a pasture. No sources of interference were observed within the vicinity of the site. QA soundings were performed 90 ft north and 80 ft east and west of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

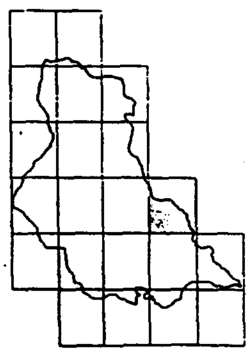
The Floridan aquifer occurs at an approximate depth of 80 ft bmsl or 100 ft bls and is overlain by Holocene to Miocene deposits (SJRWMD, personal communication). The base of the Floridan aquifer occurs at approximately 1,900 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 340 ft and the depth to the top of the Lower Floridan aquifer is approximately 670 ft bls (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.17-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.17.2 Geological Interpretation of Geoelectrical Model

The three-layer geoelectrical section consists of a low resistivity (44 ohm-m), upper layer which correlates with the Holocene to Miocene deposits above the Floridan aquifer. The thickness of Layer 1 was fixed at 30.5 m (100 ft, SJRWMD, personal communication). The second layer has high resistivity (161 ohm-m) which means that because it is greater than 80 ohm-m, the Floridan aquifer at this site contains fresh water. The thickness of the freshwater section is 323 m (1060 ft) placing the depth to the low resistivity (saltwater) layer at 354 m (1,161 ft) below ground surface. The resistivity of the saltwater layer is 14.2 ohm-m. Layer 1 is considered to be the Holocene to Miocene deposits above the Floridan aquifer, Layer 2 to be the Floridan aquifer containing fresh water, and Layer 3 to be the salt water within the Lower Floridan aquifer.

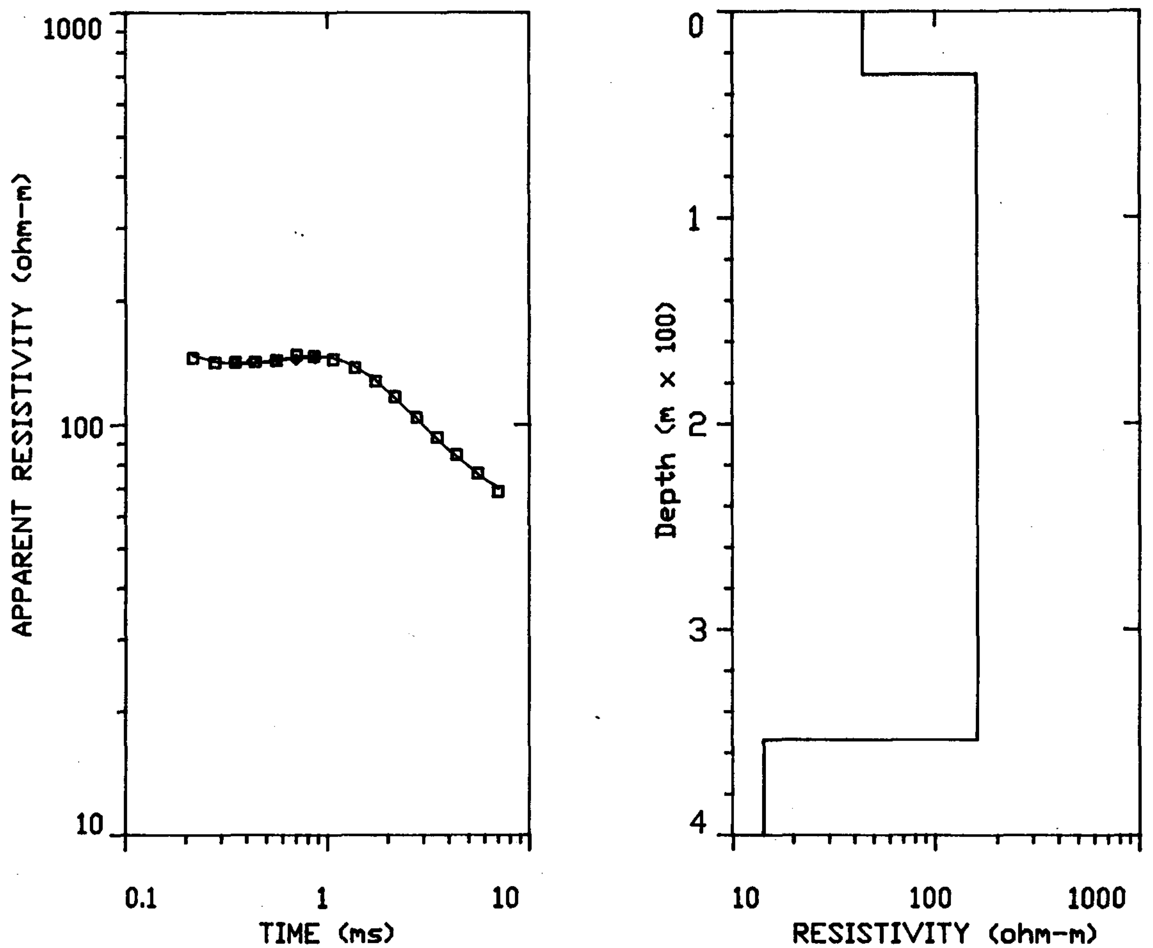




OCALA NATIONAL FOREST
QUADRANGLE LOCATION DIAGRAM

0 2000' 4000'

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 16 – ASTOR PARK LAKE COUNTY, FLORIDA	
		DESIGNED BY: JEB CHECKED BY: MJW DRAWN BY: RBT	PROJECT NO.: 95706 DRAWING NO.: LOC–16 DATE: 06/21/95
		FIGURE 5.17–1	



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 16 – ASTOR PARK
LAKE COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-16	5.17-2
DRAWN BY:	SAB	DATE:	07/26/95	

5.17.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 14.2 ohm-m, is interpreted to represent salt water. It occurs at a depth of 1;161 ft (-1,141 ft msl). Because the resistivity of Layer 2 (161 ohm-m) is greater than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken as 50 ft greater than the depth of the geoelectrical interface, or at a depth of 1,211 ft (-1,191 ft bmsl). The resistivity of Layer 3 (14.2 ohm-m) corresponds to a chloride concentration of 2,112 mg/l, assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

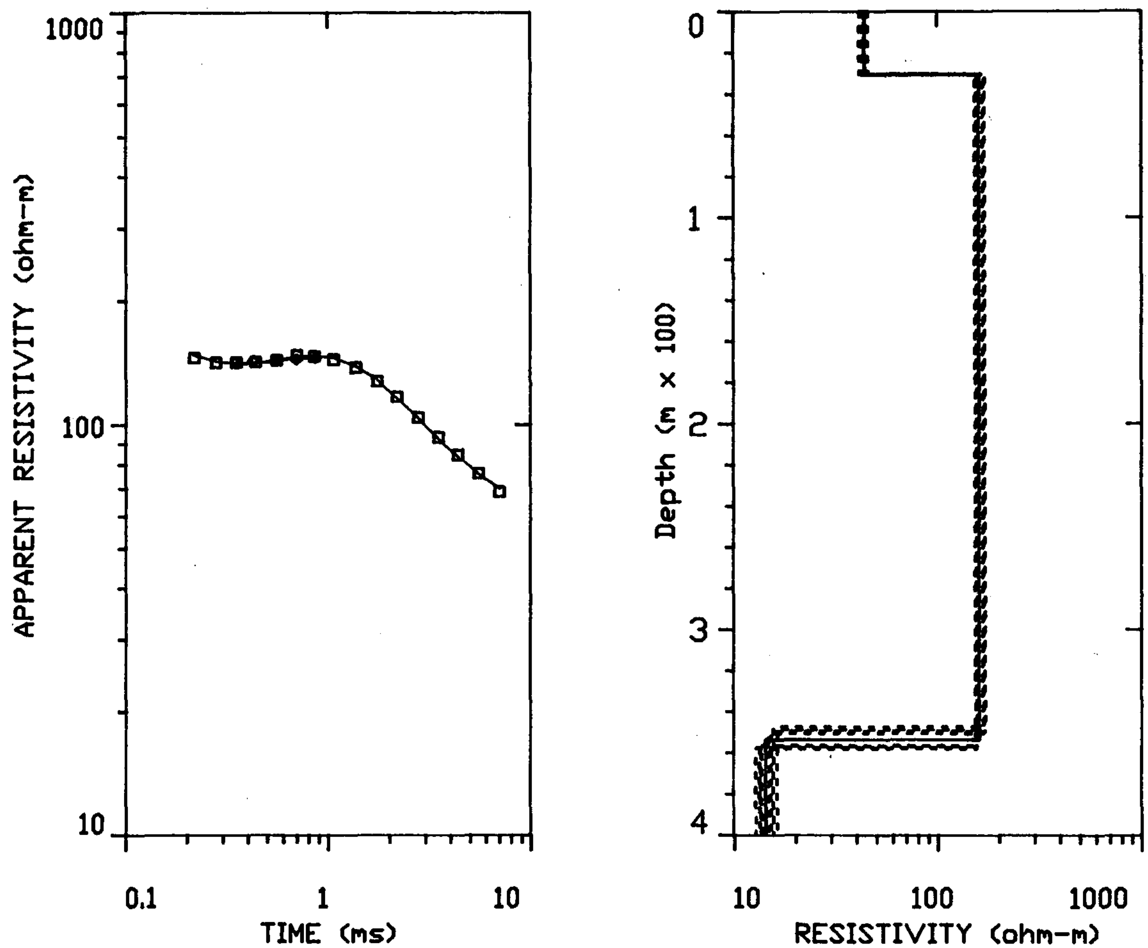
5.17.4 Depth of Occurrence of the 250 mg/l Isochlor

The resistivity of Layer 2, 161 ohm-m, corresponds to a chloride concentration of less than 250 mg/l, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. The 250 mg/l isochlor is placed in the Floridan aquifer at a depth 50 ft above the Layer 3 interface or at 1,111 ft (-1,091 ft msl).

5.17.5 Accuracy of Measurement and Interpretation

Figure 5.17-3 is the equivalence analysis at this site and the inversion table (Table 5.17-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ±5 m (16 ft) which is 1% of the total depth. The resistivity of this layer has a range of from 12.7 to 16.2 ohm-m. This corresponds to a range in interpreted chloride concentration of from 2,380 mg/l to 1,832 mg/l, again subject to the same assumptions of porosity and validity of equation (4).



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 16 – ASTOR PARK
LAKE COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-16	5.17-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 16

CLIENT:	SJRWMD	DATE:	08-MAY-95
LOCATION:	ASTOR PARK	SOUNDING:	1
COUNTY:	LAKE COUNTY	ELEVATION:	6.10 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	244.000 m by 274.000 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		

SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 1.387 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)		ELEVATION (meters)	CONDUCTANCE (Siemens)
				6.10	
1	43.94	30.50	*	-24.40	0.694
2	160.8	323.0		-347.4	2.00
3	14.19				

"*" INDICATES FIXED PARAMETER

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	41.656	43.946	45.847
	2	153.452	160.889	171.345
	3	12.739	14.195	16.242
THICK	1	30.500	0.000	30.500
	2	316.710	1.000	327.553
DEPTH	1	30.500	30.500	30.500
	2	347.210	353.522	358.053

CURRENT:	18.10 AMPS	EM-57	COIL AREA:	100.00 sq m.
FREQUENCY:	30.00 Hz	GAIN: 4	RAMP TIME:	160.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.218	15613.8	15245.8	2.35
2	0.278	8841.5	8745.4	1.08
3	0.351	4922.3	4975.8	-1.08

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 16 – ASTOR PARK
LAKE COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.17-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.438	2824.4	2850.8	-0.933
5	0.558	1520.4	1522.4	-0.135
6	0.702	818.8	831.5	-1.55
7	0.858	501.4	500.3	0.223
8	1.06	299.4	293.4	2.02
9	1.37	171.2	169.1	1.25
10	1.74	105.6	104.1	1.45
11	2.17	69.33	69.96	-0.899
12	2.77	44.74	45.05	-0.701
13	3.50	29.46	29.94	-1.65
14	4.37	19.63	19.84	-1.06
15	5.56	12.55	12.66	-0.901
16	7.03	8.15	7.93	2.76

CURRENT: 18.10 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 8 RAMP TIME: 160.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
17	0.346	5102.0	5165.0	-1.23
18	0.427	2993.1	3049.0	-1.86
19	0.550	1583.3	1590.1	-0.425
20	0.698	862.8	851.7	1.28
21	0.869	491.3	492.1	-0.155

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

	P 1	P 2	P 3	F 1	T 2
P 1	0.95				
P 2	0.06	0.93			
P 3	0.05	-0.07	0.74		
F 1	0.00	0.00	0.00	0.00	
T 2	-0.01	0.01	0.03	0.00	0.99

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WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 16 – ASTOR PARK
LAKE COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.17–1

The equivalence range of the resistivity of Layer 2 is from 153 to 171 ohm-m which corresponds to a chloride concentration of less than 250 mg/l. The chloride-to-sulfate ratio at the site is 5:1 (Table 5.1-4). Accordingly, Equation (4) is valid.

5.17.6 Summary of TDEM Sounding at Astor Park (Site 16)

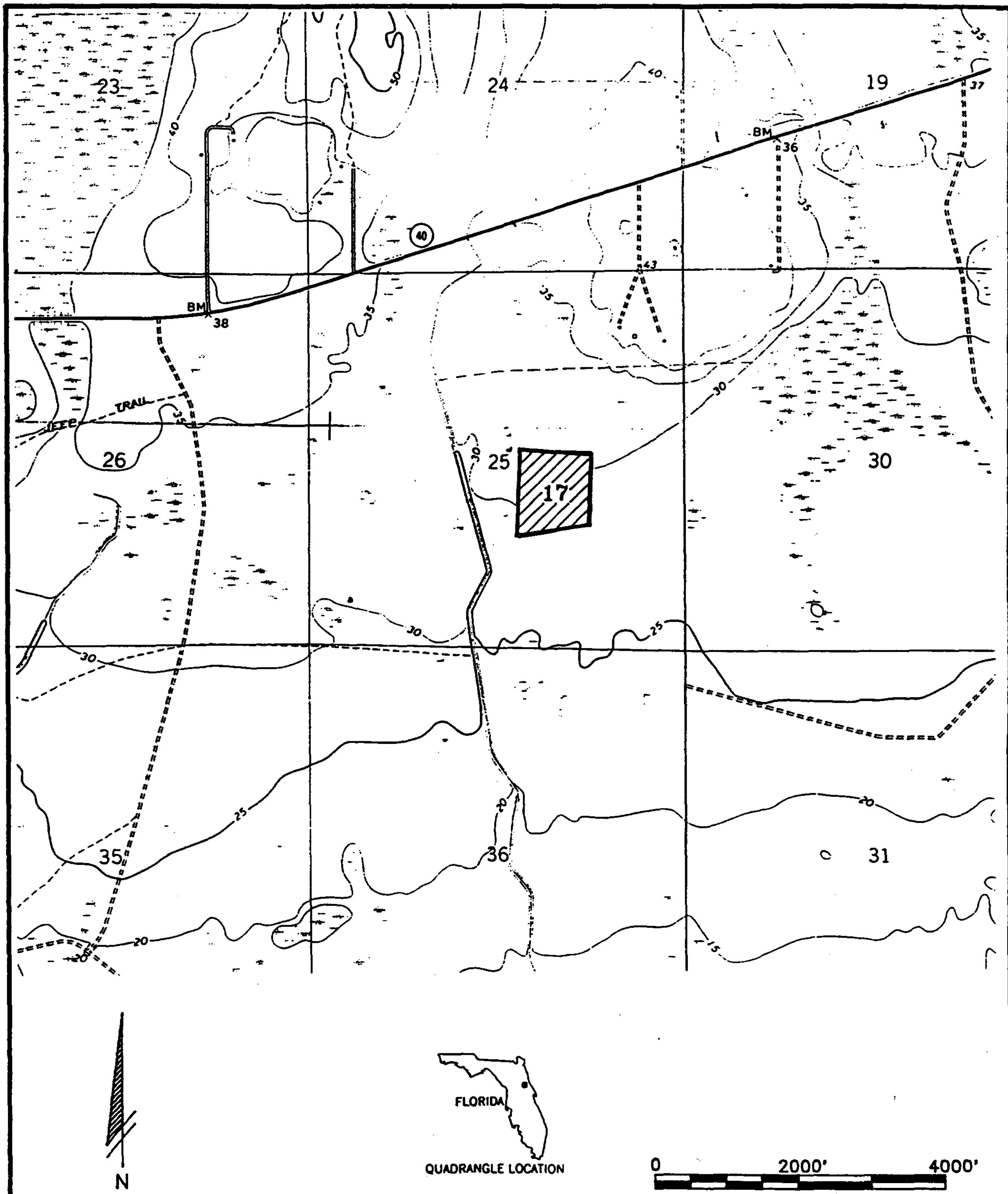
- The depth to occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 1,211 ft (-1,191 ft msl) and occur within the Lower Floridan aquifer.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration of less than 250 mg/l. The 250 mg/l isochlor is interpreted to be present in the Floridan aquifer at a depth of 1,111 ft (-1,091 ft msl).

5.18 TDEM Site 17 - Barberville

5.18.1 Location Description and Geoelectrical Section

The site is located in western Volusia County west of Barberville, Florida (Figure 5.18-1). The site is a pasture. No sources of interference were observed within the vicinity of the site. QA soundings were performed 100 ft east and 110 ft north and south of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 100 ft bmsl or 130 ft bls and is overlain by Holocene to Miocene deposits (SJRWMD, personal communication). The base of the Floridan aquifer occurs at approximately 1,950 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 350 ft and the depth to the top of the Lower Floridan aquifer is approximately 750 ft bls (Miller, 1986). Chloride concentration in the upper portion of the Floridan aquifer ranges from 0 to 50 mg/l in this area and the maximum thickness of the freshwater-saturated Floridan aquifer is 450 ft (Rutledge, 1985).



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PALATKA, FLORIDA

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DETECTION
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INCORPORATED

TDEM SURVEY LOCATION MAP
SOUNDING 17 – BARBERVILLE
VOLUSIA COUNTY, FLORIDA

DESIGNED BY: JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY: MJW	DRAWING NO.:	LOC-17	5.18-1
DRAWN BY: RBT	DATE:	06/21/95	

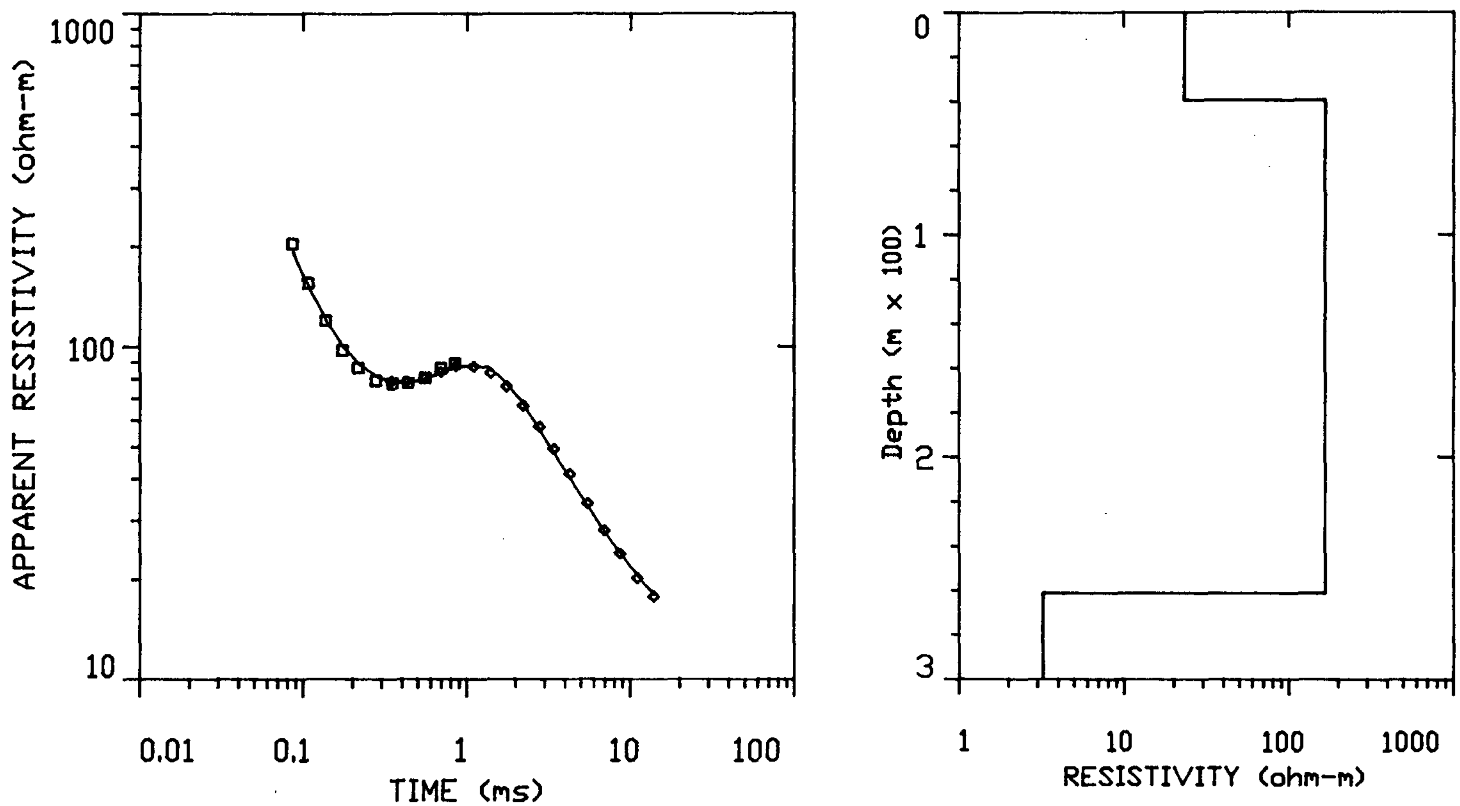
The resistivity sounding data and best-fit model inversion are presented on Figure 5.18-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.18.2 Geological Interpretation of Geoelectrical Model

The three-layer geoelectrical section consists of a low resistivity (23 ohm-m), upper layer which correlates with the Holocene to Miocene deposits above the Floridan aquifer. The thickness of Layer 1 was fixed at 39.6 m (130 ft, SJRWMD, personal communication). The second layer has high resistivity (167 ohm-m) which means that because it is greater than 80 ohm-m, the Floridan aquifer at this site contains fresh water. The thickness of the freshwater section is 222 m (728 ft) placing the depth to the low resistivity (saltwater) layer at 261 m (856 ft) below ground surface. The resistivity of the saltwater layer is 3.2 ohm-m. Layer 1 is considered to be the Holocene to Miocene deposits above the Floridan aquifer, Layer 2 to be the Floridan aquifer containing fresh water, and Layer 3 to be the salt water within the Lower Floridan aquifer.

