GEOPHYSICAL INVESTIGATION OF CYPRESS DOMES, WEST CENTRAL FLORIDA.

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Geophysical Investigation of

Cypress Domes, West Central Florida

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BACKGROUND:

This report is part of a larger project, "Hydrogeologic investigation of cypress domes in wellfields near Tampa, Florida", being conducted by the Southwest Florida Water Management District (SWFWMD). As an extension of the wetlands monitoring program, the Environmental Section at the District has identified anomalous cases where cypress domes with significantly reduced hydroperiods exist in close proximity to cypress domes with normal to near normal hydroperiods. Preliminary investigations of these affected and non-affected cypress domes indicate that they represent two general types of hydrogeologic frameworks. Affected sites appear to be sinkhole systems with considerably different stratigraphies than surrounding areas; unaffected domes appear to be shallow depressions in the surficial units and therefore have consistent stratigraphic relations with the surrounding sediments. The reduction of hydroperiods and the presence of thicker surficial sand units within the affected domes suggests a more direct connection with the underlying Floridan aquifer.

In order to determine which cypress domes might be affected by pumping stresses and to assess a potential degree of effect, it is necessary to develop a reliable and relatively inexpensive method(s) for quickly determining the hydrogeologic framework of cypress domes in large drawdown areas. Geophysical methods can be used to determine variations in shallow stratigraphy if the stratigraphic changes create recognizable geophysical signatures. This report summarizes the methods and results of geophysical studies conducted in Starkey and Eldridge-Wilde wellfields between June and September, 1989, to determine which geophysical method or methods can be used to recognize wetlands that are susceptible to pumping stresses.

OBJECTIVES OF PROJECT:

The objectives of this project are to characterize the hydrogeologic setting of seven preselected cypress domes using geophysical methods, and to determine the most effective and efficient geophysical method(s) for future investigations of this type.

METHODS:

1. Direct current resistivity in the horizontal electrical profiling mode (HEP) using an ABEM Terrameter.
2. Very Low Frequency (VLF) using the Omniplus system.
3. Loop-Loop Electromagnetics (LLEM) using Geonics EM-34.
4. Ground Penetrating Radar (GPR) using GSI radar.

EQUIPMENT:

1. DC-Resistivity survey.

   1-ABEM Terrameter
   5-stainless steel electrodes
   2-100m measuring tapes
   4-shielded electrical wire rolls
   1-hammer
   crew of three

2. VLF survey

   1-Omniplus VLF instrument with resistivity option
   2-100m measuring tapes
   1-IBM compatible PC for transfer of Omniplus data
   crew of two

3. LLEM survey

   1-Geonics EM-34-3
   2-100m measuring tapes
   supply of C and D cell batteries
   crew of 2

4. GPR survey

   1-skilled operator
   1-120mhz radar antenna and signal processor/recorder
   2-100m measuring tapes
   100-small flags

STUDY AREAS AND LOCATION OF GEOPHYSICAL TRANSECTS:

Two wellfields were chosen by the SWFWMD for this study. Figure 1 shows locations of both Starkey and Eldridge-Wilde wellfields. Five cypress domes were selected at Starkey wellfield, three with known geologic settings; Starkey east (STE), Starkey central (STC), Starkey west (STW), and two with unknown settings Unknown 1 (UN1), and Unknown 2 (UN2). Two cypress domes were selected at Eldridge-Wilde; Eldridge-Wilde west (EWW), and Eldridge-Wilde east (EWE), both have known geologic settings. The geologic cross-sections and drilling logs for STC and EWW were withheld at the beginning of the project for verification of the geophysical profiles. The sink-type cypress domes are EWE, STW, STC. The shallow-depression type are EWW and STE. UN2 has shown a significant reduction in its hydroperiod in recent years while UN1 is little affected. The geophysical transects are oriented as follows (figures 2 and 3).

1. STE - Trend N11W   This transect follows the major trail into the center of the dome. All of the transects either begin or end near the ET station in the center.