5.18.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 3.2 ohm-m, is interpreted to represent salt water. It occurs at a depth of 856 ft (-826 ft msl). Because the resistivity of Layer 2 (167 ohm-m) is greater than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken as 50 ft greater than the depth of the geoelectrical interface, or at a depth of 906 ft (-876 ft bmsl). The resistivity of Layer 3 (3.2 ohm-m) corresponds to a chloride concentration of 9,898 mg/l, assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.



——— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 17 – BARBERVILLE
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-17	5.18-2
DRAWN BY:	SAB	DATE:	07/26/95	

5.18.4 Depth of Occurrence of the 250 mg/l Isochlor

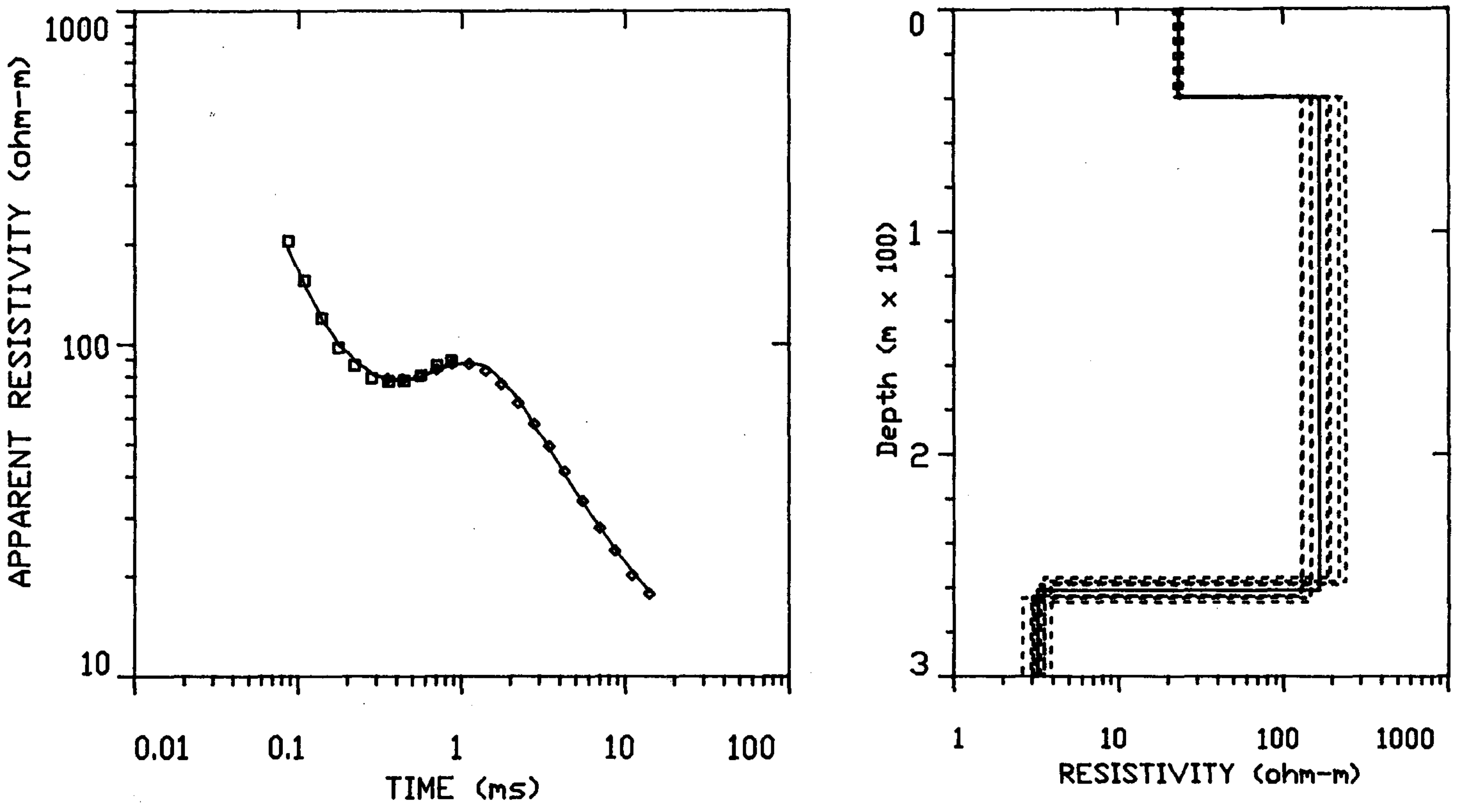
The resistivity of Layer 2, 167 ohm-m, corresponds to a chloride concentration of less than 250 mg/l, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. The 250 mg/l isochlor is placed in the Floridan aquifer at a depth 50 ft above the Layer 3 interface or at 806 ft (-776 ft msl), and the thickness of water in the Floridan aquifer below 250 mg/l is 676 ft (806 ft - 130 ft). For comparison, Rutledge (1985) estimated a maximum thickness of 450 ft for water with a chloride concentration less than 250 mg/l in the Floridan aquifer at this site. The top of the Floridan aquifer occurs at an approximate depth of 100 ft bmsl or 130 ft bls at this site (Rutledge, 1982).

5.18.5 Accuracy of Measurement and Interpretation

Figure 5.18-3 is the equivalence analysis at this site and the inversion table (Table 5.18-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ±6 m (20 ft) which is 2% of the total depth. The resistivity of this layer has a range of from 2.6 to 3.9 ohm-m. This corresponds to a range in interpreted chloride concentration of from 12,218 to 8,094 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 2 is from 128 to 240 ohm-m which corresponds to a chloride concentration of less than 250 mg/l. The results from the TDEM study agree with the water quality results from Rutledge (1985), who mapped chloride concentration of 0 to 50 mg/l in this area. The chloride-to-sulfate ratio at the site is 5:1 (Table 5.1-4). Accordingly, Equation (4) is valid.



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 17 – BARBERVILLE
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-17	5.18-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 17

CLIENT: SJRWMD
LOCATION: BARBERVILLE
COUNTY: VOLUSIA
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 342.000 m by 305.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 09-MAY-95
SOUNDING: 1
ELEVATION: 9.10 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 3.219 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)		ELEVATION (meters)	CONDUCTANCE (Siemens)
				9.10	
1	23.36	39.60	*	-30.50	1.69
2	167.2	221.5		-252.0	1.32
3	3.23				

"*" INDICATES FIXED PARAMETER

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	21.985	23.362	24.629
	2	128.183	167.203	240.452
	3	2.622	3.238	3.894
THICK	1	39.600	0.000	39.600
	2	215.841	1.000	226.815
DEPTH	1	39.600	39.600	39.600
	2	255.441	261.170	266.415

CURRENT: 20.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz GAIN: 1 RAMP TIME: 200.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	162516.7	176161.7	-8.39
2	0.108	141272.7	147543.1	-4.43
3	0.138	113068.6	113086.5	-0.0158

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE
DETECTION
INVESTIGATIONS
INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 17 – BARBERVILLE
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.18–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.175	84956.0	81340.2	4.25
5	0.218	58785.1	56239.4	4.33
6	0.278	36543.6	34908.0	4.47
7	0.351	21126.0	20750.0	1.77
8	0.438	12034.3	11984.1	0.417
9	0.558	6238.0	6303.8	-1.05
10	0.702	3173.9	3299.5	-3.95
11	0.858	1829.0	1858.5	-1.61

CURRENT: 20.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 6 RAMP TIME: 200.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
12	0.346	21329.1	21509.1	-0.843
13	0.427	12682.7	12838.8	-1.23
14	0.550	6469.3	6601.5	-2.04
15	0.698	3345.8	3398.1	-1.56
16	0.869	1816.0	1836.6	-1.13
17	1.10	996.0	980.5	1.55
18	1.40	593.0	562.2	5.20
19	1.75	391.7	378.4	3.40
20	2.22	263.8	255.5	3.13
21	2.79	185.2	190.3	-2.74
22	3.42	140.0	144.5	-3.20
23	4.26	104.9	109.0	-3.86
24	5.49	75.75	77.74	-2.62
25	6.96	55.46	55.87	-0.729
26	8.66	40.75	40.47	0.690
27	11.06	28.55	27.77	2.72
28	14.00	19.17	18.72	2.33

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.99				
P 2	0.07	0.58			
P 3	0.01	-0.10	0.82		
F 1	0.00	0.00	0.00	0.00	
T 2	0.00	0.02	0.01	0.00	1.00
	P 1	P 2	P 3	F 1	T 2

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 17 – BARBERVILLE
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.18–1

5.18.6 Summary of TDEM Sounding at Barberville (Site 17)

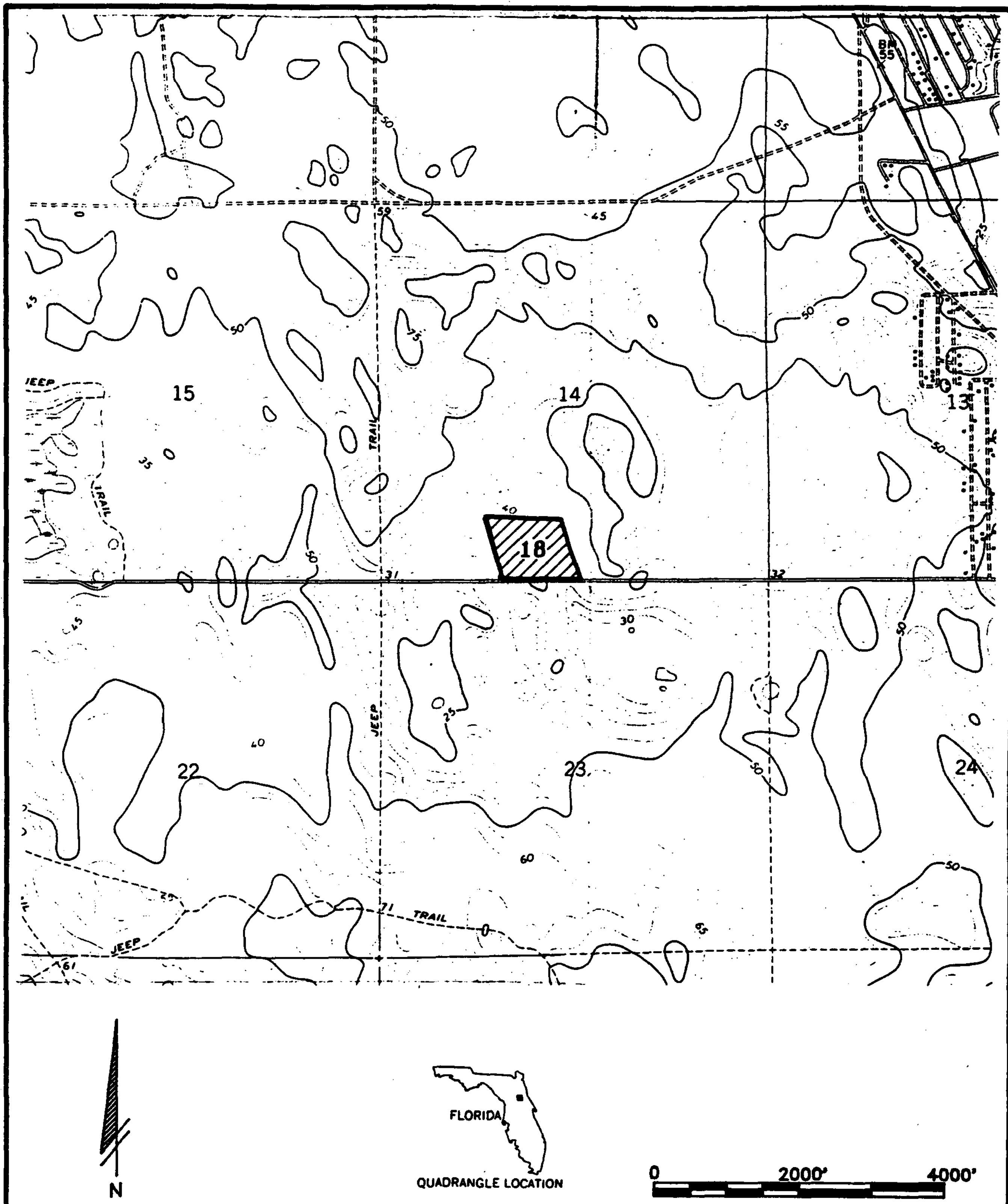
- The depth to occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 906 ft (-876 ft msl) and occur within the Lower Floridan aquifer.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration of less than 250 mg/l. The 250 mg/l isochlor is interpreted to be present in the Floridan aquifer at a depth of 806 ft (-776 ft msl). For comparison, Rutledge (1985) estimated a depth to the 250 mg/l isochlor of approximately 480 ft bls at this site.
- The results of the TDEM study agree with the chloride concentration mapped in the Upper Floridan aquifer in this area to be less than 250 mg/l (Rutledge, 1985).

5.19 TDEM Site 18 - ONF-Hopkins Prairie

5.19.1 Location Description and Geoelectrical Section

The site is located in north-eastern Marion County, Florida within the Ocala National Forest (Figure 5.19-1). Timber had been cut at the site which was now brush-covered. No sources of interference were observed in the vicinity of the site. QA soundings were performed 110 ft east, west, and north of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 65 ft bmsl or 100 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at an approximate depth of 1,850 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 300 ft and the depth to the top of the Lower Floridan aquifer is approximately 600 ft bls (Miller, 1986).



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SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SURVEY LACATION MAP
SOUNDING 18 – ONF – HOPKINS PRARIE
MARION COUNTY, FLORIDA

DESIGNED BY: JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY: MJW	DRAWING NO.:	LOC-18	5.19-1
DRAWN BY: RBT	DATE:	06/21/95	

The resistivity sounding data and best-fit model inversion are presented on Figure 5.19-2. The interpreted geoelectrical section consists of a two-layer subsurface.

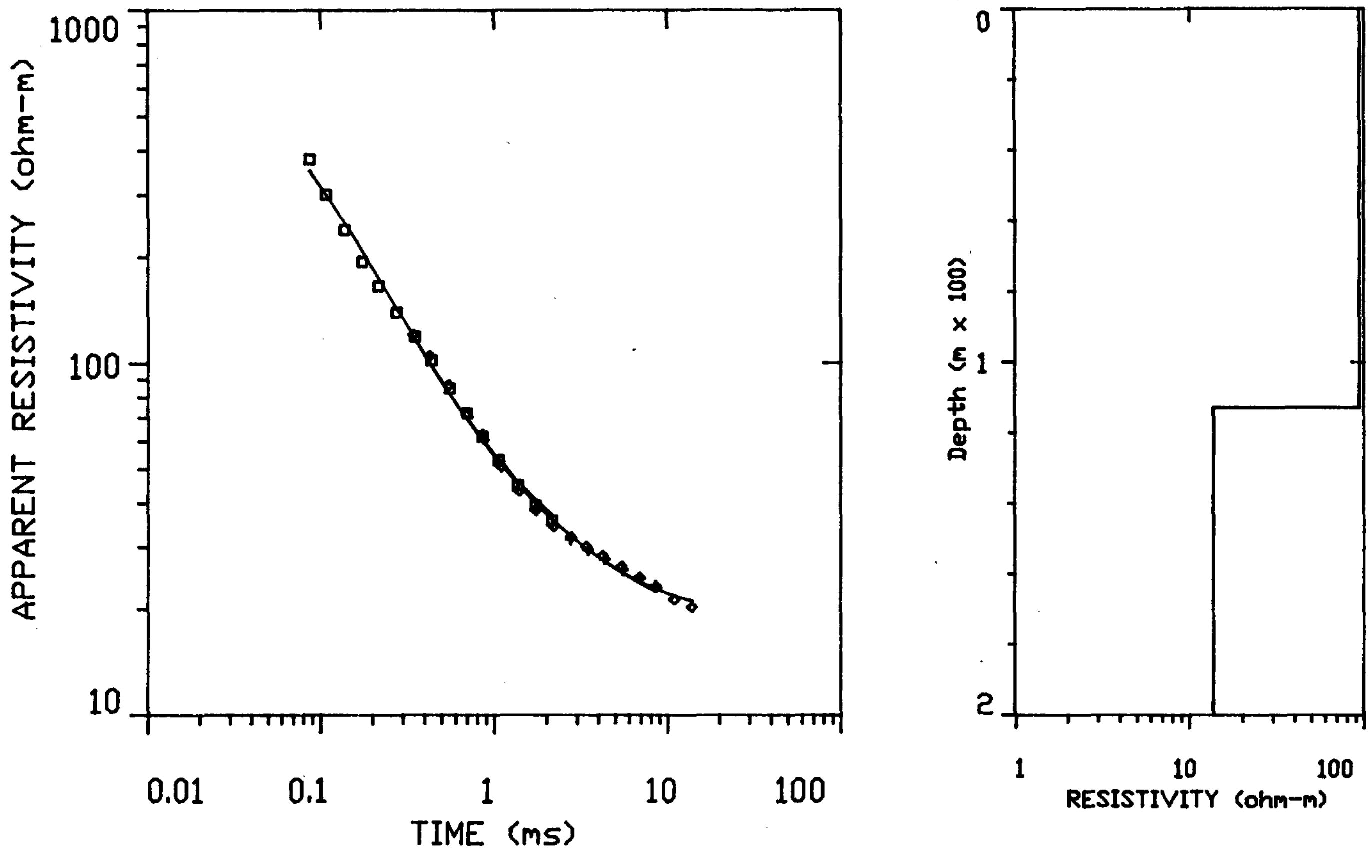
5.19.2 Geological Interpretation of Geoelectrical Model

The first layer occurs at 113 m (371 ft) bls and not at the hydrostratigraphic contact between the Holocene to Miocene deposits (100 ft bls) and the Floridan Aquifer System. Therefore, it can be interpreted that there exists a two-layer geoelectrical section with a 371 ft thick surface layer with a resistivity of 94 ohm-m overlying a low resistivity layer (13.6 ohm-m). The Holocene to Miocene deposits and the upper part of the Floridan aquifer system exist as a combined but indistinguishable (geoelectrical) layer, overlying a saltwater-saturated Floridan aquifer at a depth of 371 ft bls.

The site was also modeled using a three-layer subsurface. The estimated depth to saltwater using the three-layer model was 404 ft bls. The difference in the fitting error between the two models was negligible. The two-layer model was selected as the appropriate representation of hydrogeologic conditions because it was simpler.

5.19.3 Depth to Occurrence of Salt Water

The bottom (second) layer of the geoelectrical model, with a resistivity of 13.6 ohm-m, is interpreted to represent salt water. It occurs at a depth of 371 ft (-336 ft msl). Because the resistivity of Layer 1 (94 ohm-m) is greater than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken as 50 ft greater than the depth of the geoelectrical interface, or at a depth of 421 ft (-386 ft msl). The resistivity of Layer 2 (13.6 ohm-m) corresponds to a chloride concentration of 2,212 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.



BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 18 – ONF-HOPKINS PRAIRIE
MARION COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-18	5.19-2
DRAWN BY:	SAB	DATE:	07/26/95	

5.19.4 Depth of Occurrence of the 250 mg/l Isochlor

Since the resistivity (94 ohm-m) of Layer 1 is greater than 80 ohm-m, the chloride concentration in the Upper Floridan aquifer is less than 250 mg/l, even though Layer 1 contains Holocene to Miocene deposits. Since the resistivity of Layer 1 (94 ohm-m) is greater than 80 ohm-m, the 250 mg/l isochlor is interpreted to occur 50 ft above the boundary between Layer 1 and Layer 2. That depth is 321 ft.

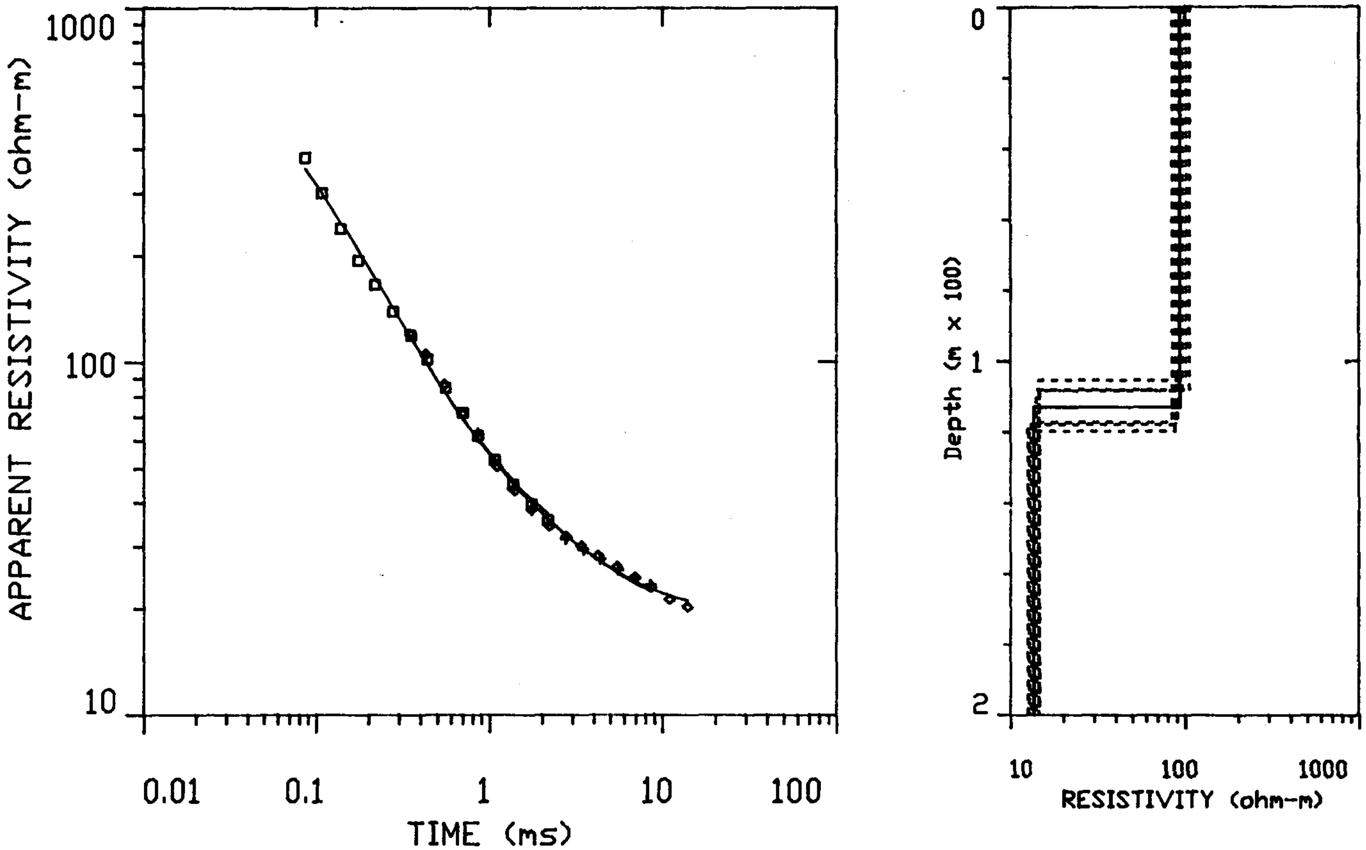
5.19.5 Accuracy of Measurement and Interpretation

Figure 5.19-3 is the equivalence analysis at this site and the inversion table (Table 5.19-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. The range of equivalence in determining the depth to the low resistivity layer is about ±7 m (23 ft) which is 6% of the total depth. The resistivity of this layer has a range of from 12.6 to 14.7 ohm-m. This corresponds to an interpreted chloride concentration ranging from 2,400 mg/l to 2,035 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 1 is from 85 to 107 ohm-m. Since the resistivity is greater than 80 ohm-m, the chloride concentration in the upper part of the Floridan aquifer is less than 250 mg/l even though Layer 1 is in part comprised of both the upper portion of the Floridan aquifer and Holocene to Miocene deposits.

5.19.6 Summary of TDEM Sounding at ONF-Hopkins Prairie (Site 18)

- The depth of occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 421 ft (-386 ft msl) and occur within the Floridan aquifer.
- The 250 mg/l isochlor is interpreted to occur at 321 ft bls. The thickness of freshwater (<250 mg/l chloride) in the Floridan aquifer at this site is interpreted to be 221 ft.



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 18 – ONF-HOPKINS PRAIRIE
MARION COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-18	5.19-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE18

CLIENT: SJRWMD
LOCATION: ONF-HOPKINS PRARIE
COUNTY: MARION COUNTY
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 350.000 m by 244.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 09-MAY-95
SOUNDING: 1
ELEVATION: 10.70 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 5.080 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			10.70	
1	94.44	112.8	-102.1	1.19
2	13.61			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	85.079	94.448	106.674
	2	12.608	13.619	14.671
THICK	1	105.331	1.000	119.700
DEPTH	1	105.331	112.849	119.700

CURRENT: 16.00 AMPS EM-57
FREQUENCY: 30.00 Hz GAIN: 5
COIL AREA: 100.00 sq m.
RAMP TIME: 160.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	42725.5	47636.7	-11.49
2	0.108	34860.2	35033.6	-0.497
3	0.138	26643.8	24944.8	6.37
4	0.175	20109.3	18160.4	9.69
5	0.218	14750.0	13674.7	7.29
6	0.278	10412.3	10043.5	3.54
7	0.351	7335.4	7470.8	-1.84
8	0.438	5334.9	5591.4	-4.80
9	0.558	3827.2	4024.0	-5.14
10	0.702	2751.3	2904.2	-5.55
11	0.858	2095.3	2148.6	-2.54
12	1.06	1543.6	1530.5	0.846
13	1.37	1051.8	1010.9	3.89
14	1.74	704.5	666.7	5.36
15	2.17	470.8	444.9	5.51

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WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 18 – ONF-HOPKINS PRAIRIE
MARION COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.19-1

CURRENT: 16.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 7 RAMP TIME: 160.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
16	0.346	7500.0	7642.2	-1.89
17	0.427	5437.1	5816.3	-6.97
18	0.550	3853.0	4136.3	-7.35
19	0.698	2828.2	2958.7	-4.61
20	0.869	2080.7	2136.0	-2.65
21	1.10	1495.6	1465.9	1.98
22	1.40	1050.5	996.2	5.17
23	1.75	728.5	683.6	6.15
24	2.22	472.9	447.5	5.36
25	2.79	296.3	293.2	1.03
26	3.42	194.9	198.6	-1.89
27	4.26	123.8	128.7	-3.99
28	5.49	73.00	76.83	-5.24
29	6.96	44.85	46.65	-3.99
30	8.66	28.55	29.09	-1.87
31	11.06	17.50	16.88	3.55
32	14.00	10.46	9.83	6.02

CURRENT: 16.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 3.00 Hz GAIN: 8 RAMP TIME: 160.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
33	0.857	2066.1	2182.8	-5.65
34	1.06	1560.6	1559.5	0.0710
35	1.37	1081.7	1038.0	4.04
36	1.74	740.2	691.7	6.54
37	2.17	491.3	467.7	4.78
38	2.77	308.4	298.5	3.21
39	3.50	190.6	191.0	-0.219
40	4.37	120.3	123.4	-2.58
41	5.56	73.10	75.84	-3.75
42	6.98	44.79	47.28	-5.55
43	8.56	29.01	30.67	-5.72

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.98		
P 2	0.00	0.99	
T 1	0.01	0.01	0.99
	P 1	P 2	T 1

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 18 – ONF–HOPKINS PRAIRIE
MARION COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.19–1

5.20 TDEM Site 19 - Volusia County Landfill

5.20.1 Location Description and Geoelectrical Section

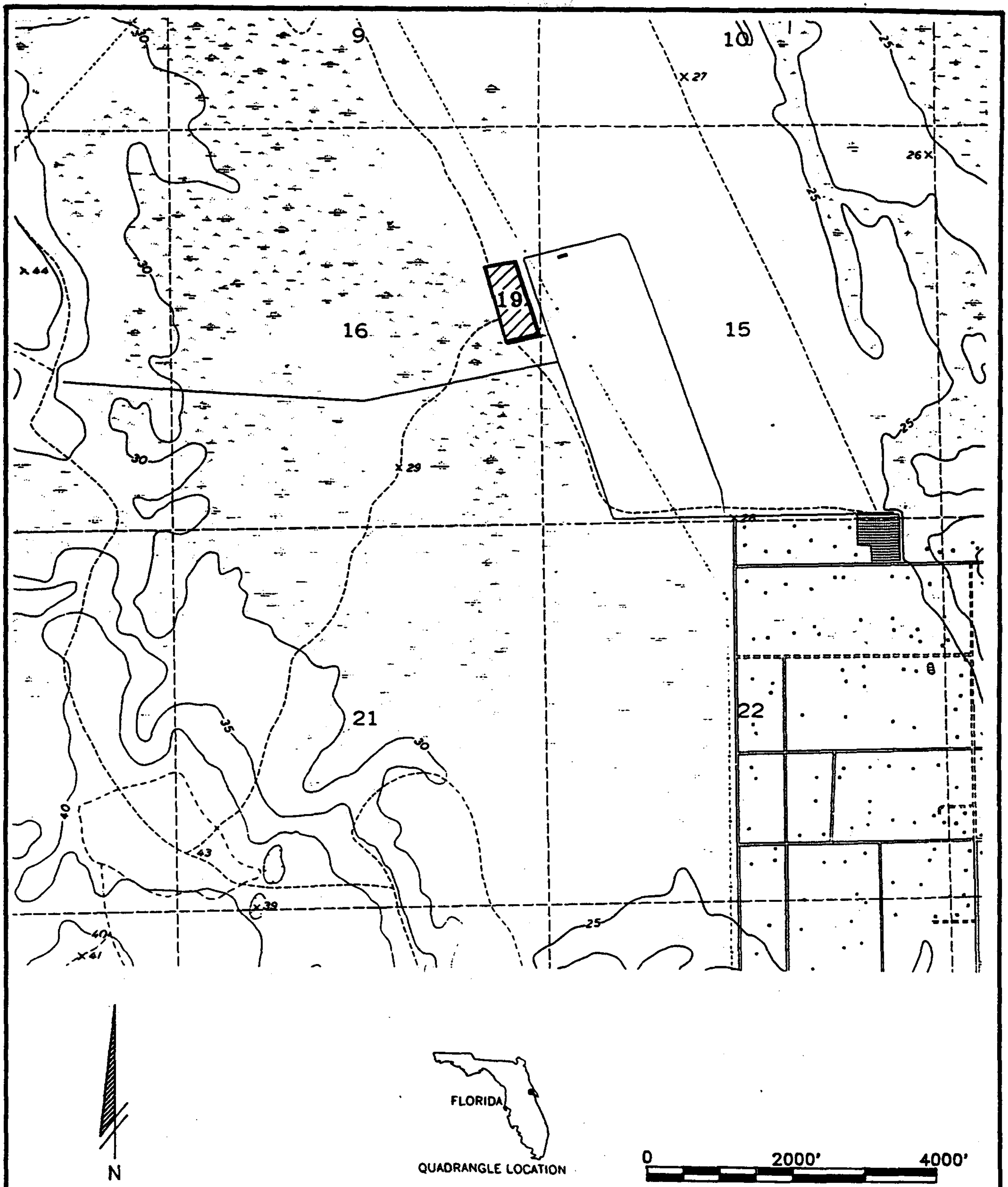
The site is located in east-central Volusia County near Daytona Beach, Florida (Figure 5.20-1). The site is located within a wooded area. A possible interference source (powerlines) existed 300 ft east of the Tx loop. QA soundings were performed 120 ft north and 50 ft east of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 60 ft bmsl or 85 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occur at approximately 2,200 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 300 ft and the depth to the top of the Lower Floridan aquifer is approximately 775 ft bls (Miller, 1986). Chloride concentration in the upper portion of the Floridan aquifer ranges from 0 to 50 mg/l in this area and the maximum thickness of the freshwater-saturated Floridan aquifer is 800 ft (Rutledge, 1985).

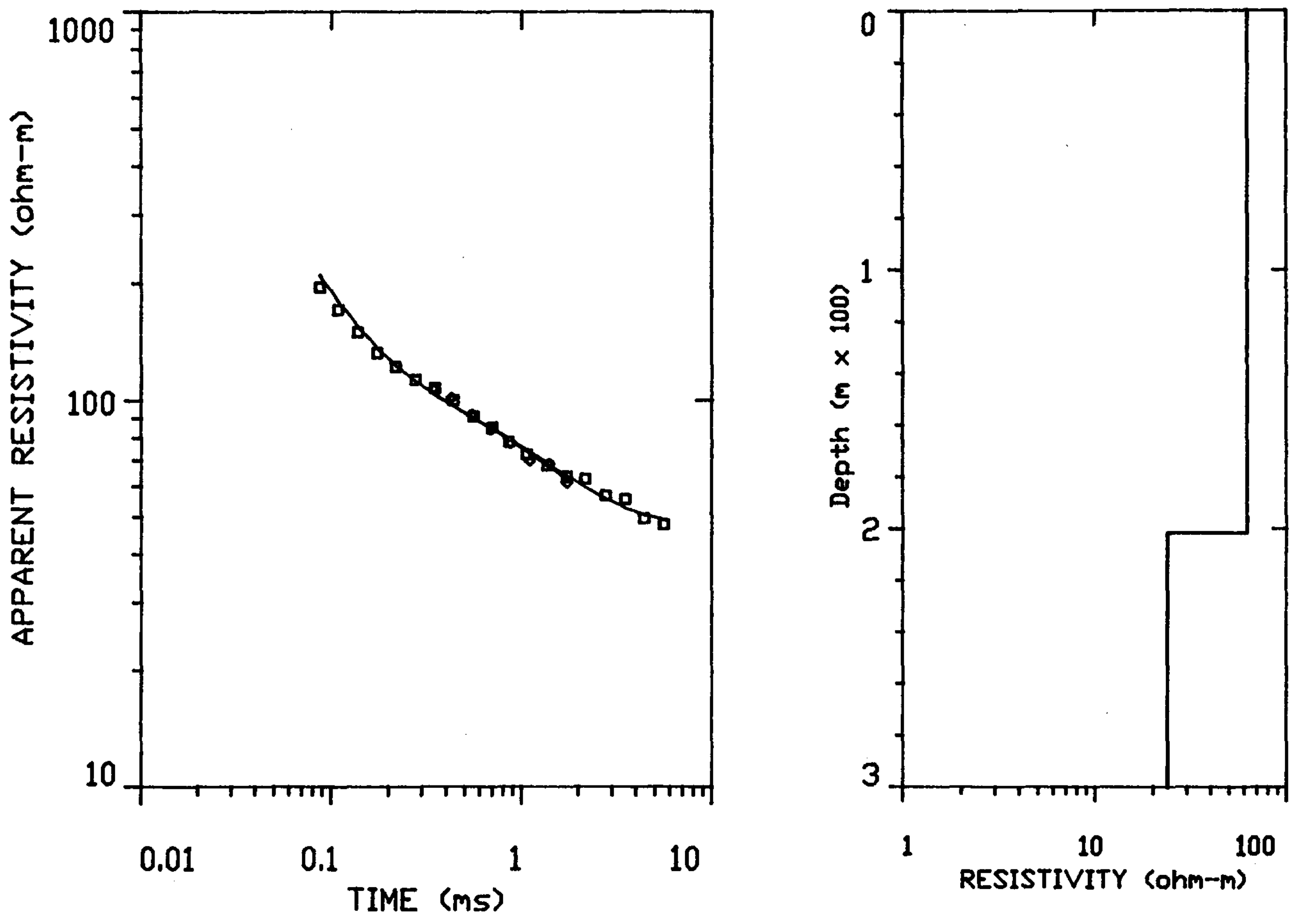
The resistivity sounding data and best-fit model inversion are presented on Figure 5.20-2. The interpreted geoelectrical section consists of a two-layer subsurface.

5.20.2 Geological Interpretation of Geoelectrical Model

There is insufficient electrical resistivity contrast between the Holocene to Miocene deposits and the underlying Floridan aquifer to distinguish the two. Fixing the thickness of the upper layer does not resolve this dilemma; therefore, it can be interpreted that there exists a two-layer geoelectrical section with a relatively thick (202 m = 663 ft) surface layer of intermediate resistivity (62 ohm-m) overlying a layer of lower intermediate resistivity.



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 19 – VOLUSIA COUNTY LANDFILL VOLUSIA COUNTY, FLORIDA		
		DESIGNED BY: JEB CHECKED BY: MJW DRAWN BY: RBT	PROJECT NO.: 95706 DRAWING NO.: LOC-19 DATE: 06/21/95	FIGURE 5.20-1



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 19 - VOLUSIA COUNTY LANDFILL
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-19	5.20-2
DRAWN BY:	SAB	DATE:	07/26/95	

The Holocene to Miocene deposits and part of the Floridan aquifer system exist as a combined but indistinguishable (geoelectrical) layer, overlying a layer with reduced porosity at a depth of 663 ft bls.

Based on the relatively-high resistivity of Layer 2 (24 ohm-m), it is suspected that the Layer 1/Layer 2 contact represents a porosity change in the middle confining unit of the Floridan aquifer and not the saltwater interface. The implication is that, for this site, the depth to the saltwater interface is beyond the depth capacity of the measurement system as defined by the loop size and current amperage.

5.20.3 Depth to Occurrence of Salt Water

The saltwater interface was not apparent in this data set.

5.20.4 Depth of Occurrence of the 250 mg/l Isochlor

Because of the inability to segregate the Floridan aquifer from the overlying Holocene to Miocene deposits, the effective chloride concentration of Layer 1 cannot be calculated. For comparison, Rutledge (1985) estimated a depth of 885 ft for the 250 mg/l isochlor.