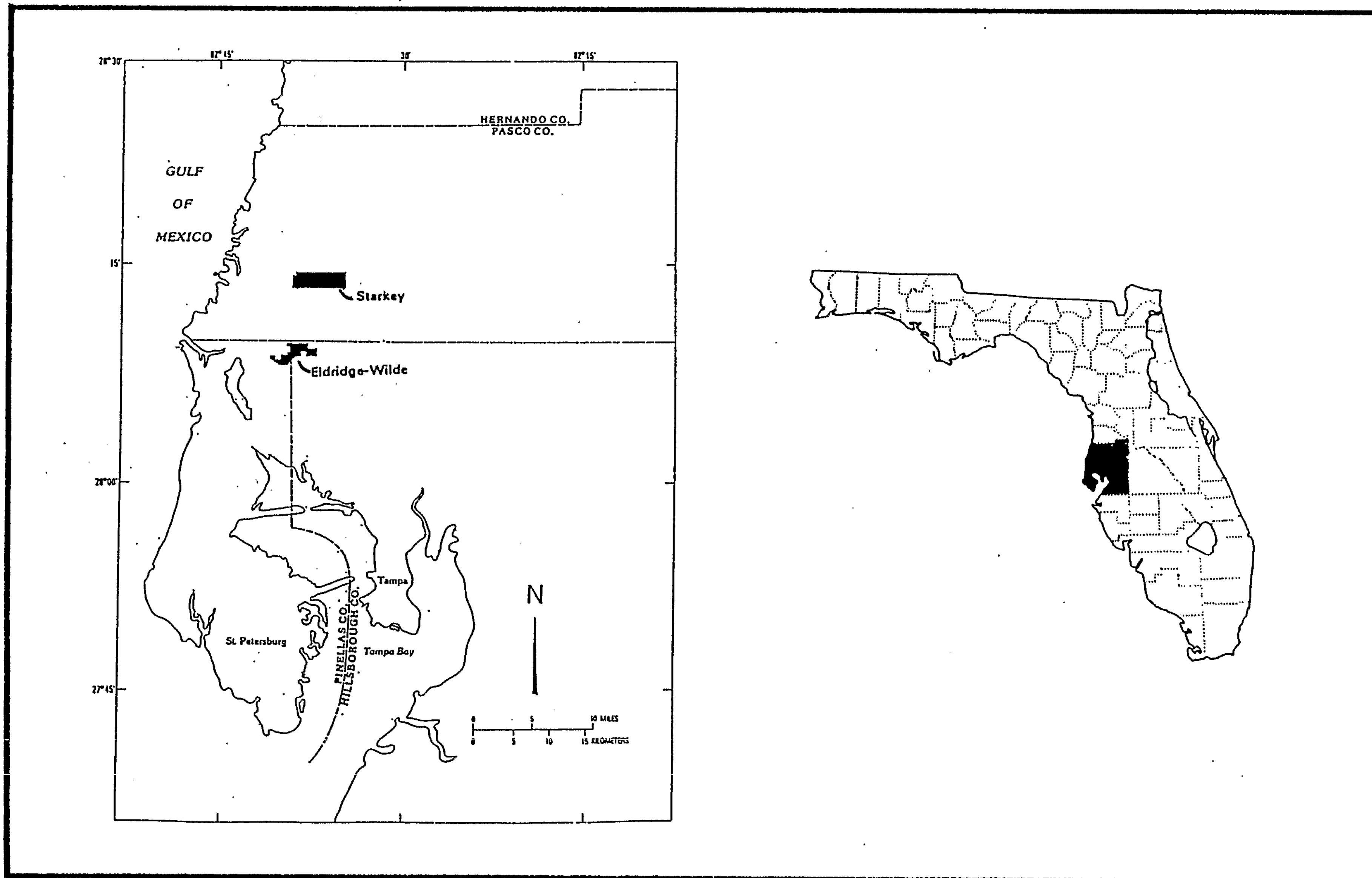


Figure 1. Location of Starkey and Eldridge-Wilde wellfields

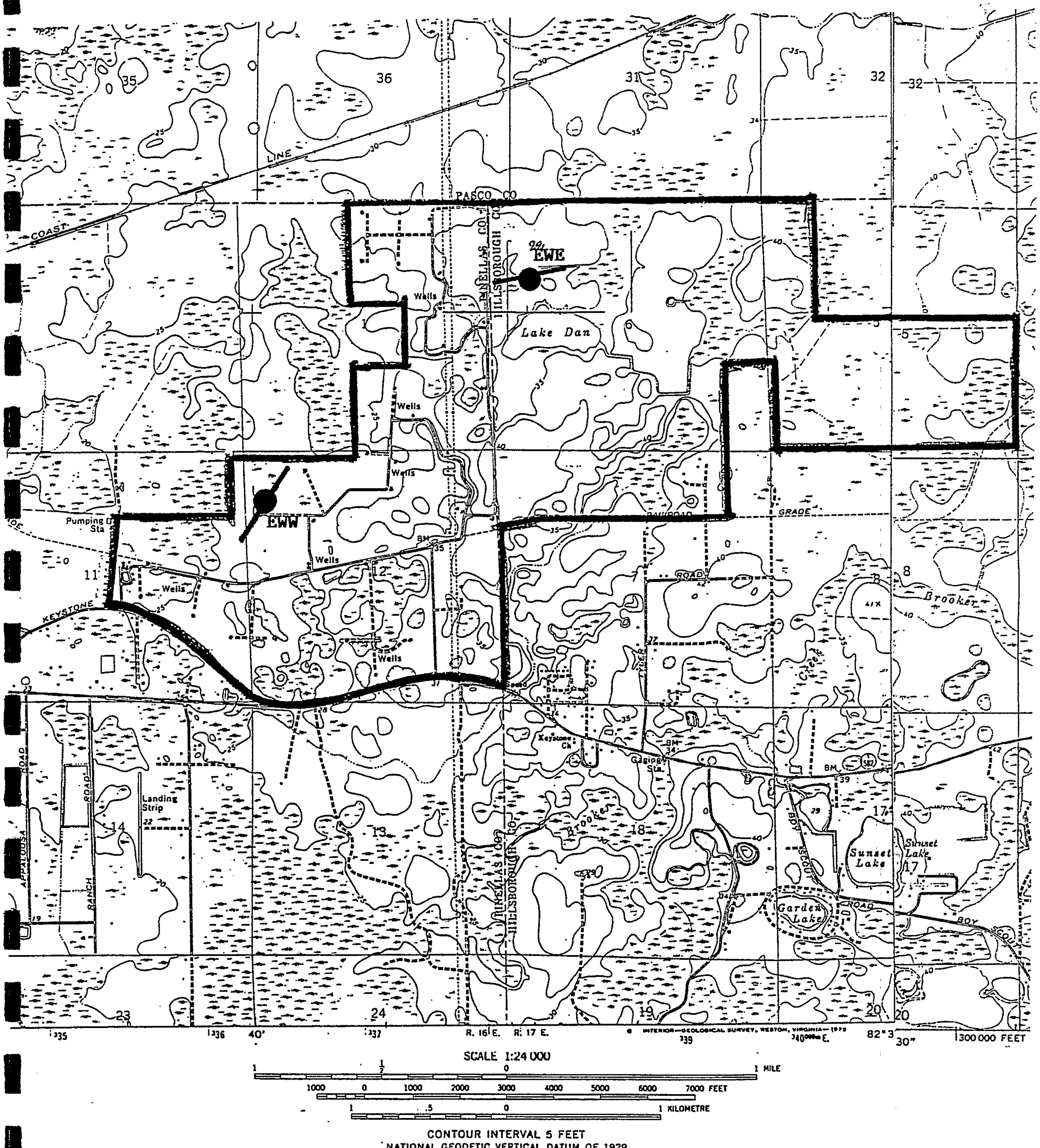


Figure 2. Location of cypress domes at Eldridge-Wilde Wellfield.