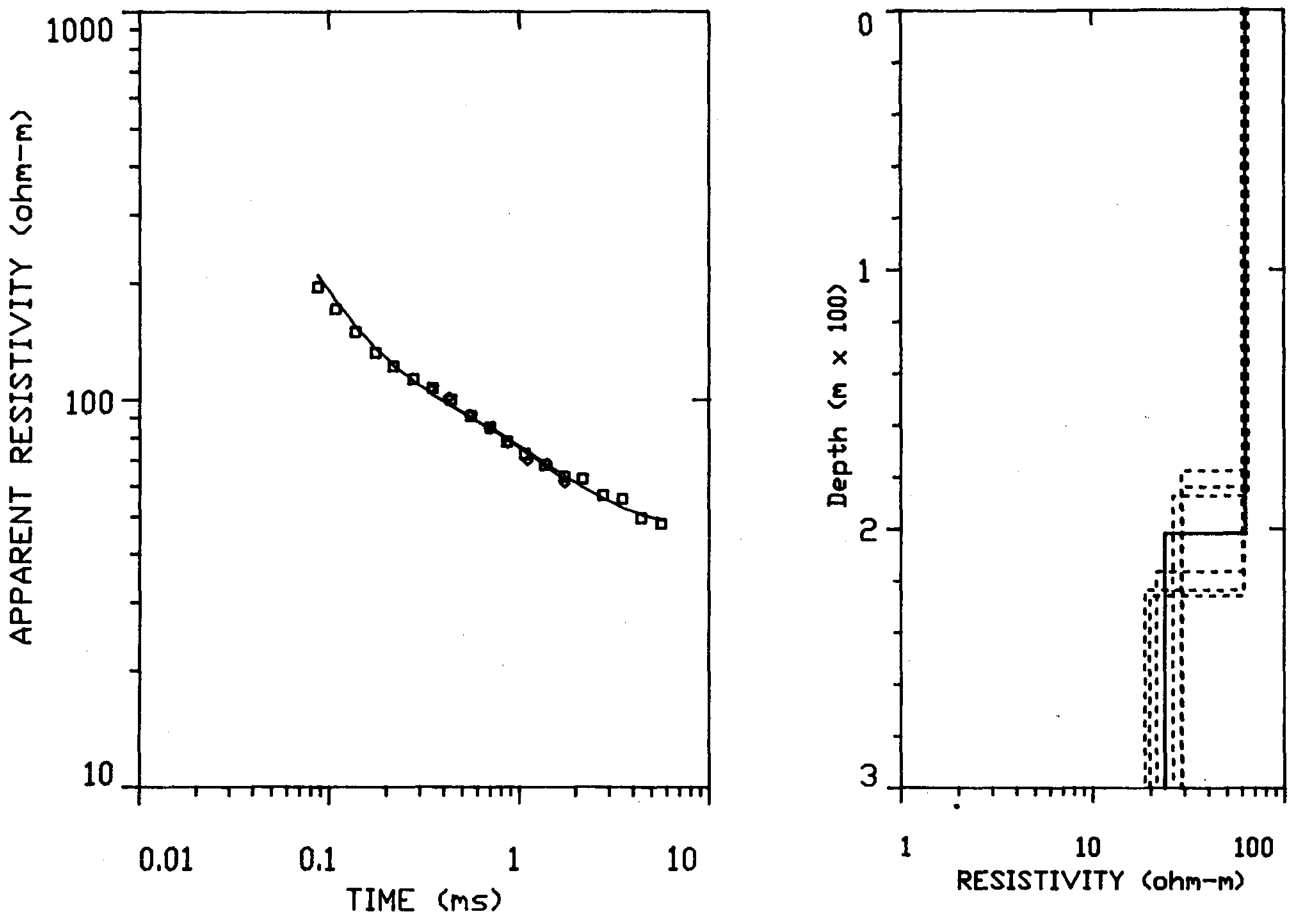
5.20.5 Accuracy of Measurement and Interpretation

Figure 5.20-3 is the equivalence analysis at this site and the inversion table (Table 5.20-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model. The depth to the low resistivity layer could not be determined.

The equivalence range of the resistivity of Layer 1 is from 60 to 64 ohm-m. A corresponding chloride concentration cannot be determined because Layer 1 is in part comprised of Holocene to Miocene deposits. Accordingly, equation (4) may not be valid.

5.20.6 Summary of TDEM Sounding at Volusia County Landfill (Site 19)

- The depth to saltwater (5,000 mg/l isochlor) was not detected at this site.
- The quality of ground water within the Floridan aquifer at this site cannot be interpreted because the analysis of the TDEM data does not allow the Holocene to Miocene deposits to be distinguished from the Floridan Aquifer System.



5-154

—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER
MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE
DETECTION
INVESTIGATIONS
INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND
EQUIVALENCE FOR 1-D INVERSION
SITE 19 - VOLUSIA COUNTY LANDFILL
VOLUSIA COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-19	5.20-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE19

CLIENT:	SJRWMD	DATE:	10-MAY-95
LOCATION:	VOLUSIA COUNTY LANDFILL	SOUNDING:	1
COUNTY:	VOLUSIA COUNTY	ELEVATION:	7.60 m
PROJECT:	SALTWATER INTERFACE DETECTION	EQUIPMENT:	Geonics PROTEM
LOOP SIZE:	152.000 m by 350.000 m	AZIMUTH:	
COIL LOC:	0.000 m (X), 0.000 m (Y)		

SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 4.823 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			7.60	
1	62.34	201.7	-194.1	3.23
2	23.68			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	60.352	62.347	64.495
	2	18.714	23.685	29.297
THICK	1	177.583	1.000	225.953
DEPTH	1	177.583	201.708	225.953

CURRENT:	17.90 AMPS	EM-57	COIL AREA:	100.00 sq m.
FREQUENCY:	30.00 Hz	GAIN: 4	RAMP TIME:	150.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	85810.9	77132.0	10.11
2	0.108	60566.2	56133.2	7.31
3	0.138	40067.1	38235.2	4.57
4	0.175	26683.0	25595.9	4.07
5	0.218	17361.6	17216.8	0.833
6	0.278	10608.2	10821.4	-2.01
7	0.351	6395.0	6790.9	-6.19

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 19 – VOLUSIA COUNTY LANDFILL
VOLUSIA COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.20–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
8	0.438	4078.8	4310.0	-5.66
9	0.558	2573.2	2609.4	-1.40
10	0.702	1607.4	1622.6	-0.944
11	0.858	1107.3	1074.5	2.95
12	1.06	717.4	692.0	3.53
13	1.37	423.0	417.0	1.40
14	1.74	257.2	256.8	0.137
15	2.17	151.5	163.6	-8.00
16	2.77	95.30	98.01	-2.83
17	3.50	54.85	59.34	-8.18
18	4.37	37.45	36.23	3.27
19	5.56	21.63	20.80	3.84

CURRENT: 17.90 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 7 RAMP TIME: 150.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
20	0.346	6685.6	7002.2	-4.73
21	0.427	4264.4	4553.0	-6.76
22	0.550	2639.3	2698.6	-2.24
23	0.698	1647.5	1651.4	-0.239
24	0.869	1086.4	1056.2	2.77
25	1.10	691.0	648.9	6.09
26	1.40	393.0	405.5	-3.19
27	1.75	269.0	261.3	2.83

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

	P 1	P 2	T 1
P 1	1.00		
P 2	-0.01	0.90	
T 1	0.00	0.04	0.97

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SOUNDING DATA TABLE SITE 19 – VOLUSIA COUNTY LANDFILL VOLUSIA COUNTY, FLORIDA PROJECT NO.: 95706 TABLE: 5.20-1

5.21 TDEM Site 20 - ONF-Forest Hills

5.21.1 Location Description and Geoelectrical Section

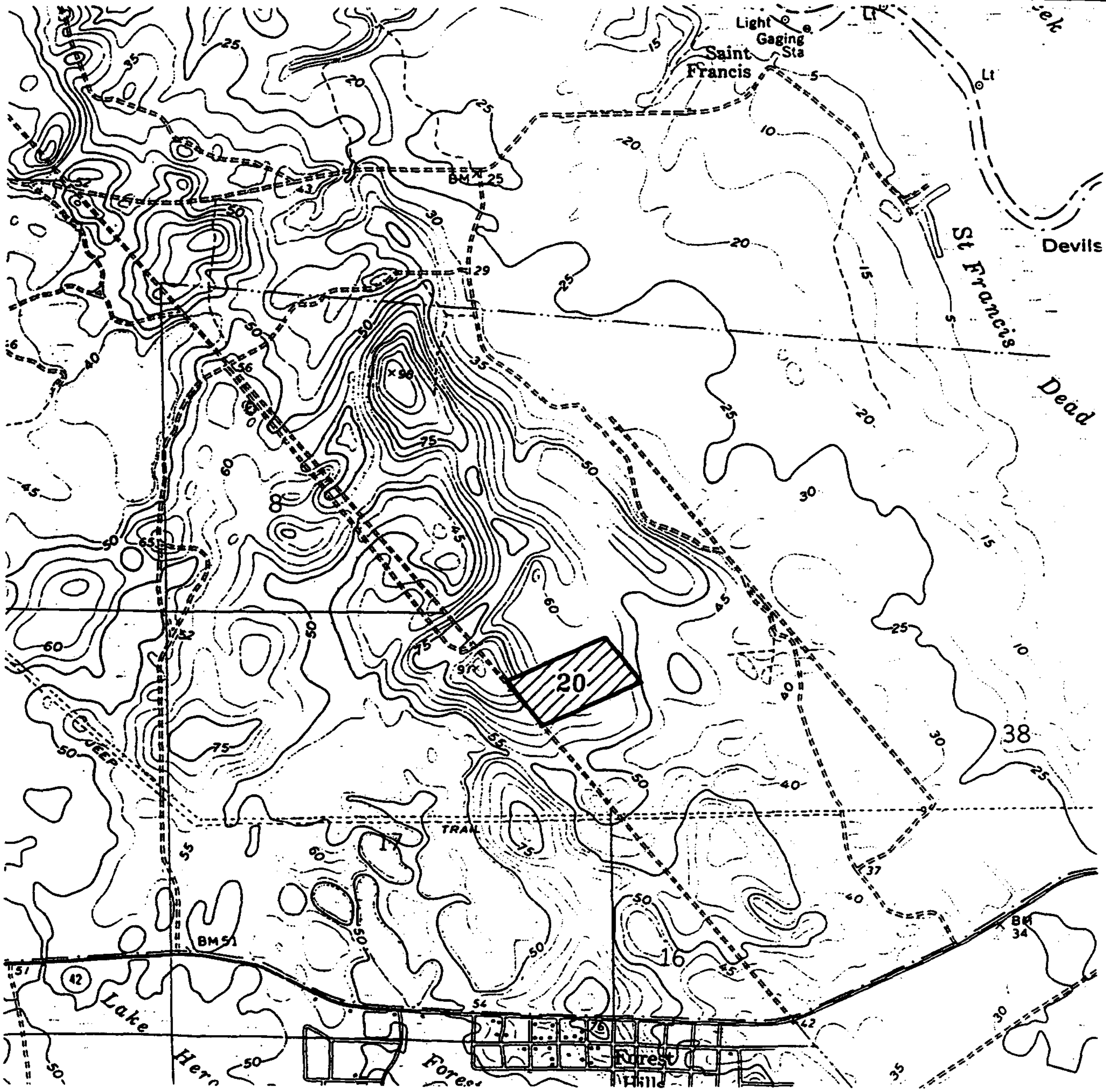
The site is located in eastern Lake County near Forest Hills, Florida (Figure 5.21-1). Timber had been cut at the site which was now brush-covered. No sources of interference were observed within the vicinity of the site. QA soundings were performed 130 ft west and south of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 40 ft bmsl or 105 ft bls and is overlain by Holocene to Miocene deposits (SJRWMD, personal communication). The base of the Floridan aquifer occurs at approximately 2,050 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 350 ft and the depth to the top of the Lower Floridan aquifer is approximately 675 ft bls (Miller, 1986).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.21-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.21.2 Geological Interpretation of Geoelectrical Model

The three-layer geoelectrical section consists of an upper layer with a resistivity of 102 ohm-m which correlates with the Holocene to Miocene deposits above the Floridan aquifer. The thickness of Layer 1 was fixed at 32 m (105 ft, SJRWMD, personal communication). The second layer has high resistivity (202 ohm-m) which means that because it is greater than 80 ohm-m the Floridan aquifer at this site contains fresh water. The thickness of the freshwater section is 376 m (1,234 ft) placing the depth to the low resistivity (saltwater) layer at 408 m (1,339 ft) below ground surface. The resistivity of the saltwater layer is 14.4 ohm-m. Layer 1 is considered to be the Holocene to Miocene deposits above the Floridan aquifer, Layer 2 to be the Floridan aquifer containing fresh water, and Layer 3 to be the salt water within the Lower Floridan aquifer.



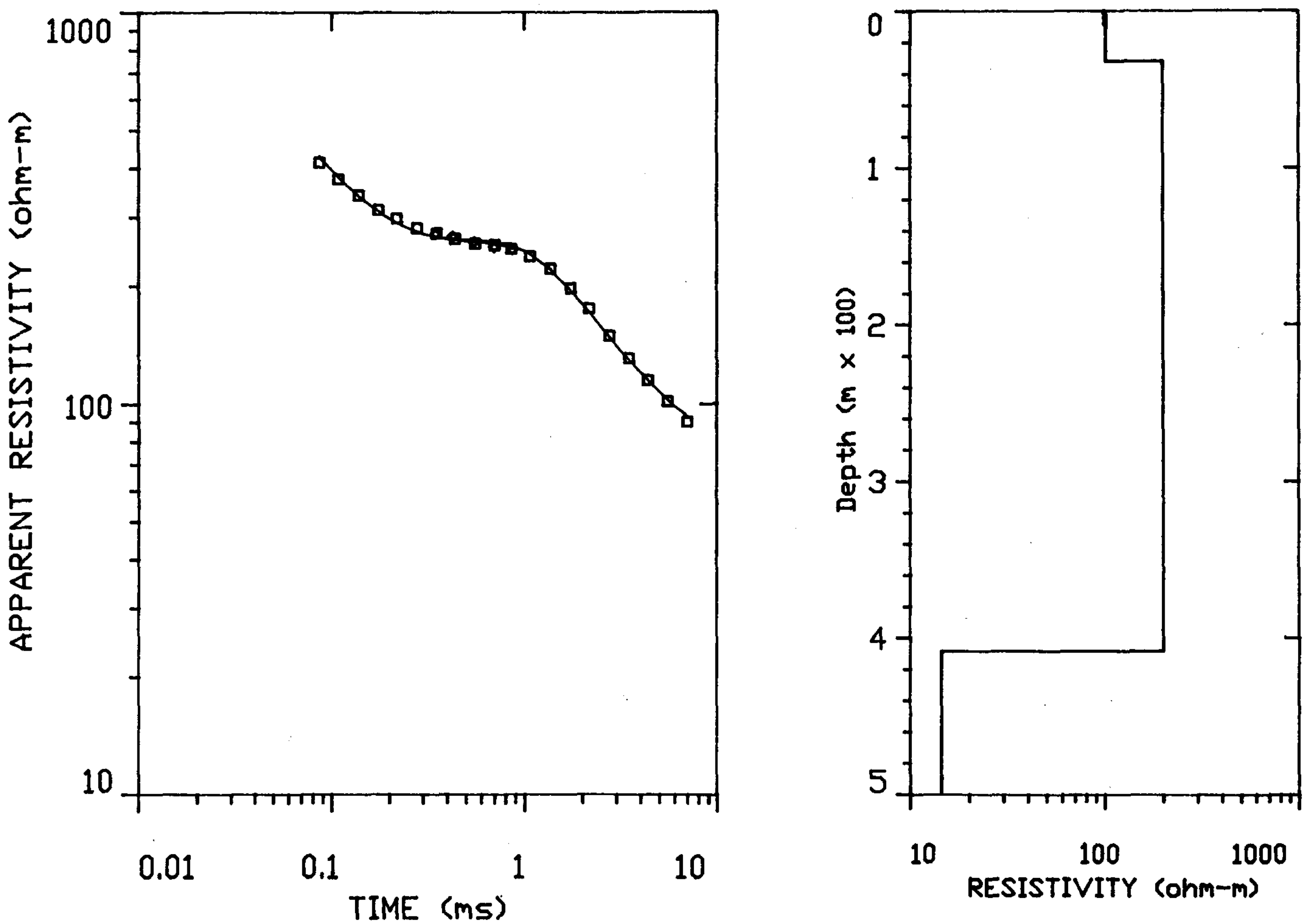
N

QUADRANGLE LOCATION

0 2000' 4000'

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 20 – ONF – FOREST HILLS LAKE COUNTY, FLORIDA

DESIGNED BY: JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY: MJW	DRAWING NO.:	LOC–20	5.21–1
DRAWN BY: RBT	DATE:	06/21/95	



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 20 - ONF-FOREST HILLS
LAKE COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-20	5.21-2
DRAWN BY:	SAB	DATE:	07/26/95	

5.21.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 14.2 ohm-m, is interpreted to represent salt water. It occurs at a depth of 1,339 ft (-1,274 ft msl). Because the resistivity of Layer 2 (202 ohm-m) is greater than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken as 50 ft greater than the depth of the geoelectrical interface, or at a depth of 1,389 ft (-1,324 ft bmsl). The resistivity of Layer 3 (14.4 ohm-m) corresponds to a chloride concentration of 2,081 mg/l, assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

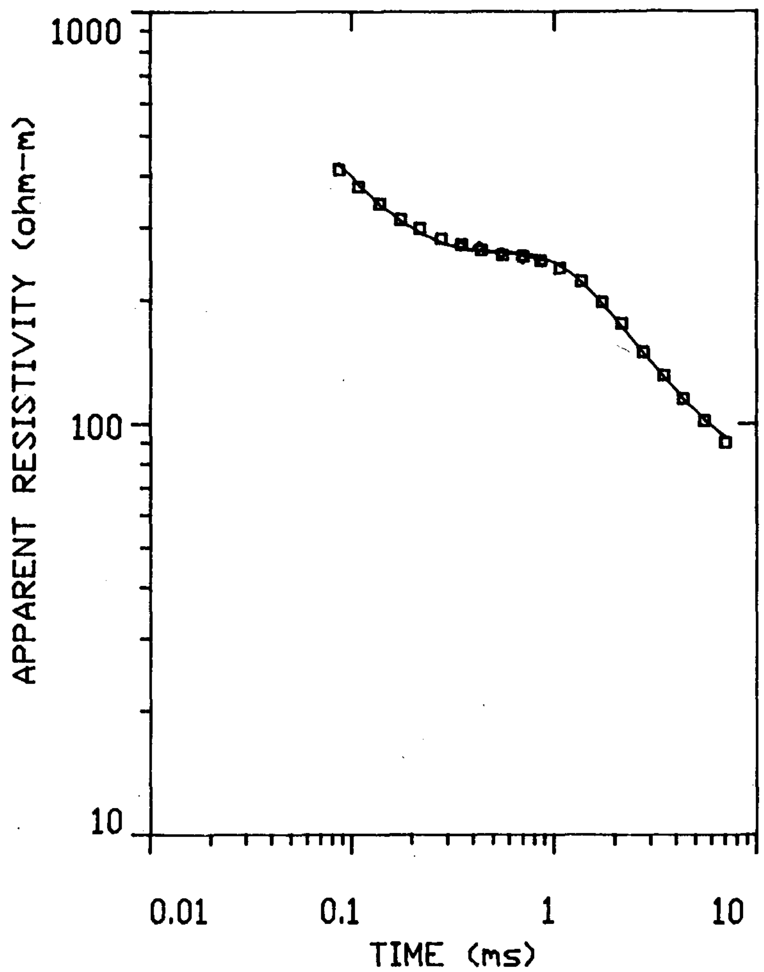
5.21.4 Depth of Occurrence of the 250 mg/l Isochlor

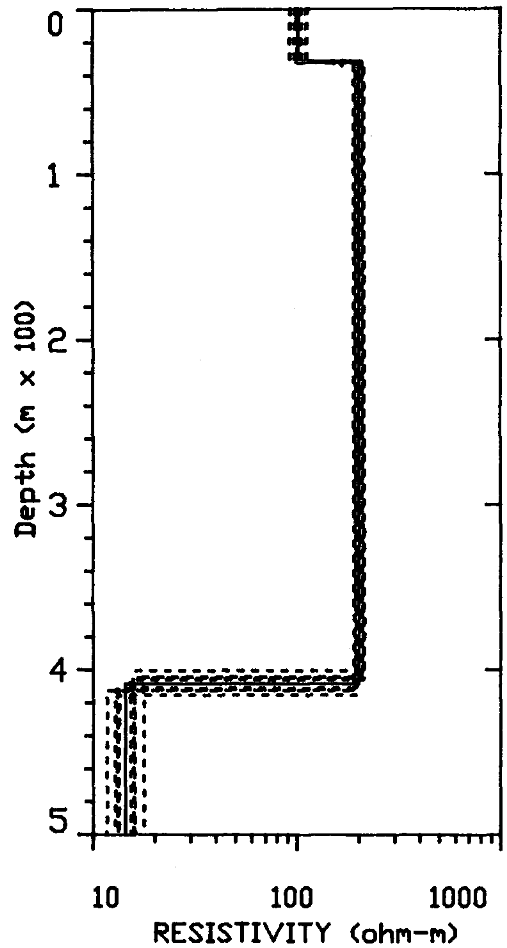
The resistivity of Layer 2, 202 ohm-m, corresponds to a chloride concentration of less than 250 mg/l, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. The 250 mg/l isochlor is placed in the Floridan aquifer at a depth 50 ft above the Layer 3 interface or at 1,289 ft (-1,224 ft msl).

5.21.5 Accuracy of Measurement and Interpretation

Figure 5.21-3 is the equivalence analysis at this site and the inversion table (Table 5.21-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ±7 m (23 ft) which is 2% of the total depth. The resistivity of this layer has a range of from 11.7 to 17.8 ohm-m. This corresponds to a range in interpreted chloride concentration of from 2,596 to 1,654 mg/l, again subject to the same assumptions of porosity and validity of equation (4).





—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 20 – ONF-FOREST HILLS
LAKE COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-20	5.21-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 20

CLIENT: SJRWMD
LOCATION: ONF-FOREST HILLS
COUNTY: LAKE COUNTY
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 396.000 m by 213.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 10-MAY-95
SOUNDING: 1
ELEVATION: 19.80 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 2.654 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)		ELEVATION (meters)	CONDUCTANCE (Siemens)
				19.80	
1	102.1	32.00	*	-12.20	0.313
2	201.5	376.4		-388.6	1.86
3	14.42				

"*" INDICATES FIXED PARAMETER

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	93.234	102.132	112.940
	2	190.211	201.517	213.605
	3	11.739	14.422	17.759
THICK	1	32.000	0.000	32.000
	2	368.562	1.000	383.481
DEPTH	1	32.000	32.000	32.000
	2	400.562	408.493	415.481

CURRENT: 15.90 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz GAIN: 5 RAMP TIME: 160.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	37862.0	35971.8	4.99
2	0.108	25278.9	24757.7	2.06
3	0.138	15771.3	15884.2	-0.715

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 20 – ONF–FOREST HILLS
LAKE COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.21–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.175	9923.6	10053.8	-1.31
5	0.218	6167.4	6420.6	-4.10
6	0.278	3663.4	3790.7	-3.47
7	0.351	2143.7	2219.2	-3.51
8	0.438	1293.9	1302.4	-0.660
9	0.558	736.5	716.2	2.75
10	0.702	419.1	408.0	2.64
11	0.858	263.3	254.6	3.31
12	1.06	163.2	159.2	2.44
13	1.37	97.20	97.83	-0.644
14	1.74	63.59	64.65	-1.65
15	2.17	43.80	45.08	-2.91
16	2.77	30.20	30.57	-1.21
17	3.50	20.55	20.88	-1.60
18	4.37	14.34	14.38	-0.253
19	5.56	9.46	9.37	0.920
20	7.03	6.30	6.03	4.39

CURRENT: 15.90 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 7 RAMP TIME: 160.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
21	0.346	2239.9	2302.0	-2.77
22	0.427	1350.3	1392.8	-3.14
23	0.550	753.8	748.7	0.678
24	0.698	433.7	420.0	3.15
25	0.869	256.8	253.5	1.28

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.94				
P 2	0.03	0.98			
P 3	0.04	-0.04	0.76		
F 1	0.00	0.00	0.00	0.00	
T 2	0.00	0.00	0.01	0.00	1.00
	P 1	P 2	P 3	F 1	T 2

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WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 20 – ONF–FOREST HILLS
LAKE COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.21–1

The equivalence range of the resistivity of Layer 2 is from 190 to 214 ohm-m which corresponds to a chloride concentration of less than 250 mg/l. The chloride-to-sulfate ratio at the site is 2:1 (Table 5.1-4). Accordingly, Equation (4) may not be valid.

5.21.6 Summary of TDEM Sounding at ONF-Forest Hills (Site 20)

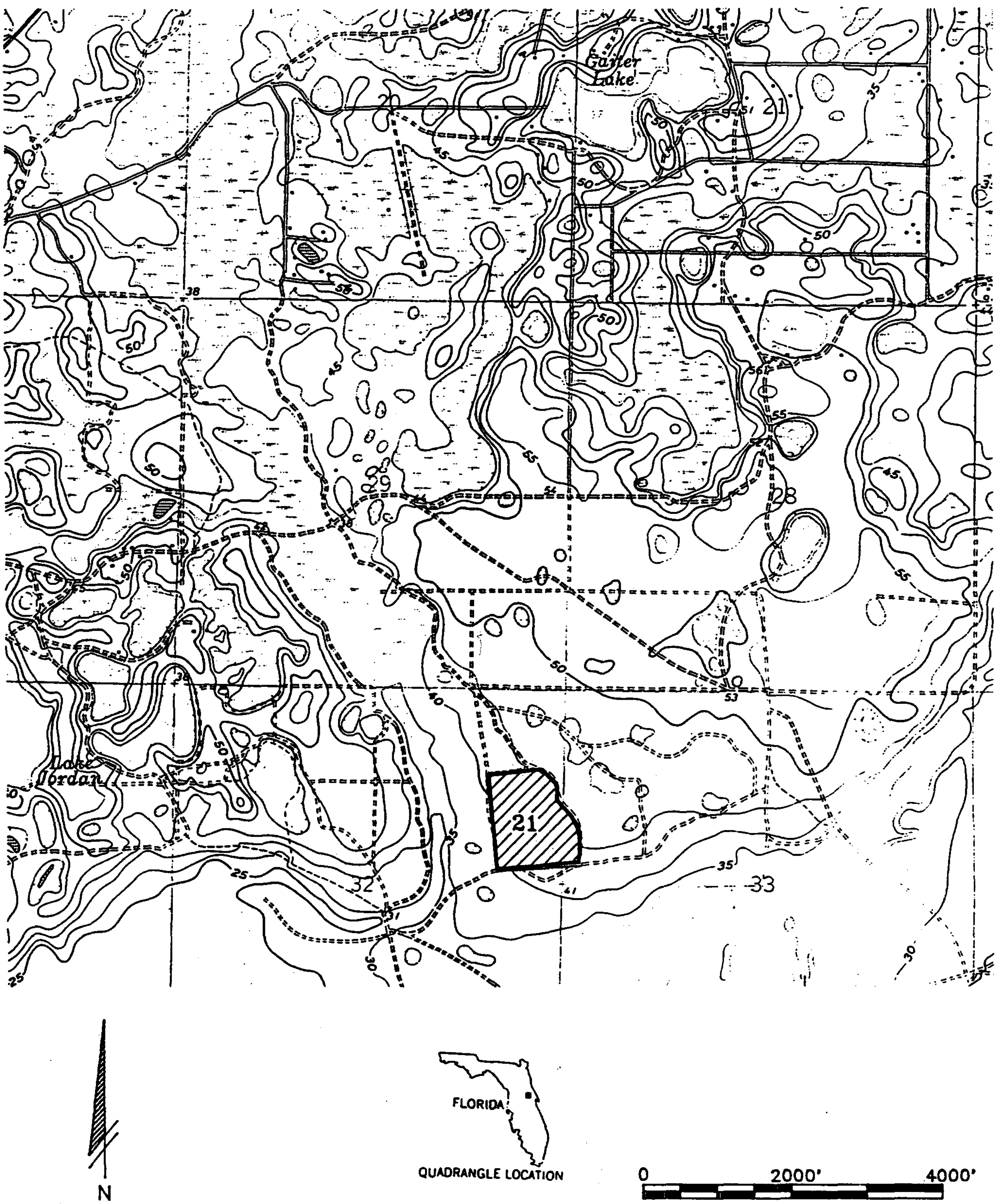
- The depth to occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 1,389 ft (-1,324 ft msl) and occur within the Lower Floridan aquifer.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration of less than 250 mg/l. The 250 mg/l isochlor is interpreted to be present in the Floridan aquifer at a depth of 1,289 ft (-1,224 ft msl).

5.22 TDEM Site 21 - Seminole State Forest

5.22.1 Location Description and Geoelectrical Section

The site is located in east Lake County, Florida (Figure 5.22-1). The site is located within an area of dense vegetation. No visible sources of interference were observed in the area of the site. QA soundings were performed 130 ft to the south and 118 ft west of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 30 ft bmsl or 70 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at approximately 2,100 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 350 ft and the depth to the top of the Lower Floridan aquifer is approximately 690 ft bls (Miller, 1986).



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PALATKA, FLORIDA

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SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SURVEY LOCATION MAP
SOUNDING 21 – SEMINOLE STATE FOREST
LAKE COUNTY, FLORIDA

DESIGNED BY: JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY: MJW	DRAWING NO.:	LOC–21	5.22–1
DRAWN BY: RBT	DATE:	06/21/95	

The resistivity sounding data and best-fit model inversion are presented on Figure 5.22-2. The interpreted geoelectrical section consists of a three-layer subsurface.

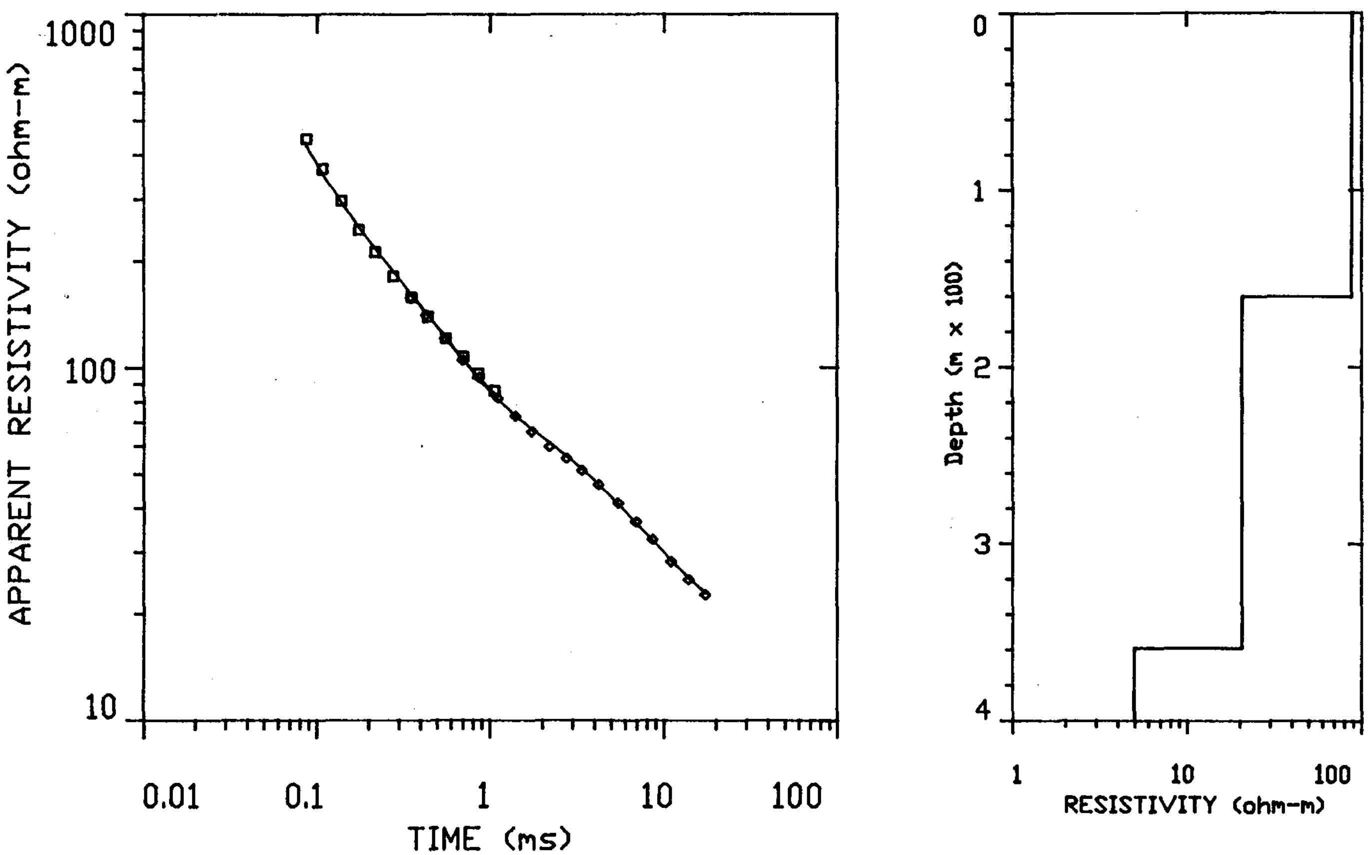
5.22.2 Geological Interpretation of Geoelectrical Model

There is a sufficient electrical resistivity contrast to distinguish two geological layers above a third saltwater saturated layer. The first layer occurs at a depth of 160 m (525 ft) and not at the hydrostratigraphic contact (70 ft bls) between the Holocene to Miocene deposits and the Floridan Aquifer System. The first layer has a high resistivity (88 ohm-m) and is considered to represent the Holocene to Miocene deposits combined with the upper portion of the Floridan aquifer. The second layer has an intermediate resistivity (21 ohm-m) which, because it is less than 80 ohm-m, suggests the Floridan aquifer at this site contains brackish water. The third layer occurs at a depth of 359 m (1,178 ft) with a resistivity of 5.0 ohm-m and is considered to represent a saltwater saturated Lower Floridan aquifer.

5.22.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 5.0 ohm-m, is interpreted to represent salt water. It occurs at a depth of 1,178 ft bls (-1,138 ft msl). Because the resistivity of Layer 2 (21 ohm-m) is interpreted to represent brackish water within the Floridan aquifer (i.e., is less than 80 ohm-m), the interpretated depth to the 5,000 mg/l isochlor is equal to the geoelectric interface, or at 1,178 ft depth (-1,135 ft msl).

The resistivity of Layer 3 (5.0 ohm-m) corresponds to a chloride concentration of 6,280 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, the concentration of Layer 3 is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.



— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 21 - SEMINOLE STATE FOREST
LAKE COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-21	5.22-2
DRAWN BY:	SAB	DATE:	07/26/95	

5.22.4 Depth of Occurrence of the 250 mg/l Isochlor

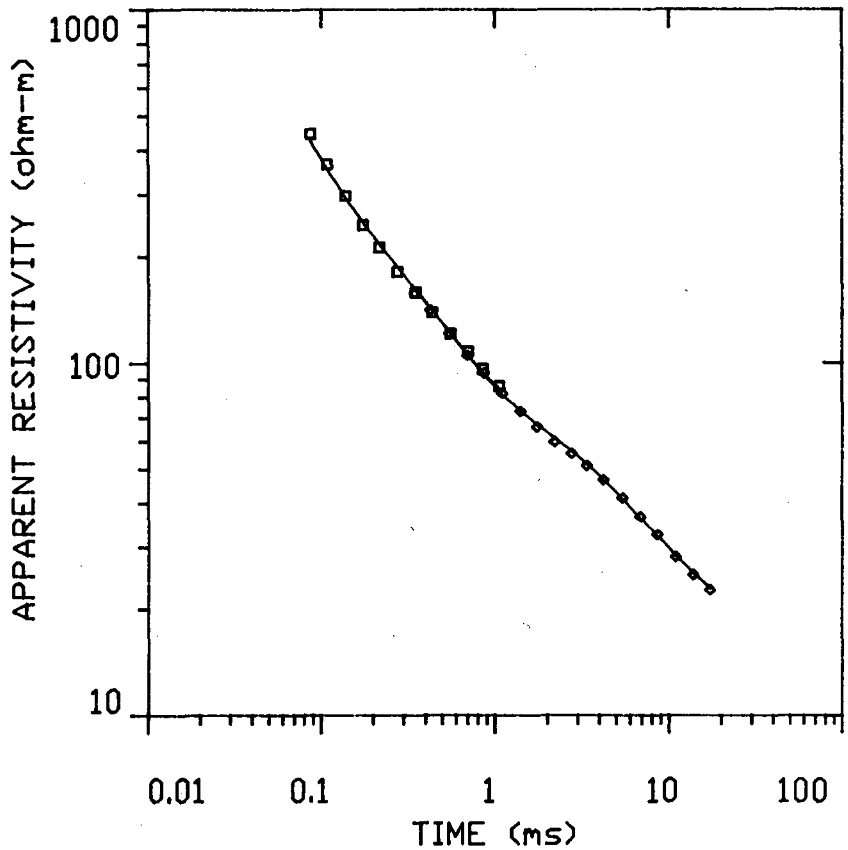
The resistivity of Layer 1 (88 ohm-m,) corresponds to a chloride concentration of less than 250 mg/l, even though Layer 1 is in part comprised of Holocene to Miocene deposits. The 250 mg/l isochlor is placed in the Floridan aquifer at a depth 50 ft above the Layer 2 interface or at 525 ft (-485 ft msl).

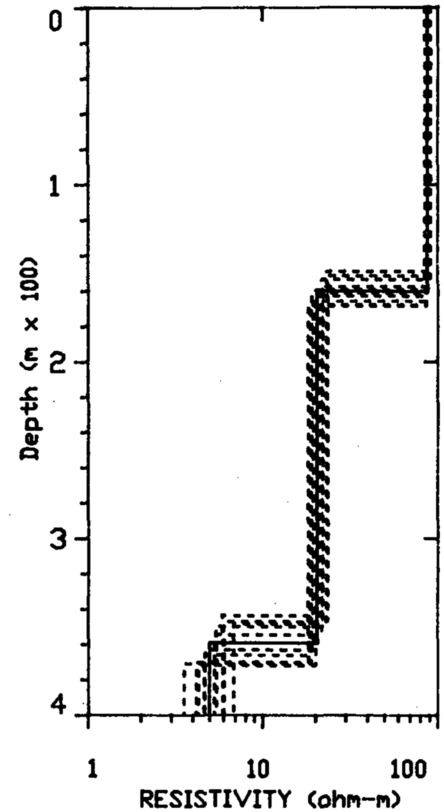
5.22.5 Accuracy of Measurement and Interpretation

Figure 5.22-3 is the equivalence analysis at this site and the inversion table (Table 5.22-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ±14 m (46 ft) which is 4% of the total depth. The resistivity of this layer has a range of from 3.5 to 6.8 ohm-m. This corresponds to a range in interpreted chloride concentration from 9,037 to 4,577 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity for Layer 1 is from 85 to 91 ohm-m. Since the resistivity is greater than 80 ohm-m, the chloride concentration in the upper part of the Floridan aquifer is less than 250 mg/l even though Layer 1 is in part comprised of both the upper portion of the Floridan aquifer and Holocene to Miocene deposits.





—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 21 – SEMINOLE STATE FOREST
LAKE COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-21	5.22-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 21

CLIENT: SJRWMD — DATE: 11-MAY-95
LOCATION: SEMINOLE STATE FOREST — SOUNDING: 1
COUNTY: LAKE COUNTY — ELEVATION: 12.20 m
PROJECT: SALTWATER INTERFACE DETECTION — EQUIPMENT: Geonics PROTEM
LOOP SIZE: 369.000 m by 402.000 m — AZIMUTH:
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

FITTING ERROR: 2.782 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			12.20	
1	87.99	160.2	-148.0	1.82
2	20.52	198.9	-346.9	9.69
3	4.96			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	85.085	87.991	91.561
	2	18.177	20.526	23.573
	3	3.547	4.966	6.840
THICK	1	149.117	-0.081	168.620
	2	182.398	1.000	212.543
DEPTH	1	149.117	160.204	168.620
	2	343.737	359.152	371.888

CURRENT: 17.50 AMPS — EM-57 — COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz — GAIN: 4 — RAMP TIME: 205.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	62703.9	67085.4	-6.98
2	0.108	48777.5	51418.2	-5.41
3	0.138	35947.0	36829.7	-2.45

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PALATKA, FLORIDA

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SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 21 – SEMINOLE STATE FOREST
LAKE COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.22–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.175	26390.9	25893.8	1.88
5	0.218	18919.1	18404.5	2.71
6	0.278	13062.1	12526.0	4.10
7	0.351	8927.8	8670.6	2.88
8	0.438	6239.6	6140.1	1.59
9	0.558	4203.6	4206.5	-0.0696
10	0.702	2822.8	2923.2	-3.55
11	0.858	2024.5	2104.1	-3.92
12	1.06	1392.3	1443.5	-3.67

CURRENT: 17.50 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 7 RAMP TIME: 205.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
13	0.346	9328.5	8904.7	4.54
14	0.427	6528.9	6424.2	1.60
15	0.550	4355.5	4338.6	0.386
16	0.698	2976.3	2984.7	-0.283
17	0.869	2038.4	2092.9	-2.67
18	1.10	1357.2	1378.6	-1.57
19	1.40	898.0	899.4	-0.154
20	1.75	603.0	590.7	2.04
21	2.22	384.8	372.0	3.30
22	2.79	243.6	239.3	1.78
23	3.42	164.9	162.6	1.40
24	4.26	109.4	109.5	-0.0168
25	5.49	69.52	70.18	-0.955
26	6.96	46.22	47.02	-1.73
27	8.66	31.87	32.46	-1.84
28	11.06	21.48	21.35	0.604
29	14.00	14.21	14.03	1.26
30	17.47	9.48	9.33	1.61

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

	P 1	P 2	P 3	T 1	T 2
P 1	1.00				
P 2	-0.01	0.94			
P 3	-0.01	-0.08	0.65		
T 1	0.01	0.02	0.02	0.99	
T 2	0.00	0.01	0.05	0.00	0.98

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WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 21 – SEMINOLE STATE FOREST
LAKE COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.22-1

5.22.6 Summary of TDEM Sounding at Seminole State Forest (Site 21)

- The depth to occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 1,178 ft (-1,138 ft msl) and occur within the Lower Floridan aquifer.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration of less than 250 mg/l. The 250 mg/l isochlor is interpreted to be present in the Floridan aquifer at a depth of 525 ft (-485 ft msl).