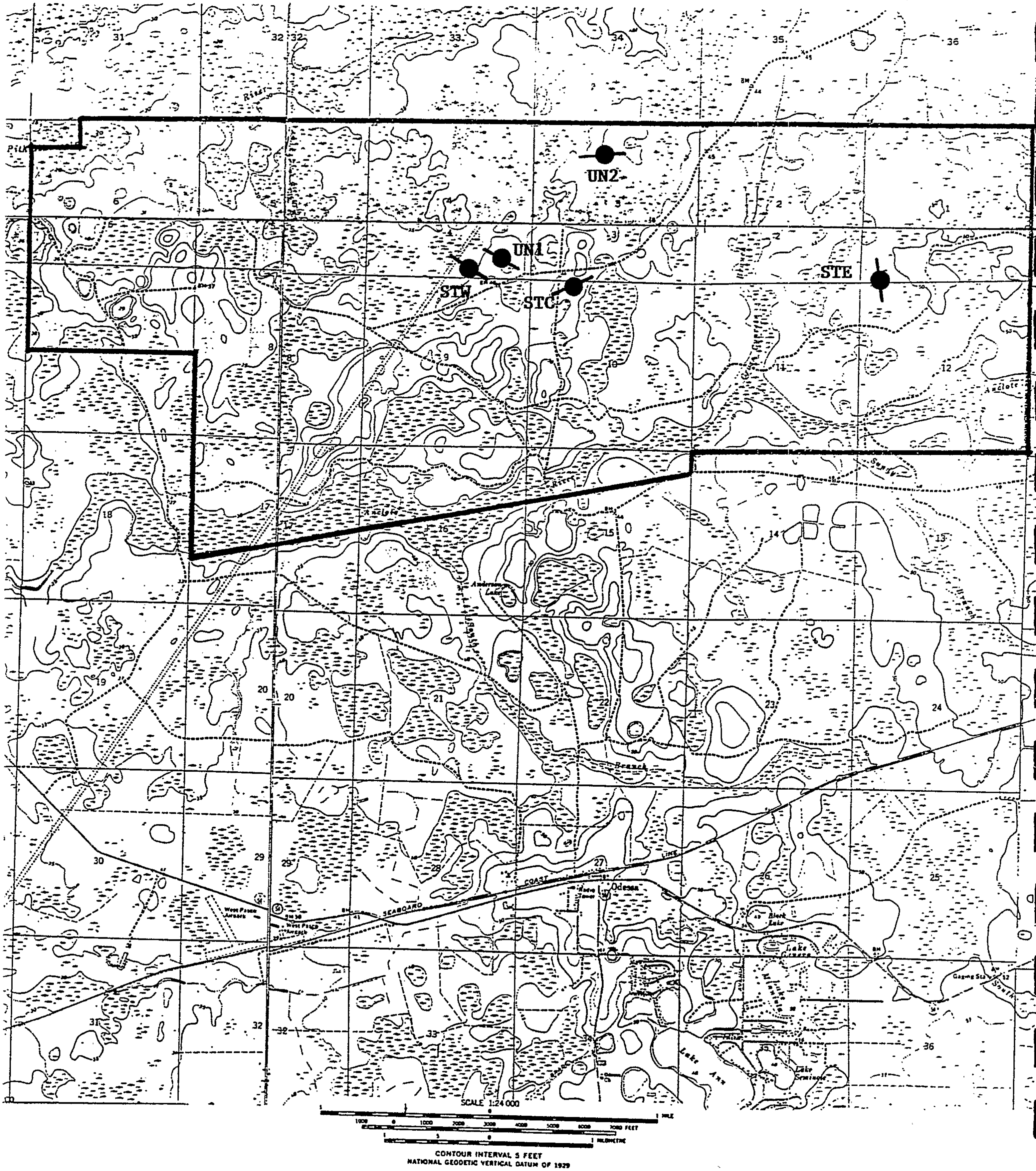


Figure 3. Location of cypress domes at Starkey Wellfield.

2. STC - Trend N41E		This transect follows the major trail cut through the dome. All of the transects begin or end at the shallow depression at the NW edge of the dome.
3. STW - Trend N45W		This transect enters the dome on the southeastern edge next to the monitor well 3AW and ends just past well 2AW.
4. UN1 - Trend N44W		This transect enters the dome from the south west along the No. 7 wellhouse road and ends at the subsidence station in the center.
5. UN2 - Trend N72E		This transect enters the dome from the southwest and crosses the dome completely.
6. EWW - Trend N20E		This transect parallels the monitor well line and completely crosses the dome.
7. EWE - Trend N40E		This transect parallels the monitor well line and ends at the center near monitor well 2AE.

PRELIMINARY ANALYSIS:

A photolinear analysis was conducted prior to the geophysical surveys to determine the spatial relationships of the photolinears to the seven cypress domes. Photolinears are linear trends identified on aerial photographs that may represent zones of increased fracture density. Photolinears that are determined to represent zones of increased fracture density are termed fracture traces. Fracture traces are vertical zones of generally higher hydraulic conductivity that can be vertical pathways for ground-water flow between the surficial and semi-confined aquifers. A strong correlation between fracture traces and affected wetlands might be useful for identifying potentially problematic wetlands. The aerial photo analysis, conducted for this study, indicates a moderate but non-conclusive correlation between affected cypress domes and photolinears (figures 4 and 5). Affected sites EWE, STW and UN2 are intersected by photolinears. However, unaffected site STE appears to have a high concentration of photolinears near its northern edge. A more statistically significant analysis might provide a stronger correlation. Furthermore, the physical character of the photolinements needs to be determined. This involves determining those photolinears which represent fracture traces and those which are not related to geological features. Geophysical methods, such as the EM-34 method used for this report, have been used for determining zones of increased fracture density. Clearly, a preliminary analysis using aerial photographs could help to limit the number of wetlands to be studied. More importantly, if a larger data base were collected, the relationship between affected domes and photolinears might become a primary method for predicting the effects of ground-water withdrawals on cypress domes.

GEOPHYSICAL METHODS:

Horizontal electrical profiling

Horizontal electrical profiling (HEP) is a direct current resistivity method used for determining lateral changes in subsurface stratigraphy. In general, a current is applied to two electrodes that are driven into the soil and the resulting electrical potential is measured by a second pair of electrodes. The apparent resistivity is calculated from the separation and