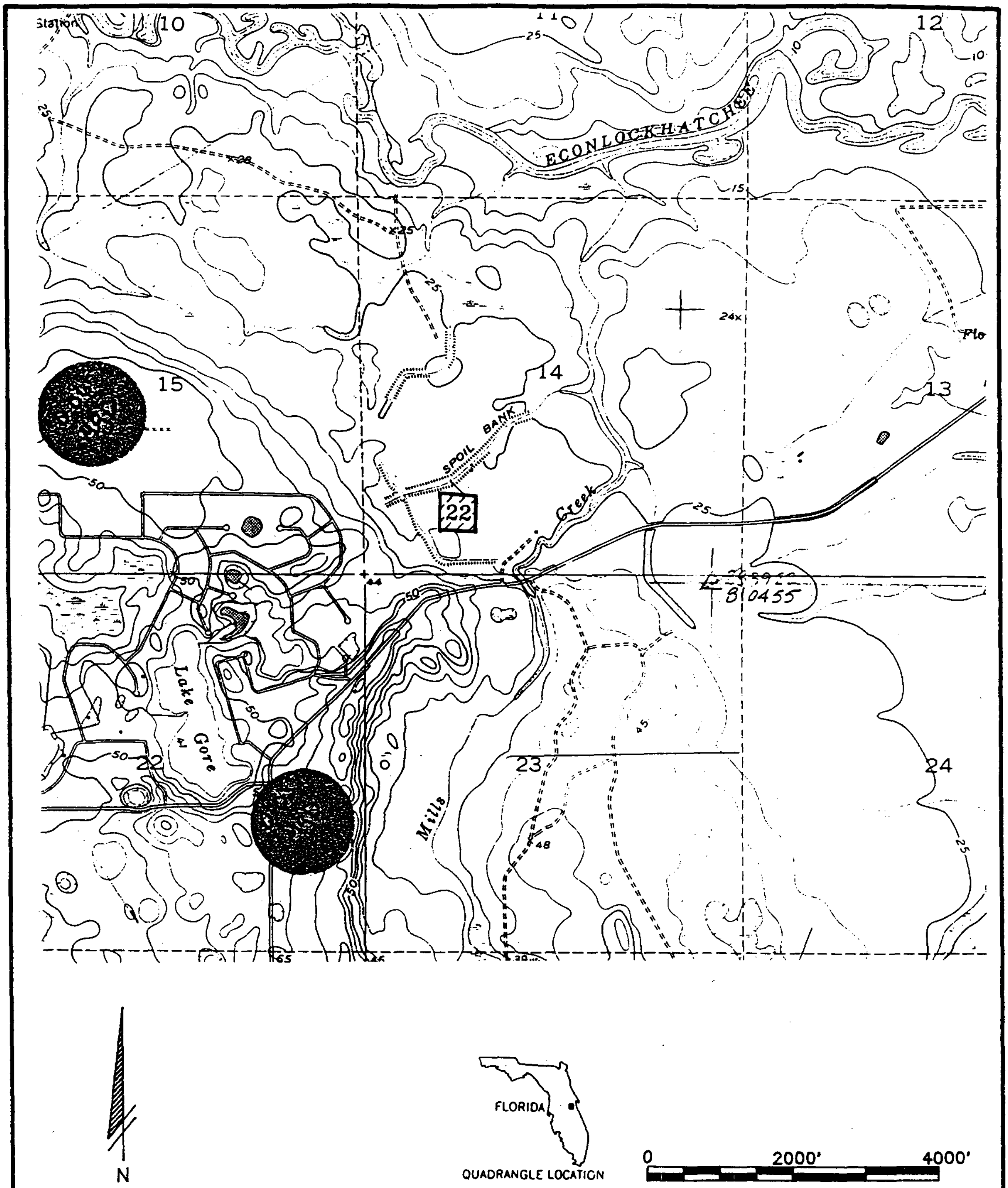
5.23 TDEM Site 22 - Big Oak Ranch

5.23.1 Location Description and Geoelectrical Section

The site is located in southeastern Seminole County, Florida (Figure 5.23-1). The site is a pasture. A possible interference source (powerlines) existed 400 ft north of the Tx loop. QA soundings were performed 50 ft east and north of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 55 ft bmsl or 80 ft bls and is overlain by Holocene to Miocene deposits (SJRWMD, personal communication). The base of the Floridan aquifer occurs at approximately 2,400 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 290 ft and the depth to the top of the Lower Floridan aquifer is approximately 975 ft bls (Miller, 1986). Chloride concentration in the Upper Floridan aquifer is above 250 mg/l in this area (Tibbals, 1990, and CEES, 1992/SJ93-SP2).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.23-2. The interpreted geoelectrical section consists of a three-layer subsurface.



ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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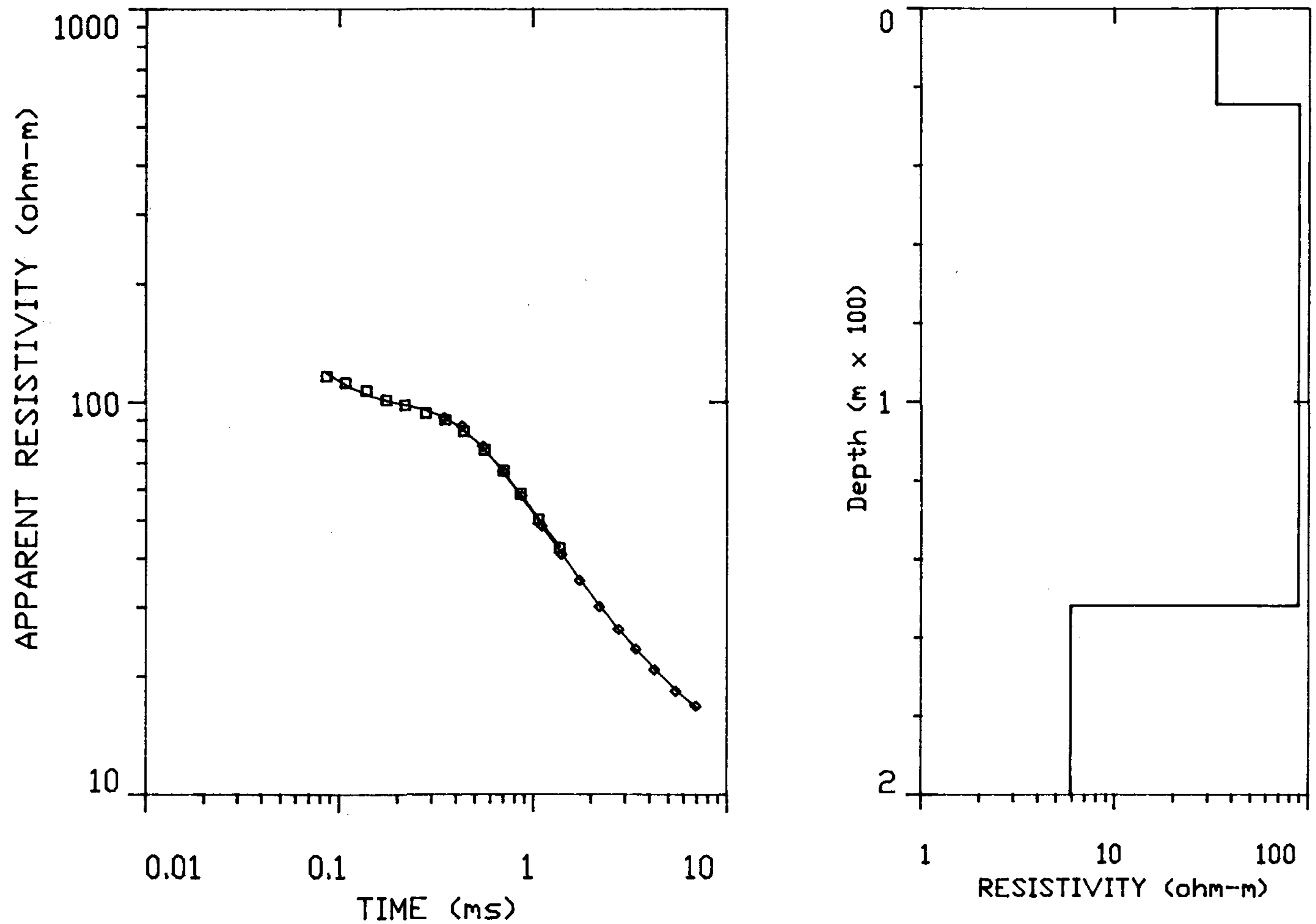
SUBSURFACE
DETECTION
INVESTIGATIONS
INCORPORATED

TDEM SURVEY LOCATION MAP
SOUNDING 22 – BIG OAK RANCH
SEMINOLE COUNTY, FLORIDA

DESIGNED BY: JEB	PROJECT NO.: 95706	FIGURE
CHECKED BY: MJW	DRAWING NO.: LOC–22	5.23–1
DRAWN BY: RBT	DATE: 06/21/95	



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 22 – BIG OAK RANCH
SEMINOLE COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-22	5.23-2
DRAWN BY:	SAB	DATE:	07/26/95	

5.23.2 Geological Interpretation of Geoelectrical Model

The three-layer geoelectrical section consists of a low resistivity (33 ohm-m) upper layer which correlates with the Holocene to Miocene deposits above the Floridan aquifer. The thickness of Layer 1 was fixed at 24.4 m (80 ft, SJRWMD, personal communication). The second layer has high resistivity (89 ohm-m) which means that because it is greater than 80 ohm-m the Floridan aquifer at this site contains fresh water. The thickness of the freshwater section is 128 m (420 ft) placing the depth to the low resistivity (saltwater) layer at 152 m (499 ft) below ground surface. The resistivity of the saltwater layer is 5.9 ohm-m. Layer 1 is considered to be the Holocene to Miocene deposits above the Floridan aquifer, Layer 2 to be the Floridan aquifer containing fresh water, and Layer 3 to be salt water below the Upper Floridan aquifer.

5.23.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 5.9 ohm-m, is interpreted to represent salt water. It occurs at a depth of 499 ft (-474 ft msl). Because the resistivity of Layer 2 (89 ohm-m) is greater than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken as 50 ft greater than the depth of the geoelectrical interface, or at a depth of 549 ft (-524 ft bmsl). According to CEES (1992/SJ93-SP1), depth to the 5,000 mg/l isochlor is approximately 300 ft bls. The resistivity of Layer 3 (5.9 ohm-m) corresponds to a chloride concentration of 5,298 mg/l, assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

5.23.4 Depth of Occurrence of the 250 mg/l Isochlor

The resistivity of Layer 2, 89 ohm-m, corresponds to a chloride concentration of less than 250 mg/l, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. The 250 mg/l isochlor is placed in the Floridan aquifer at a depth 50 ft above the Layer 3 interface or at 449 ft (-424 ft msl). According to CEES (1992/SJ93-SP2) and Tibbals (1990), the Floridan aquifer does not contain potable water in this area.

5.23.5 Accuracy of Measurement and Interpretation

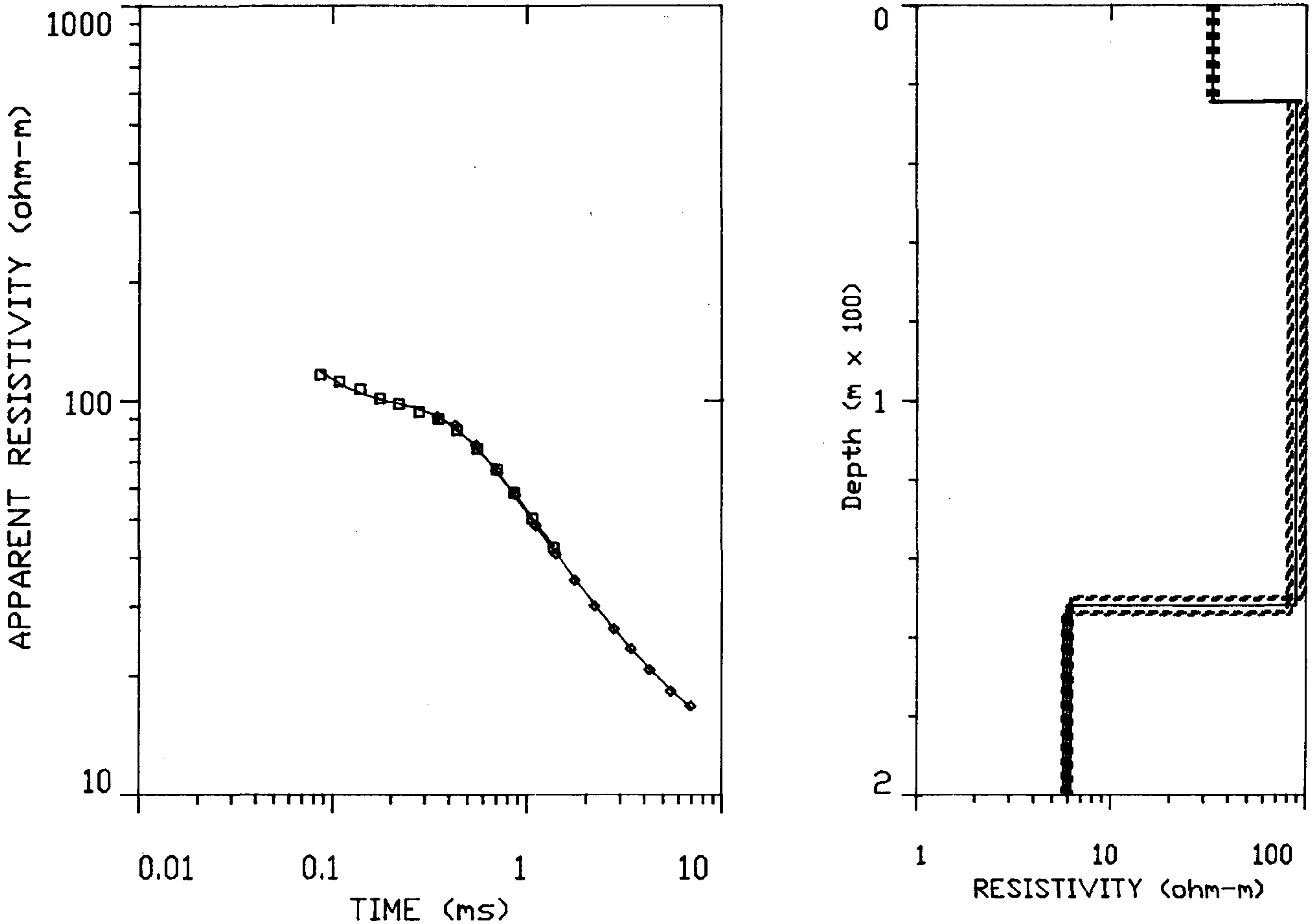
Figure 5.23-3 is the equivalence analysis at this site and the inversion table (Table 5.23-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ±2 m (7 ft) which is 1% of the total depth. The resistivity of this layer has a range of from 5.6 to 6.2 ohm-m. This corresponds to a range in interpreted chloride concentration of from 5,590 to 5,035 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 2 is from 80 to 100 ohm-m which corresponds to a chloride concentration of less than 250 mg/l. The chloride-to-sulfate ratio at the site is 5:1 (Table 5.1-4). Accordingly, Equation (4) is valid. The discrepancy in the water quality results between the TDEM survey and Rutledge (1985) may be due to localized variations in the limestone of the Floridan aquifer. Such variations may include changes in porosity or other factors which would result in a deviation in the empirically derived constants used in Archie's Law as derived by Kwader (1982).

5.23.6 Summary of TDEM Sounding at Big Oak Ranch (Site 22)

- The depth to occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 549 ft (-524 ft msl) and occur below the Upper Floridan aquifer. For comparison, the depth to the 5,000 mg/l isochlor from CEES (1992/SJ93-SP2) was approximately 300 ft bls.



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 22 – BIG OAK RANCH
SEMINOLE COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-22	5.23-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 22

CLIENT: SJRWMD
LOCATION: BIG OAK RANCH
COUNTY: SEMINOLE
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 152.000 m by 152.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 11-MAY-95
SOUNDING: 1
ELEVATION: 7.60 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 1.552 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)		ELEVATION (meters)	CONDUCTANCE (Siemens)
				7.60	
1	33.01	24.40	*	-16.80	0.739
2	89.01	127.5		-144.3	1.43
3	5.90				

"*" INDICATES FIXED PARAMETER

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	31.036	33.010	35.198
	2	79.810	89.018	99.924
	3	5.564	5.901	6.235
THICK	1	24.400	0.000	24.400
	2	125.257	1.000	129.945
DEPTH	1	24.400	24.400	24.400
	2	149.657	151.921	154.345

CURRENT: 23.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz GAIN: 2 RAMP TIME: 130.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	96000.4	92916.8	3.21
2	0.108	58702.0	59836.5	-1.93
3	0.138	34066.6	35278.4	-3.55

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 22 – BIG OAK RANCH
SEMINOLE COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.23–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.175	20434.2	20598.5	-0.803
5	0.218	12344.0	12325.3	0.151
6	0.278	7222.2	7020.2	2.79
7	0.351	4279.0	4186.9	2.15
8	0.438	2719.8	2677.3	1.56
9	0.558	1748.1	1726.8	1.22
10	0.702	1179.8	1187.2	-0.629
11	0.858	876.6	874.6	0.236
12	1.06	636.9	632.1	0.766
13	1.37	438.4	434.4	0.922

CURRENT: 23.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 6 RAMP TIME: 130.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
14	0.346	4345.1	4340.2	0.112
15	0.427	2767.9	2833.8	-2.38
16	0.550	1757.5	1792.2	-1.97
17	0.698	1209.5	1219.0	-0.784
18	0.869	862.3	878.3	-1.85
19	1.10	613.7	616.4	-0.433
20	1.40	437.5	437.2	0.0573
21	1.75	316.3	314.9	0.466
22	2.22	220.2	218.6	0.741
23	2.79	151.7	152.1	-0.277
24	3.42	108.4	108.8	-0.300
25	4.26	75.36	74.87	0.653
26	5.49	48.22	47.72	1.02
27	6.96	30.36	30.81	-1.49

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.94				
P 2	0.10	0.81			
P 3	0.02	-0.05	0.95		
F 1	0.00	0.00	0.00	0.00	
T 2	-0.01	0.02	0.01	0.00	0.99
	P 1	P 2	P 3	F 1	T 2

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE
DETECTION
INVESTIGATIONS
INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 22 – BIG OAK RANCH
SEMINOLE COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.23–1

- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration of less than 250 mg/l. The 250 mg/l isochlor is interpreted to be present in the Floridan aquifer at a depth of 449 ft (-424 ft msl). The results of the TDEM survey are not in agreement with the results from CEES (1992/SJ93-SP2) and Tibbals (1990).

5.24 TDEM Site 23 - Lake Louise

5.24.1 Location Description and Geoelectrical Section

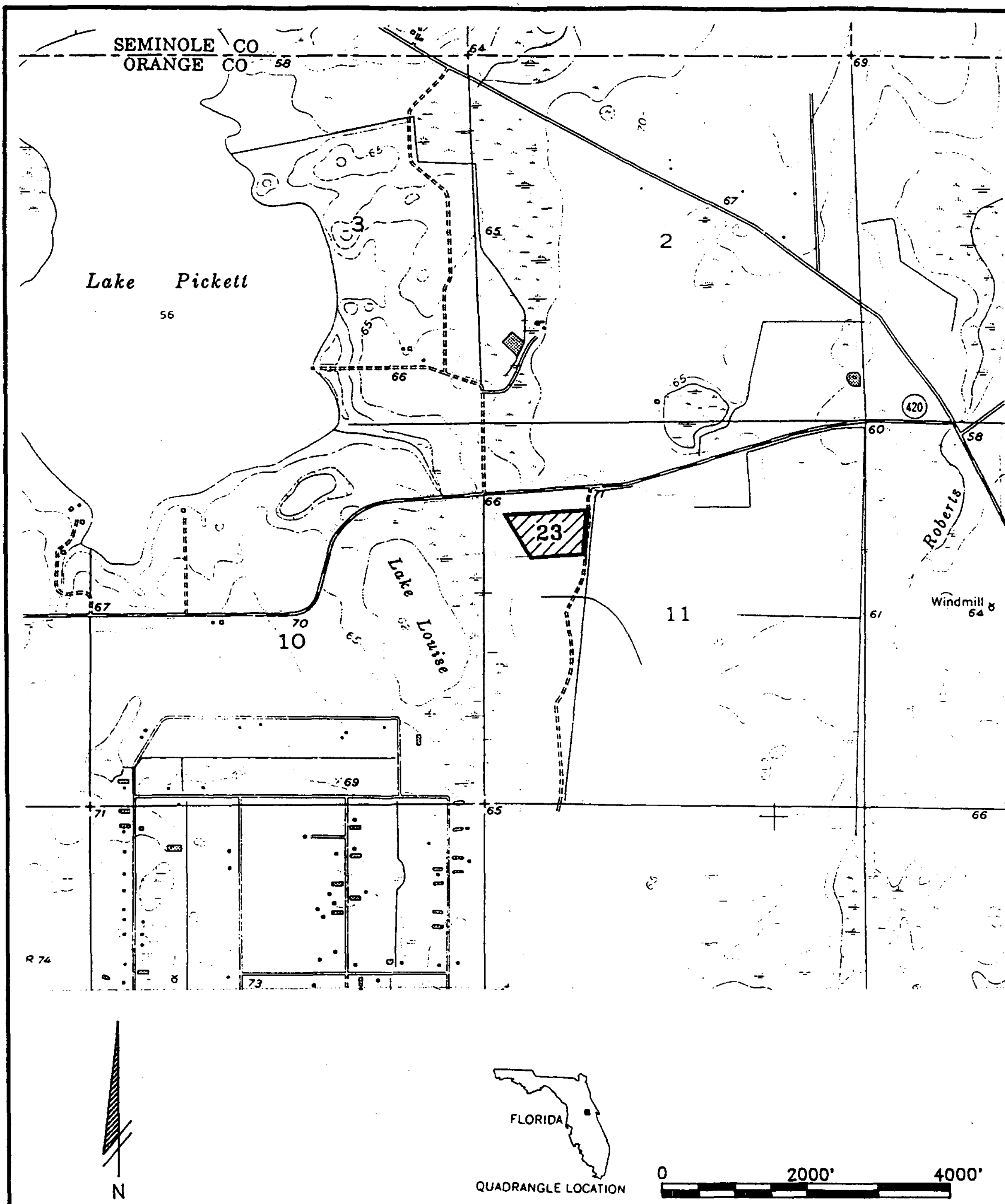
The site is located in north Orange County, Florida (Figure 5.24-1). The site is located within a tree farm. A possible interference source (powerlines) existed 300 ft north of the Tx loop. QA soundings were performed 63 ft east and 100 ft north of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

The Floridan aquifer occurs at an approximate depth of 75 ft bmsl or 140 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at approximately 2,400 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 290 ft and the depth to the top of the Lower Floridan aquifer is approximately 1050 ft bls (Miller, 1986). The average chloride concentration in the Upper Floridan aquifer is below 250 mg/l (SJRWMD, personal communication).

The resistivity sounding data and best-fit model inversion are presented on Figure 5.24-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.24.2 Geological Interpretation of Geoelectrical Model

The three-layered geoelectrical section consists of a low resistivity (41 ohm-m) upper layer which is considered to be the Holocene to Miocene deposits above the Floridan aquifer. The thickness of Layer 1 was fixed at 42.7 m (140 ft, SJRWMD, personal communication).



ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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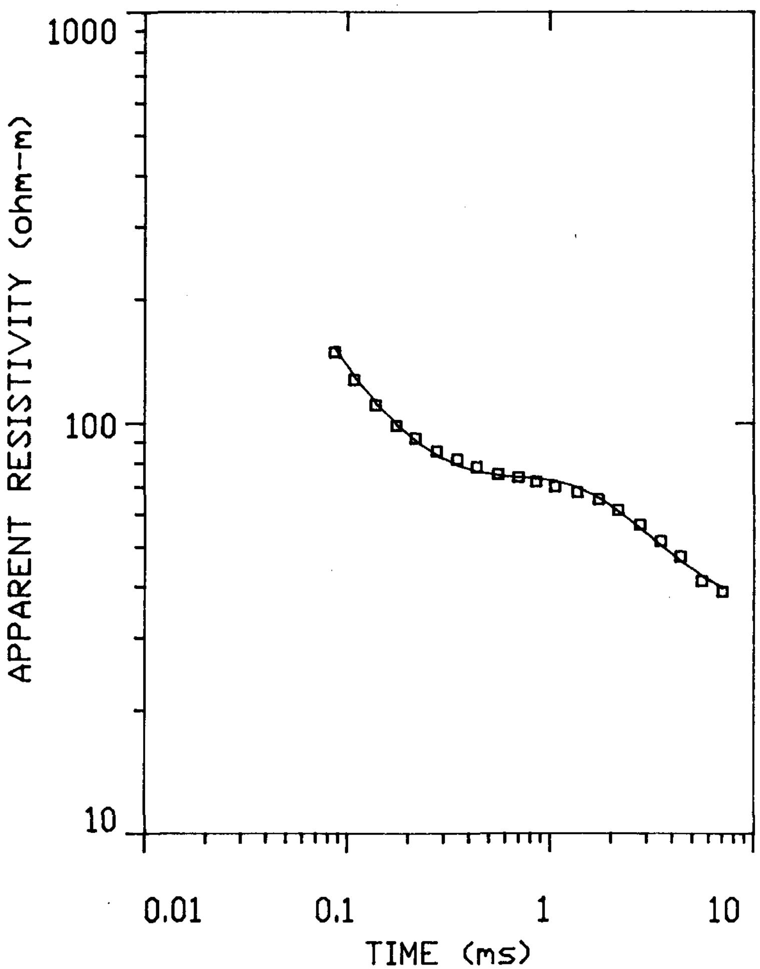
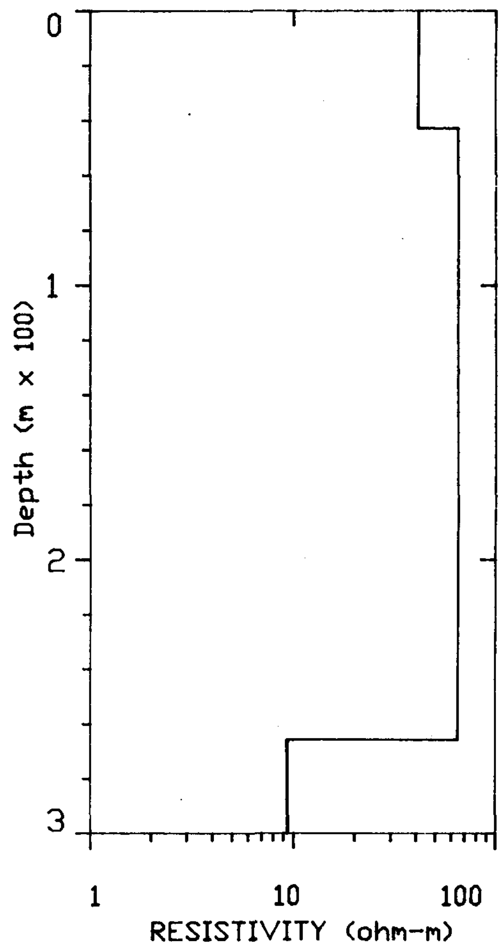
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SURVEY LOCATION MAP
SOUNDING 23 – LAKE LOUISE
ORANGE COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	LOC-23	5.24-1
DRAWN BY:	RBT	DATE:	06/21/95	





—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1-D INVERSION
SITE 23 – LAKE LOUISE
ORANGE COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL-23	5.24-2
DRAWN BY:	SAB	DATE:	07/26/95	

The second layer has only intermediate resistivity (65 ohm-m) which, because it is less than 80 ohm-m, suggests the Floridan aquifer at this site contains brackish water. The thickness of the brackish section is 223 m (732 ft), placing the depth to the low resistivity (saltwater) layer at 266 m (873 ft) below ground surface. The resistivity of the saltwater saturated layer is 9.4 ohm-m. Layer 1 is considered to be the Holocene to Miocene deposits above the Floridan aquifer, Layer 2 to be the Floridan aquifer (brackish), and Layer 3 to be the salt water within the Floridian aquifer.

5.24.3 Depth to Occurrence of Salt Water

The bottom (third) layer of the geoelectrical model, with a resistivity of 9.4 ohm-m, is interpreted to represent salt water. It occurs at a depth of 873 ft (-808 ft msl). Because the resistivity of Layer 2 (65 ohm-m) is interpreted to represent brackish water within the Floridan aquifer (is less than 80 ohm-m), the interpreted depth to the 5,000 mg/l isochlor is equal to the depth of the geoelectrical interface, or at 873 ft depth (-808 ft msl). The resistivity of Layer 3 (9.4 ohm-m) corresponds to a chloride concentration of 3,269 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

5.24.4 Depth of Occurrence of the 250 mg/l Isochlor

The resistivity of Layer 2, 65 ohm-m, corresponds to a chloride concentration above 250 mg/l, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. As the interpreted chloride concentration exceeds 250 mg/l, the 250 mg/l isochlor does not occur within the Floridan aquifer at this site. This conclusion does not agree with SJRWMD (personal communication) who report an average chloride concentration in the Upper Floridan aquifer to be below 250 mg/l.

5.24.5 Accuracy of Measurement and Interpretation

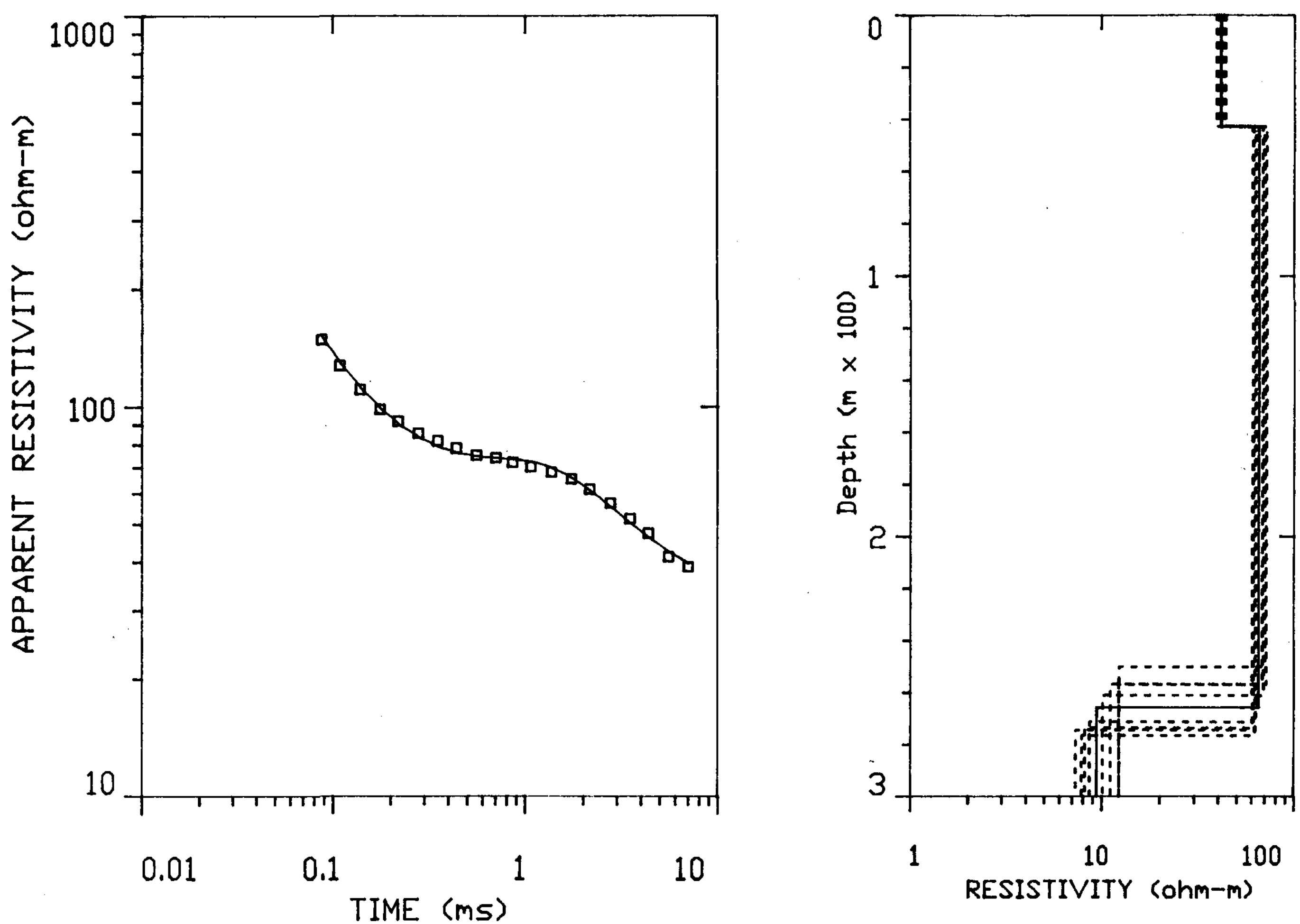
Figure 5.24-3 is the equivalence analysis at this site and the inversion table (Table 5.24-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.

The range of equivalence in determining the depth to the low resistivity layer is about ±13 m (43 ft) which is 5% of the total depth. The resistivity of this layer has a range from 7.3 to 12.3 ohm-m. This corresponds to a range in interpreted chloride concentration of from 4,253 to 2,462 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 2 is from 61 to 72 ohm-m which corresponds to a chloride concentration above 250 mg/l. The results of the TDEM study are not in agreement with SJRWMD (personal communication). The chloride-to-sulfate ratio at the site is 5:1 (Table 5.1-4). Accordingly, equation (4) is valid. The discrepancy in the water quality results between the TDEM survey and SJRWMD (personal communication) is probably due to the averaging of water quality in the Floridan aquifer by TDEM. There is not a sufficient resistivity contrast to locate the 250 mg/l isochlor at this site. As a consequence, TDEM yields an average resistivity for Layer 2.

5.24.6 Summary of TDEM Sounding at Lake Louise (Site 23)

- The depth to occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 873 ft (-808 ft msl) and occur within the Floridan aquifer.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration above 250 mg/l. The 250 mg/l isochlor is not interpreted to be present within the Floridan aquifer. This conclusion is not consistent with the chloride concentration in the Upper Floridan aquifer. SJRWMD (personal communication) report this concentration to be below 250 mg/l.



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1-D INVERSION
SITE 23 - LAKE LOUISE
ORANGE COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU-23	5.24-3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 23

CLIENT: SJRWMD
LOCATION: LAKE LOUISE
COUNTY: ORANGE COUNTY
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 196.000 m by 278.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 12-MAY-95
SOUNDING: 1
ELEVATION: 20.00 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 3.237 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)		ELEVATION (meters)	CONDUCTANCE (Siemens)
				20.00	
1	41.15	42.70	*	-22.70	1.03
2	65.40	223.0		-245.7	3.40
3	9.38				

"*" INDICATES FIXED PARAMETER

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	39.085	41.160	43.566
	2	60.555	65.409	71.652
	3	7.295	9.388	12.333
THICK	1	42.700	0.000	42.700
	2	207.425	1.000	233.839
DEPTH	1	42.700	42.700	42.700
	2	250.125	265.732	276.539

CURRENT: 19.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz GAIN: 2 RAMP TIME: 150.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0867	131274.0	126765.0	3.43
2	0.108	95481.0	92721.4	2.89
3	0.138	63986.3	62938.6	1.63

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE
DETECTION
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TDEM SOUNDING DATA TABLE
SITE 23 – LAKE LOUISE
ORANGE COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.24–1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.175	42096.9	41687.3	0.972
5	0.218	26997.3	27637.1	-2.36
6	0.278	16363.0	16974.7	-3.73
7	0.351	9781.9	10307.1	-5.36
8	0.438	6007.6	6251.6	-4.06
9	0.558	3487.5	3518.2	-0.879
10	0.702	2009.3	2012.4	-0.151
11	0.858	1265.7	1230.4	2.78
12	1.06	766.7	729.4	4.86
13	1.37	428.5	412.0	3.83
14	1.74	250.3	247.5	1.13
15	2.17	157.7	159.5	-1.15
16	2.77	96.92	99.86	-3.02
17	3.50	62.02	64.31	-3.70
18	4.37	40.54	42.01	-3.61
19	5.56	27.32	26.12	4.36
20	7.03	16.61	16.09	3.13

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.99				
P 2	0.01	0.98			
P 3	0.01	-0.03	0.79		
F 1	0.00	0.00	0.00	0.00	
T 2	0.00	0.01	0.03	0.00	0.99
	P 1	P 2	P 3	F 1	T 2

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 23 – LAKE LOUISE
ORANGE COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.24–1

5.25 TDEM Site 24 - Rosen Property

5.25.1 Location Description and Geoelectrical Section

The site is located in north Orange County, Florida (Figure 5.25-1). The site is located within a pasture. No sources of interference were observed in the vicinity of the site. QA soundings were performed 60 ft north and 110 ft west of the initial Rx coil location. Results from the QA soundings indicate that the apparent resistivity values were unaffected by any interference sources.

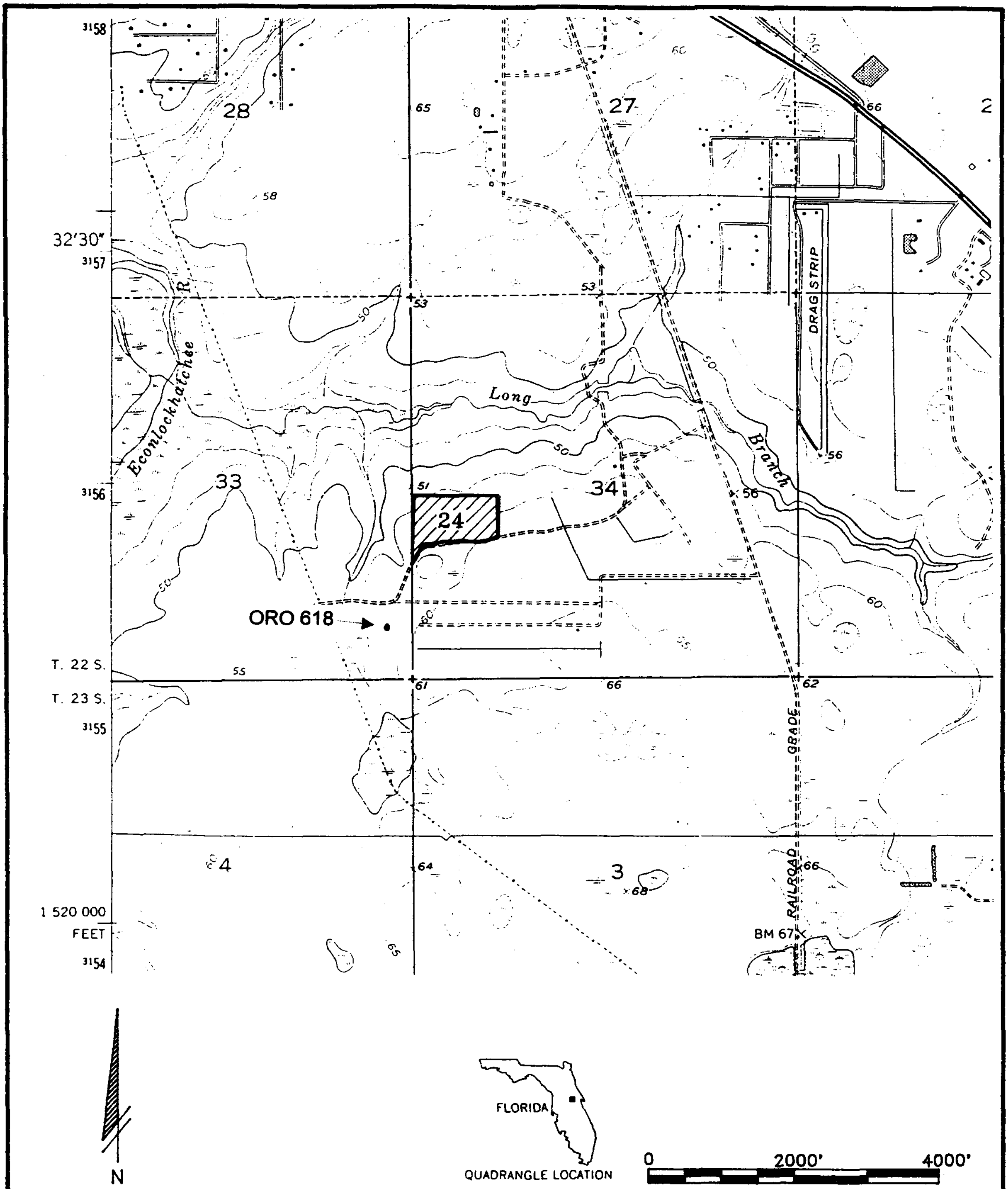
The Floridan aquifer occurs at an approximate depth of 160 ft bmsl or 220 ft bls (SJRWMD, personal communication) and is overlain by Holocene to Miocene deposits. The base of the Floridan aquifer occurs at approximately 2,400 ft bmsl (Tibbals, 1990). The thickness of the Upper Floridan aquifer is approximately 290 ft and the depth to the top of the Lower Floridan aquifer is approximately 1,100 ft bls (Miller, 1986). The average chloride concentration in the Upper Floridan aquifer is below 250 mg/l in this area (SJRWMD, personal communication).