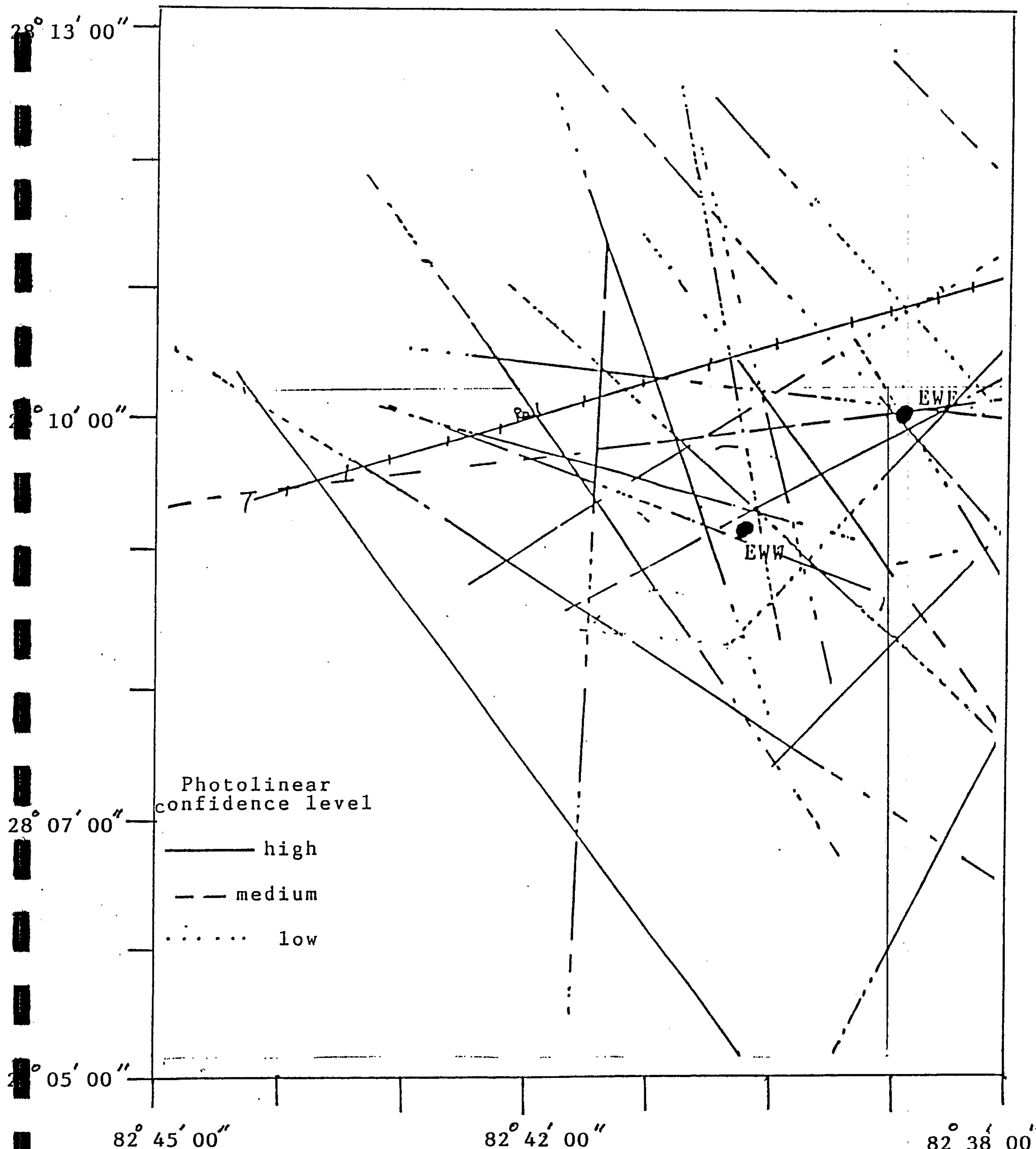


Figure 4. Photolinear analysis of Eldridge-Wilde wellfield from color infrared 1:56,000 aerial photo 35-24. Date of photography 2-7-84.

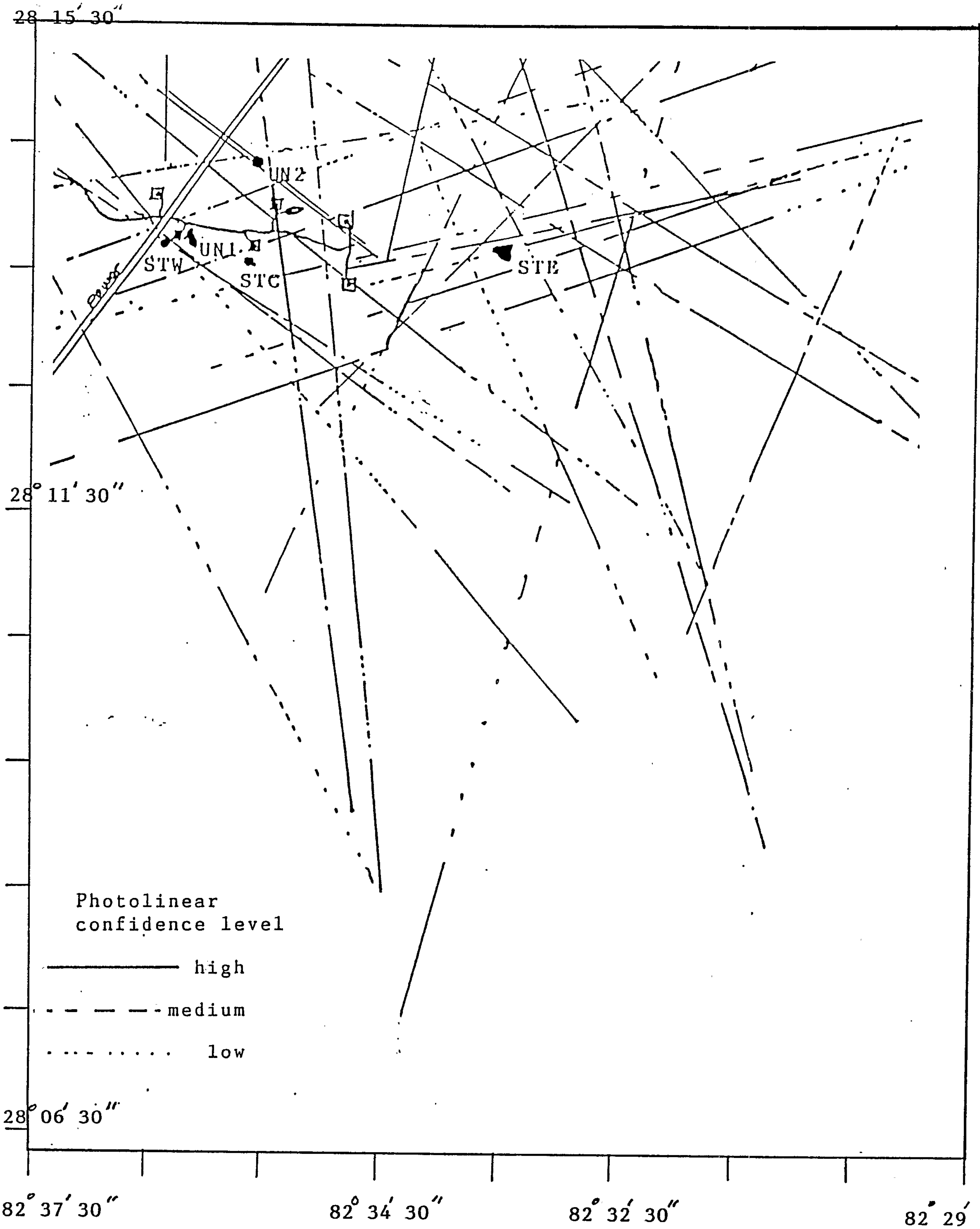


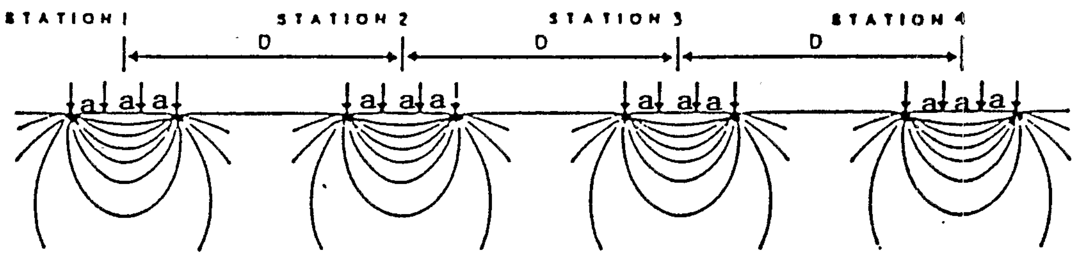
Figure 5. Photolinear analysis of Stakey wellfield from color infrared 1:56,000 aerial photo 33-173. Date of photograp hy 2-7-84.

geometry of the electrodes, and the measured resistance value in ohms. The entire array is then moved along a profile line and the procedure repeated. Dobrin and Savit, 1988 provide a detailed description of the theory and application of HEP.

In this study the Wenner array was used. The Wenner array is a four-electrode arrangement where there are equal distances between adjacent electrodes ("a" spacing, figure 6a). For the Wenner array, the equation for apparent resistivity is;

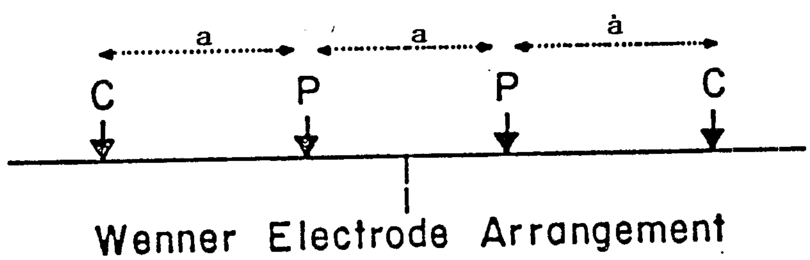
$$\rho_a = 2\pi a(\Delta V/I);$$ where ρ_a = apparent resistivity, a = electrode spacing (M) (V/I) = resistivity in ohm.

By increasing the "a" spacing, successively deeper layers are included in the apparent resistivity reading measured at the surface. The "a" spacings selected for this study were 10,20, and 30 meters(32.8, 65.6, and 99.4 feet), which correspond to effective exploration depths (EED) of roughly 6,12, and 18 meters(19.7, 39.4, and 59.1 feet), respectively. Materials above the EED contribute 70% of the total apparent resistivity measured at the surface. This is an important concept since it is easy to mistakenly think of the EED as the depth from which the resistivity measurement is being taken. Rather, it is the total thickness of material above the EED which is contributing 70% of the response measured at the surface. Therefore, apparent resistivity cannot be used to describe any individual geologic unit's resistivity. For each station readings were taken for each "a" spacing and the entire array was then moved 10 meters (32.8 feet) and the process repeated. Figure six(b) is a schematic diagram of the HEP method. The vertical arrows



(a)

D = distance between stations.



(b)

a = electrode spacing

Figure 6a. Schematic diagram of HEP method.
6b. Schematic diagram of WEnner electrode arrangement.
(from Benson, 1981)

represent the electrodes (figure 6a), with the distance between them equal to the "a" spacing and the distance between sucessive stations the distance "D". The results for each "a" spacing were plotted versus distance to form horizontal electrical profiles. Anomalies associated with vertical features or boundaries are often indicated by rapid increases or decreases in apparent resistivity.

Very Low Frequency (VLF)

Very low frequency (VLF) radio transmissions can be used to obtain subsurface geologic information by measuring the interaction between powerful, low frequency (17-25 kHz) radio transmissions and earth materials. These transmissions are intended for military communications; however, far from their sources they are excellent for geophysical studies. In the United States there are three VLF transmitters; Cutler, ME (24.0 kHz), Seattle, WA (24.8 kHz), and Annapolis, MD (21.4 kHz). The VLF signal provides a primary electromagnetic field that can used to locate vertical geologic contacts. At long distances from the transmitters (exceeding 500 miles) the VLF field consists of a vertical electrical component, a horizontal electrical component, and a primary horizontal magnetic field. For conventional VLF surveys (tilt angle) measurement is made of the magnetic field which, in the absence of subsurface conductors, is horizontal and linearly polarized (Wright, 1989). Subsurface changes in resistivity, such as vertical geologic contacts, cause the field to become elliptically polarized and the major axis (Ez) to tilt in relation to the size of the horizontal axis (Ex) (figure 7).

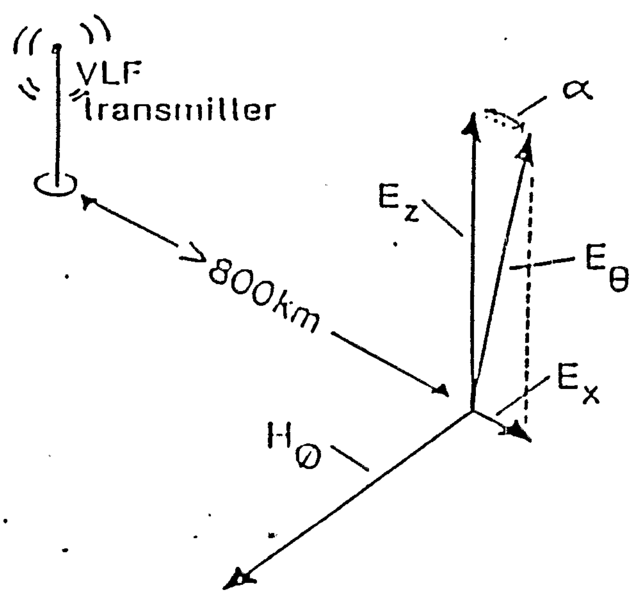
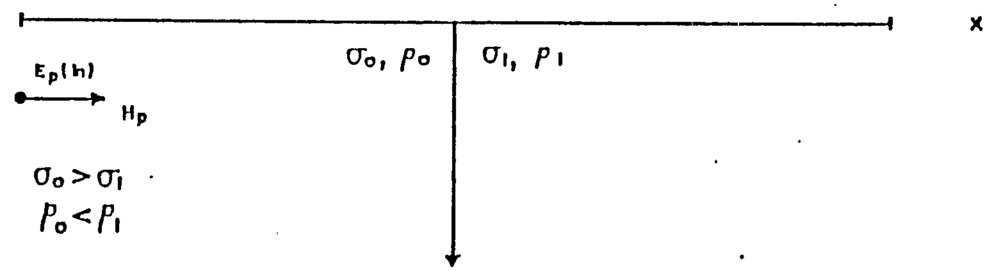


Figure 7. Principle components of the primary VLF field at distances greater than 500 mi from the transmitter. E_θ and H_θ are the electrical and magnetic components of the field, respectively. E_z and E_x are the vertical and horizontal components of E_θ. The angle α is the tilt of field E_θ from the vertical. Both α and E_θ increase with increasing apparent resistivity. (from Wright, 1988)

On figure 7 E_θ is the vector sum of Ez and Ex. For measurements of VLF resistivity to be made, two electrodes are placed into the ground at right angles. The electrodes measure the shallow earth materials response (ratio of the horizontal electric field to the horizontal magnetic field) to the propagating electromagnetic field (figure 7). The resulting ratio of the two fields is directly related to the apparent resistivity of the shallow earth materials. Figure 8 shows the typical tilt angle response over a vertical contact with varying resistivity. In the resistivity mode, the response is identical to a conventional DC resistivity survey. In either, the conventional VLF or the VLF resistivity modes, the resulting data (tilt angle or apparent resistivity) are generally plotted versus distance and qualitatively interpreted.