During the summer of 1995, SJRWMD drilled a test well (ORO 618) approximately a 1/4 mile south of this site (Figure 5.25-1). The interface and the 250 mg/l isochlor occurred between 1,082 and 1,138 ft. The 5,000 mg/l isochlor occurred between 1,355 and 1,448 ft.

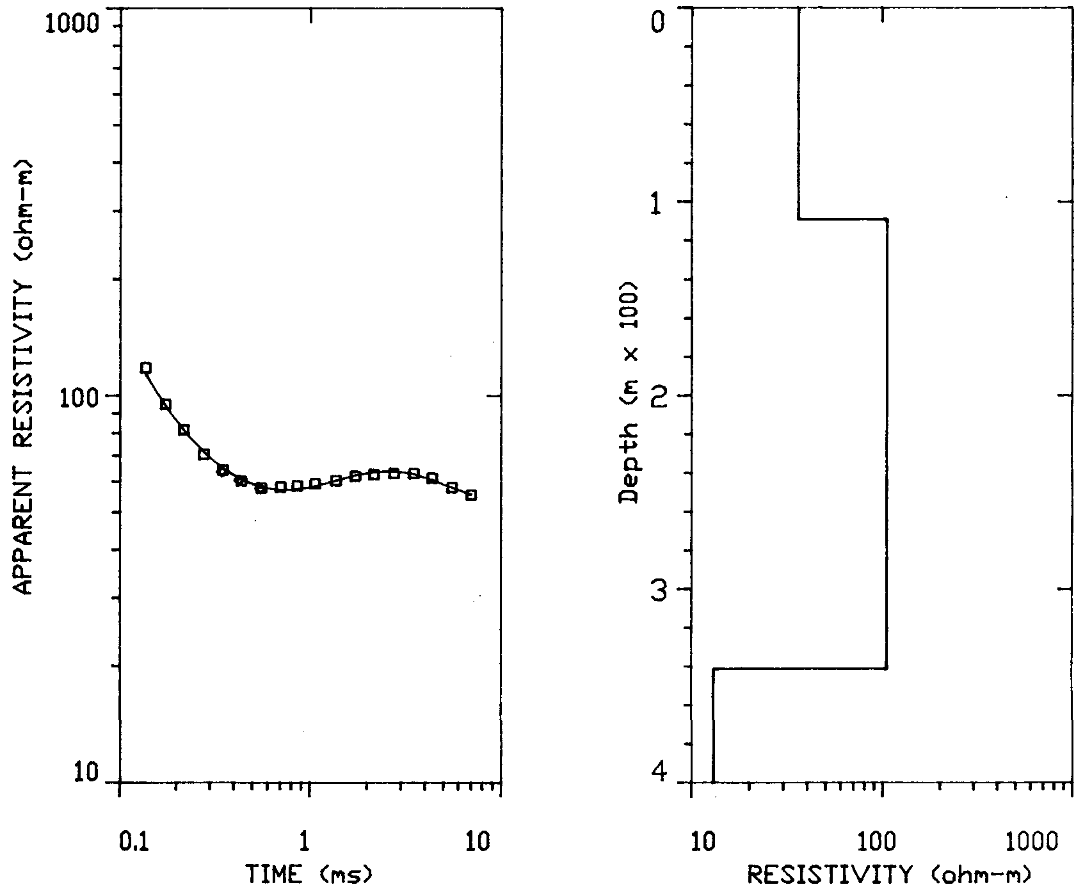
The resistivity sounding data and best-fit model inversion are presented on Figure 5.25-2. The interpreted geoelectrical section consists of a three-layer subsurface.

5.25.2 Geological Interpretation of Geoelectrical Model

The three-layered geoelectrical section consists of a low resistivity (36 ohm-m) upper layer which is considered to be combined Holocene to Miocene deposits and the upper portion of the Floridan aquifer. The second layer has a high resistivity (106 ohm-m) which, because it is greater than 80 ohm-m, suggests the Floridan aquifer at this site contains fresh water. The thickness of the freshwater section is 232 m (761 ft), placing the depth to the low resistivity



ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PALATKA, FLORIDA	SDII SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED	TDEM SURVEY LOCATION MAP SOUNDING 24 – ROSEN PROPERTY ORANGE COUNTY, FLORIDA		
		DESIGNED BY: JEB CHECKED BY: MJW DRAWN BY: RBT	PROJECT NO.: 95706 DRAWING NO.: LOC-24 DATE: 08/21/95	FIGURE 5.25-1



—— BEST-FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND 1–D INVERSION
SITE 24 – ROSEN PROPERTY
ORANGE COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	MDL–24	5.25–2
DRAWN BY:	SAB	DATE:	07/26/95	

(saltwater) layer at 341 m (1,119 ft) below ground surface. The resistivity of the saltwater saturated layer is 13.0 ohm-m. Layer 1 is considered to be the Holocene to Miocene deposits combined with the upper portion of the Floridan aquifer, Layer 2 to be the Floridan aquifer containing freshwater, and Layer 3 to be the salt water within the Lower Floridan aquifer.

5.25.3 Depth to Occurrence of Salt Water

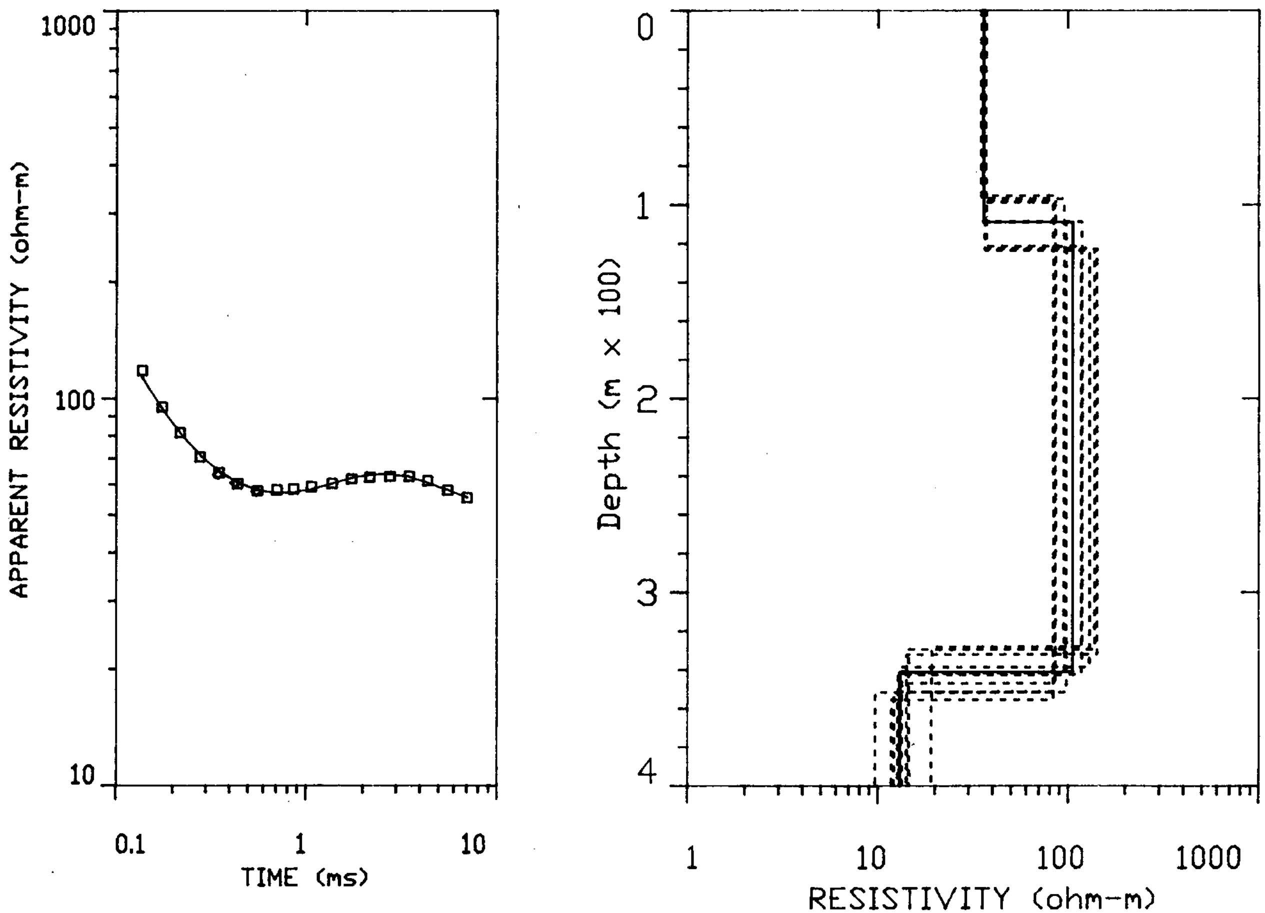
The bottom (third) layer of the geoelectrical model, with a resistivity of 13.0 ohm-m, is interpreted to represent salt water. It occurs at a depth of 1,119 ft (-1,059 ft msl). Because the resistivity of Layer 2 (106 ohm-m) is greater than 80 ohm-m, the interpreted depth to the 5,000 mg/l isochlor is taken as 50 ft greater than the depth to the geoelectrical interface, or at 1,169 ft depth (-1,109 ft msl). The resistivity of Layer 3 (13.0 ohm-m) corresponds to a chloride concentration of 2,321 mg/l assuming a porosity of 25% and the validity and applicability of equation (4) of Section 4.2. It is presumed that because of the expected high chlorinity gradients, this value is sufficiently close to the 5,000 mg/l isochlor that they represent the same effective depth.

5.25.4 Depth of Occurrence of the 250 mg/l Isochlor

The resistivity of Layer 2, 106 ohm-m, corresponds to a chloride concentration of less than 250 mg/l, assuming a 25% porosity and the validity and applicability of equation (4) of Section 4.2. The 250 mg/l isochlor is placed in the Floridan aquifer at a depth 50 ft above the Layer 3 interface or at 1,069 ft (-1,009 ft msl).

5.25.5 Accuracy of Measurement and Interpretation

Figure 5.25-3 is the equivalence analysis at this site and the inversion table (Table 5.25-1) lists the upper and lower bounds of the inverted parameters of the geoelectrical model.



——— BEST–FIT MODELED CURVE

□ APPARENT RESISTIVITY VALUES USED IN MODEL

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

SDII
SUBSURFACE DETECTION INVESTIGATIONS INCORPORATED

MEASURED TDEM APPARENT RESISTIVITY AND EQUIVALENCE FOR 1–D INVERSION
SITE 24 – ROSEN PROPERTY
ORANGE COUNTY, FLORIDA

DESIGNED BY:	JEB	PROJECT NO.:	95706	FIGURE
CHECKED BY:	MJW	DRAWING NO.:	EQU–24	5.25–3
DRAWN BY:	SAB	DATE:	07/26/95	

DATA SET: SITE 24

CLIENT: SJRWMD
LOCATION: ROSEN PROPERTY
COUNTY: ORANGE COUNTY
PROJECT: SALTWATER INTERFACE DETECTION
LOOP SIZE: 198.000 m by 391.000 m
COIL LOC: 0.000 m (X), 0.000 m (Y)
SOUNDING COORDINATES: E: 0.0000 N: 0.0000

DATE: 12-MAY-95
SOUNDING: 1
ELEVATION: 18.30 m
EQUIPMENT: Geonics PROTEM
AZIMUTH:

FITTING ERROR: 2.318 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			18.30	
1	36.14	108.8	-90.58	3.01
2	106.2	232.2	-322.7	2.18
3	13.03			

ALL PARAMETERS ARE FREE

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	35.045	36.148	37.199
	2	83.572	106.252	141.604
	3	9.647	13.031	19.178
THICK	1	95.327	-1.019	123.598
	2	206.943	1.000	257.702
DEPTH	1	95.327	108.888	123.598
	2	328.143	341.091	355.618

CURRENT: 15.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 30.00 Hz GAIN: 4 RAMP TIME: 150.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.138	67969.8	72350.2	-6.44
2	0.175	51902.9	52436.6	-1.02
3	0.218	37683.1	37602.3	0.214

ST. JOHNS RIVER
WATER MANAGEMENT DISTRICT
PALATKA, FLORIDA

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INVESTIGATIONS
INCORPORATED

TDEM SOUNDING DATA TABLE
SITE 24 – ROSEN PROPERTY
ORANGE COUNTY, FLORIDA

PROJECT NO.: 95706
TABLE: 5.25-1

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
4	0.278	25520.6	24970.4	2.15
5	0.351	16395.9	16171.4	1.36
6	0.438	10401.5	10292.7	1.04
7	0.558	6042.3	6015.0	0.452
8	0.702	3375.5	3483.5	-3.19
9	0.858	2026.7	2099.6	-3.59
10	1.06	1154.1	1185.5	-2.72
11	1.37	599.6	603.1	-0.581
12	1.74	316.6	314.6	0.621
13	2.17	179.5	175.7	2.08
14	2.77	96.75	94.64	2.18
15	3.50	53.93	54.17	-0.444
16	4.37	32.20	32.80	-1.84
17	5.56	19.18	19.18	0.0165
18	7.03	11.41	11.41	-0.0239

CURRENT: 15.00 AMPS EM-57 COIL AREA: 100.00 sq m.
FREQUENCY: 7.50 Hz GAIN: 6 RAMP TIME: 150.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
19	0.346	17295.7	16641.0	3.78
20	0.427	11037.0	10873.7	1.48
21	0.550	6313.7	6228.9	1.34

PARAMETER RESOLUTION MATRIX:
"F" INDICATES FIXED PARAMETER

P 1	0.99				
P 2	-0.02	0.42			
P 3	0.00	-0.17	0.38		
T 1	-0.02	-0.25	0.00	0.85	
T 2	0.01	0.21	0.09	0.09	0.91
	P 1	P 2	P 3	T 1	T 2

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TDEM SOUNDING DATA TABLE
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The range of equivalence in determining the depth to the low resistivity layer is about ±14 m (46 ft) which is 4% of the total depth. The resistivity of this layer has a range from 9.6 to 19.2 ohm-m. This corresponds to a range in interpreted chloride concentration of 3,197 to 1,522 mg/l, again subject to the same assumptions of porosity and validity of equation (4).

The equivalence range of the resistivity of Layer 2 is from 84 to 142 ohm-m which corresponds to a chloride concentration of less than 250 mg/l. The chloride-to-sulfate ratio at the site is 5:1 (Table 5.1-4). Accordingly, equation (4) is valid.

5.25.6 Summary of TDEM Sounding at Rosen Property (Site 24)

- The depth to occurrence of salt water (5,000 mg/l isochlor) is interpreted to be 1,169 ft (-1,109 ft msl) and occur within the Lower Floridan aquifer at this site.
- The ground water within the Floridan aquifer at this site is interpreted to contain an average chloride concentration of less than 250 mg/l. The 250 mg/l isochlor is interpreted to be present in the Floridan aquifer at a depth of 1,069 ft (1,009 ft msl). For comparison, this isochlor occurs between 1,082 and 1,138 ft in a test well (ORO 618) located 1/4 mile south of this site.
- TDEM located an interface at 1,119 ft bls. The interface depth determined by TDEM agrees with that obtained from a test well (ORO 618) located approximately 1/4 mile south of this site.

6.0 SUMMARY AND CONCLUSIONS

A TDEM survey was performed at 24 sites in the St. Johns River Water Management District during the month of May, 1995. The principal findings of this survey can be summarized as follows:

TDEM is a geoelectrical method which can be used to estimate the vertical variation of resistivity of subsurface formations and/or hydrostratigraphic units. Translating the geophysical measurement of electrical resistivity into a model of geology and water quality depends upon comparison to other available subsurface data, consistency of data sets from nearby soundings from this and prior years, and application of empirical relationships to produce interpreted water-quality results. As outlined in Section 4, the conversions to water quality values (chloride concentrations) are based upon the relationships established using Kwader's (1982) data for Seminole County, as used for SJRWMD in previous studies (Blackhawk, 1990; CEES, 1992/SJ93-SP1; SDII, 1993 and 1994). The formulae employed use assumptions of a 25% porosity, similar water chemistry (specifically, a 5:1 chloride-to-sulfate ratio) as Kwader's data, and that the saltwater interface occurs within the Floridan Aquifer System. With regards the latter point, chloride concentration values are generally presented only for those portions of the geoelectrical section which correspond to the Floridan aquifer.

Under circumstances where there is little contrast in resistivity between the Holocene to Miocene deposits, surficial sediments, or Hawthorn Group and the Floridan aquifer, the chloride concentration of the ground water above the freshwater/saltwater interface cannot generally be determined. This is because of the assumptions implicit in equation (4) are not valid. However, if the resistivity of such a layer is either greater than 80 ohm-m or less than 20 ohm-m, it can be concluded that the chloride concentration in the Upper Floridan aquifer is either below or above 250 mg/l, respectively.

Finally, because the freshwater/saltwater boundary is not an abrupt interface but a transition zone, criteria relating to the relative resistivities above and below the geoelectrical interface were used to establish an empirical definition of depths to the 250 and 5,000 mg/l isochlors. Again, these were the same criteria as used in past years' TDEM surveys (Blackhawk, 1990; CEES, 1992/SJ93-SP1; SDII, 1993 and 1994) in order to maintain consistency from year to year.

6.1 Determining the Depth of the Interface Between Fresh Water and Ground Water of High Chloride Concentration (Greater Than 1,450 mg/l)

As stated in previous years' reports (Blackhawk, 1990; CEES, 1992/SJ93-SP1; SDII, 1993 and 1994), "ground water with a chloride content greater than 1,450 mg/l is characterized in the Floridan aquifer by resistivities less than 20 ohm-m when the aquifer has a porosity of about 25%." In accordance with this statement, a deep layer with a resistivity of less than 15 ohm-m was detected at 22 of the 24 sites surveyed. At the Herlong Airport (Site 1) and Volusia County Landfill (Site 19) sites, the TDEM system did not have a sufficient depth range to detect the basal saltwater-saturated layer. The remaining 22 sites show variation in depth to this interface to range from approximately 200 to 1,339 ft. All the interpreted depths place the saltwater interface within the Floridan Aquifer System.

6.2 Water Quality in the Floridan aquifer and Depth of Occurrence of the 250 mg/l Isochlor

Based on the assumptions that: (a) The Floridan aquifer has a porosity of 25%, (b) ground water within the study area have a chemistry similar to those analyzed by Kwader (1982), and (c) equation (4) in Section 4.2 is valid, ground water having chloride concentrations of less than 250 mg/l correspond to geoelectrical layers having resistivities in excess of 80 ohm-m. The distribution of resistivities of the Floridan aquifer show, for the most part, high resistivities and, therefore, fresh waters of less than 250 mg/l are present in the Floridan aquifer at 10 of the sites. At four of the sites, the average resistivity of the Floridan aquifer was less than 80 ohm-m and brackish water is interpreted to be present. There was an insufficient resistivity contrast to locate the 250 mg/l isochlor at these sites. When a layer with a chloride concentration of less than 250 mg/l is interpreted, the position of the 250 mg/l isochlor is fixed by the relative resistivities of the deep, conductive layer and the fresh (resistive) layer above - generally placing it 50 ft above the geoelectrical interface. When the resistivity of the Floridan aquifer is such that the interpreted chloride concentration exceeds 250 mg/l, a depth to the 250 mg/l isochlor was not determined as the entire system is considered to be brackish.

6.3 Summary of TDEM Mapping of Salt Water in the Floridan Aquifer

A total of 104 TDEM soundings have been performed for the District from 1990 to 1995. Approximate location of the TDEM soundings are presented on Figure 6.1. Results from those soundings are presented in this and previous studies (Blackhawk, 1990; CEES, 1992; and SDII, 1993 and 1994). The estimated depth to salt water has been determined at 94 sites. At 10 of the sites, the depth to salt water could not be determined because either; (a) the suspected depth to salt water was beyond the capability of the TDEM system used for that survey, the lowermost layer in the geoelectric model included sediments from the overlying Holocene to Miocene deposits, or (c) there was not sufficient contrast in the resistivity of the geoelectric layers to confidently estimate the depth to the 5,000 mg/l isochlor.

Hydrogeologic cross-sections showing the depth to the 5,000 mg/l isochlor are provided on Figure 6.3-1. Cross-sections A-A' and B-B' trend in a general east/west direction and demonstrate the change in depth to the 5,000 mg/l isochlor from the Atlantic coast to the St. Johns River. Cross-section C-C' trends in a general north/south direction and shows the change in the depth to the 5,000 mg/l isochlor along and near the St. Johns River.

7.0 REFERENCES

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