In this study, the Omniplus VLF system was used. The Omniplus is a self-contained unit which samples three VLF stations at the same time. The Omniplus measures the tilt angle and apparent resistivity (if VLF resistivity option is used) and stores the values electronically for later transfer to a PC for processing. The survey is conducted by initializing the Omniplus to the selected VLF stations and taking readings at a preselected station spacing which was 5 meters (16.4 feet) for this study. The Omniplus automatically increments the station spacing after each reading and also stores the relative strength of the primary VLF fields, so that the strongest stations can be determined. For this study, two people operated the Omniplus, one took the readings and the other placed the electrodes for the VLF



ρ = apparent resistivity

σ = conductivity

$E_p(h)$ = Primary horizontal electric field

H_p = Primary magnetic field

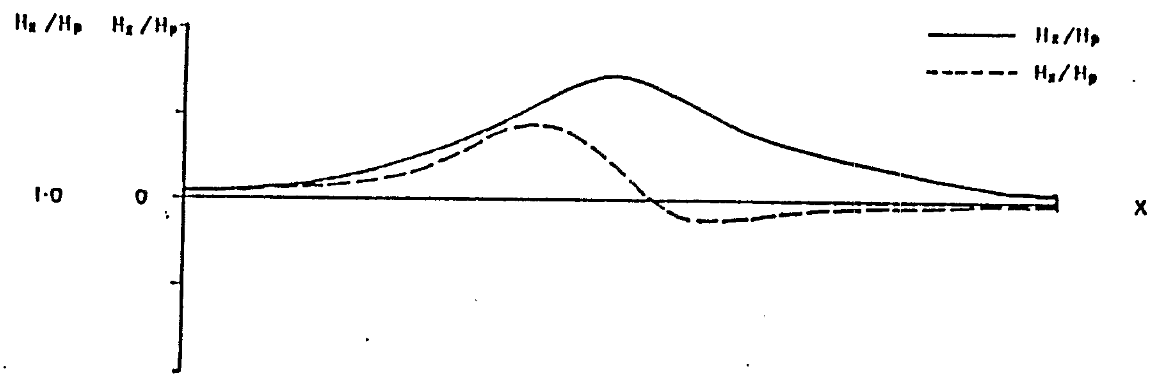


Figure 8. The upper diagram is the geologic model used to create the anomalies in the lower diagram.
Hz/Hp = tilt angle Hx/Hp = quadrature
(from Wright, 1988)

resistivity measurements.

The effective exploration depth (EED) is approximately 3.6 times the square root of the apparent resistivity. The apparent resistivity for a specific site can be determined by the VLF resistivity option or by preliminary DC resistivity surveys. This calculation results in an average EED of 25 meters (82.02 feet) for Starkey and Eldridge-Wilde wellfields, when an average apparent resistivity of 50 ohm-m is used.

<u>Loop-Loop Electromagnetics</u>

The Geonics EM-34-3 is a loop-loop electromagnetic instrument designed to read terrain conductivity directly. The unit is composed of a transmitter coil, a receiver coil, and two control units. The transmitter coil creates a time-varying electromagnetic field which induces eddy currents in the earth. The eddy currents generate a secondary magnetic field which , along with the primary field, is sensed by the receiver coil (McNeil, 1980). In general, the secondary magnetic field is a non-linear function of the intercoil spacing, the operating frequency, and the ground conductivity. McNeil (1980) developed the EM-34 with specific frequencies (1600, 800, and 400 Hz) and coil spacings (10, 20, and 40 meters or 32.8, 65.6, and 131.2 feet) which make the ratio of the secondary to primary magnetic field linearly proportional to the terrain conductivity. Under these conditions, known as operating under low induction numbers, the instrument reads directly in terrain conductivity and no conversions are needed. The EM-34 can also be operated with the coils (always co-planer) in either the vertical (horizontal coils) or horizontal (vertical coils) dipole modes. The vertical dipole mode is more sensitive to vertical geologic contacts.

For this study the unit was usually operated with horizontal coils and 10 and 20 meter (32.8 and 65.6 feet) coil spacings. Stations were spaced at three meter intervals and the transects were oriented from the center toward the edge of the dome. The 10 and 20 meter coil spacings in the horizontal mode correspond to an EED of 15 and 30 meters (49.2 and 98.4 feet). Terrain conductivity is basically the inverse of apparent resistivity and can be easily converted by dividing the conductivity value (milliSiemens/M) into 1000 for resistivity in ohm-m. McNeil (1980) provides a complete analysis of the theory and use of the EM-34.

Ground Penetrating Radar (GPR)

Ground penetrating radar (GPR) is a very effective method for mapping shallow subsurface features quickly. Basically, a radar beam is transmitted into the ground at a fixed frequency. As the signal passes down through the earth, part of the signal is reflected back to the surface and part continues to penetrate to deeper layers (figure 9). The energy that is reflected back to the surface is picked up by a receiver, processed, and converted to a graphic display. The graphic display shows two-way travel time in nanoseconds (nsec) versus horizontal distance. Interfaces between layers with different dielectric constants show up as three black bands on the strip chart. Generally the second black band is interpreted as the interface between layers (Geoscan, 1988; figure 10). The vertical time scale can be

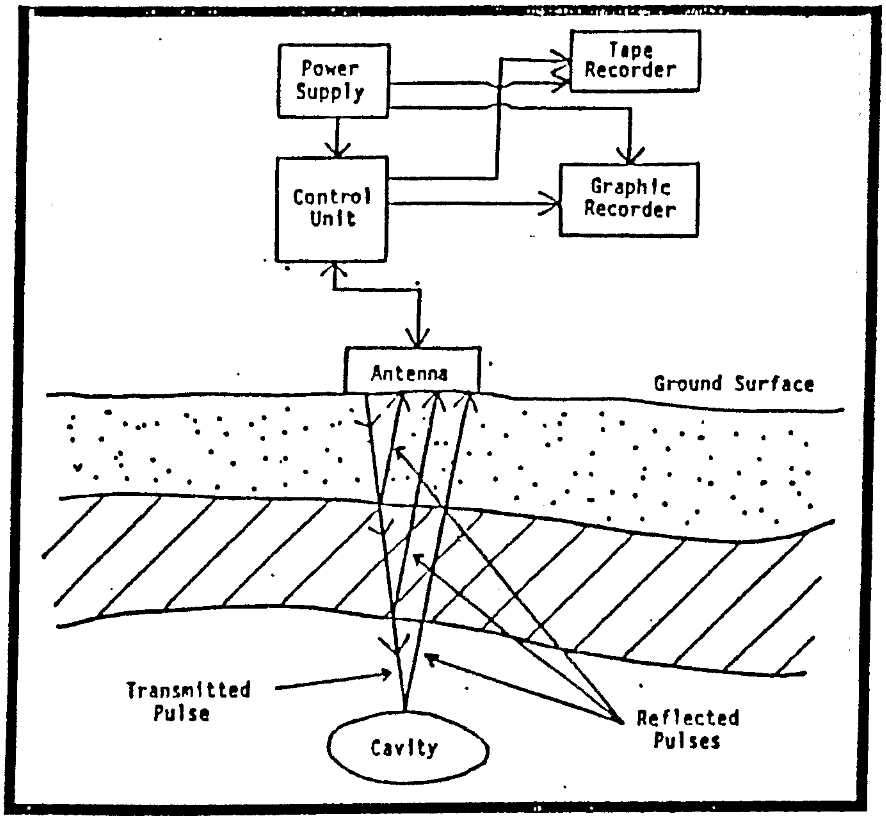
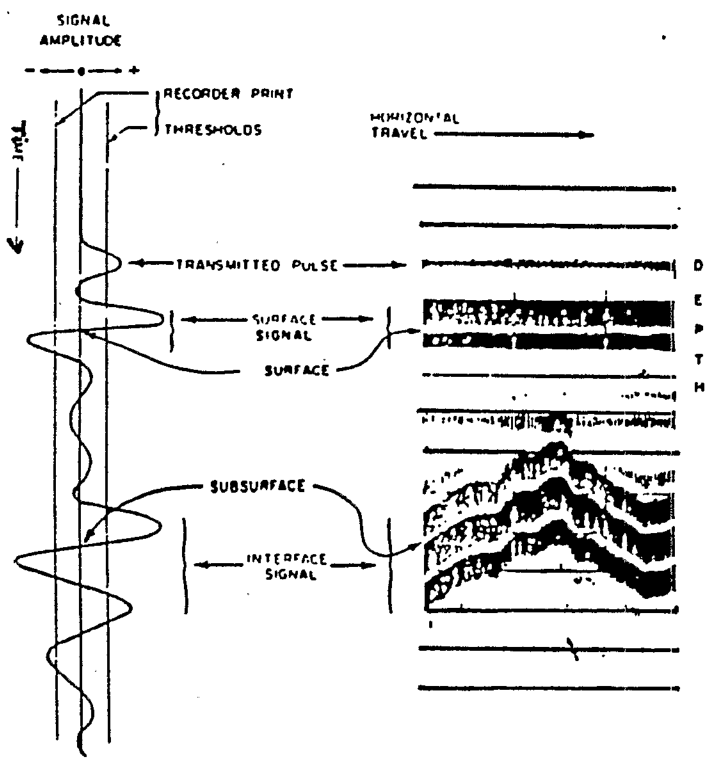


Figure 9. Functional diagram of GPR system. (from Geoscan, 1988)



Sketch of a single impulse and reflections as seen by the receiver.

Example of profile information as displayed by the graphic recorder.

Figure 10. The major features of a graphic GPR record. There are typically three dark bands produced at each interface. The reflections are produced when the radar signal crosses layers with different dielectric constants. (from Geoscan, 1988)

converted to a depth scale provided the velocity of propagation is known. The depth of penetration for a fixed frequency is related to the resistivity, degree of saturation, and dielectric constant (measured in electromagnetic units or emu) of the earth material. Depth of penetration is inversely proportional to the frequency of the transmitted signal. The general equation for the depth of penetration is:

$$D = ct/2(e)^{0.5}$$

Where e = dielectric constant (emu)
t = two way travel time (sec)
c = velocity of light (m/sec)

The approximate vertical scale conversion for a typical semi-saturated loose packed sand is 5 nsec/foot. If resistivity is known, the total exploration depth is approximately 0.3 meters per ohm-meter of resistivity. Therefore, a 300 nsec sweep of 100 ohm-m sediment yields 30 meters of total penetration. By towing the antenna along the surface of the ground, lateral changes in near-surface stratigraphy can be mapped. GPR works well in resistive environments, but the signal is strongly attenuated in conductive environments (refer to table 1). Clay layers often completely attenuate the signal. Two important concepts to understand are reflection-free zones and attenuation. Reflection-free zones are zones with no apparent interfaces to reflect the signal. They are typically "white", reflection free zones on the graphic display. Attenuation absorbs the downward propagating signal. Once the signal is completely attenuated, no further reflections can be recorded. On a graphic display the complete attenuation of the signal results in a reflectionless zone similar to a "true" reflection free zone. The difference is

Material	GPR Two-Way Travel time (ft/nsec)	Resistivity (ohm-m)	Conductivity (millimho/m)	Notes
Peat	0.25-0.50 dry 0.15-0.35 wet	10 to 100	10 to 100	Transparent to radar when dry. Highly conductive when wet.
Clay/Marl	0.125-0.20	1 to 10	100 to 1000	Attenuates radar. Conductive target for EM and VLF.
Silt	0.125-0.25	10 to 100	10 to 100	Produces some strong radar reflections. Moderately conductive.
Sand	0.20-0.35 dry 0.10-0.30 wet	20 to 10,000	.1 to 50	Can be reflection free when "clean" Resistor for HEP.
Limestone	0.10-0.20	40 to 2000	.5 to 25	Generally below the depth of exploration. Reflection free for radar.

Table 1. Common electrical properties of earth materials found at Starkey and Eldridge-Wilde wellfields. Note: GPR properties converted to two-way travel time.

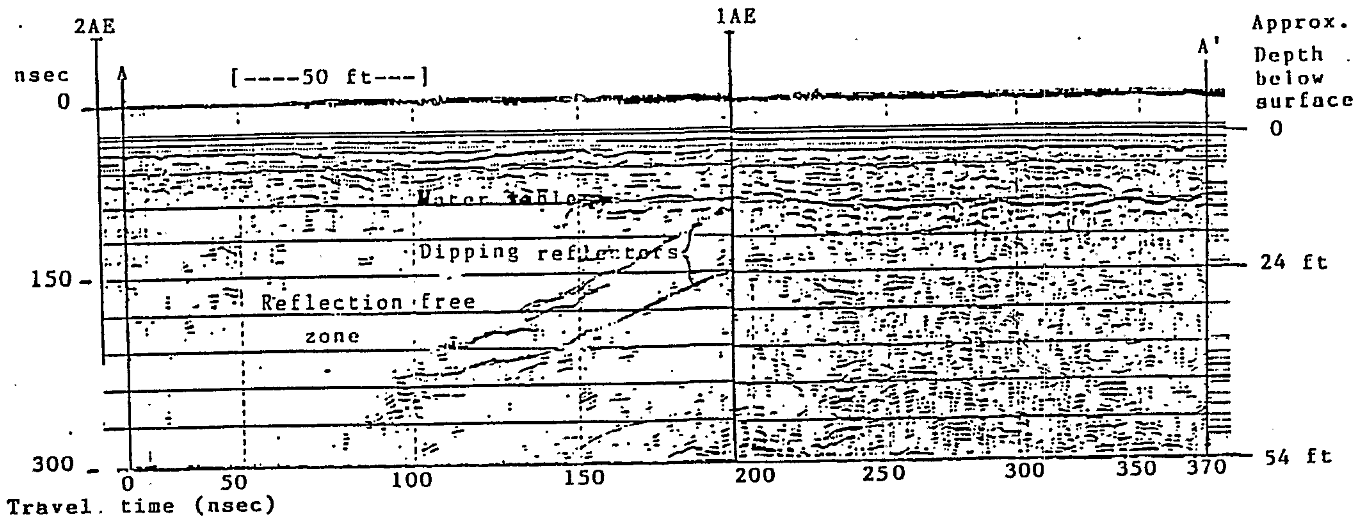
that signals can be returned from below a reflection free zone and can not below a reflectionless zone, ie complete attenuation.

For this study a 120 mHz antenna was used because it provides deeper penetration (lower frequency). However, the increased penetration of the 120 mHz antenna caused a decrease in the resolution, but since this study is concerned with large scale features the loss of resolution does not affect interpretations. The instrument was pulled by hand through the cypress dome and lateral distance was recorded on the graphic display. The graphic recorder/signal processor has a control which allows the total two-way travel time, recorded on the graphic display, to be adjusted to the specific conditions encountered at a site. During this study, the control unit was set so that the graphic display recorded either 200 or 300 nsecs of two-way travel time. Using a maximum average apparent resistivity of 100 ohm-m (none of the sites exceeded this average value) for conversion, the GPR unit was able to delineate features as deep as 30 meters or approximately 100 feet. Other controls on the recorder/signal processor were set to the specific condition encountered in the cypress domes.

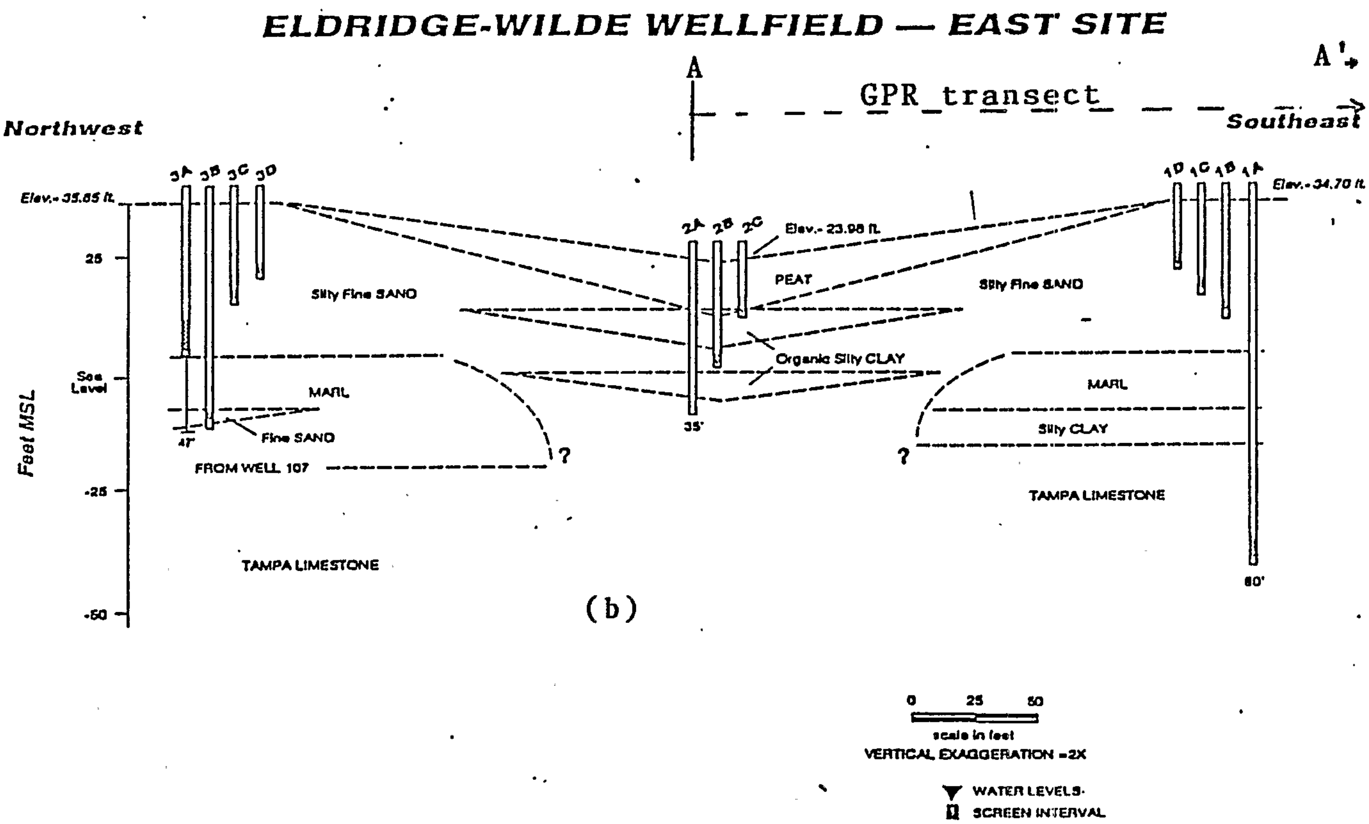
RESULTS: GPR

Calibration to known geologic profiles

Figure 11_a shows the 300 nsec sweep of EWE (an affected site) extending from the center of the dome near well 2AE (also refer to the geologic cross-section figure 11_b; A to A') to approximately 65 meters (213.2 feet) outside of the dome. The



(a)



(b)

Figure 11_a. 300 nsec sweep of EWE showing major features. (note: horizontal scale on 11a is not constant)

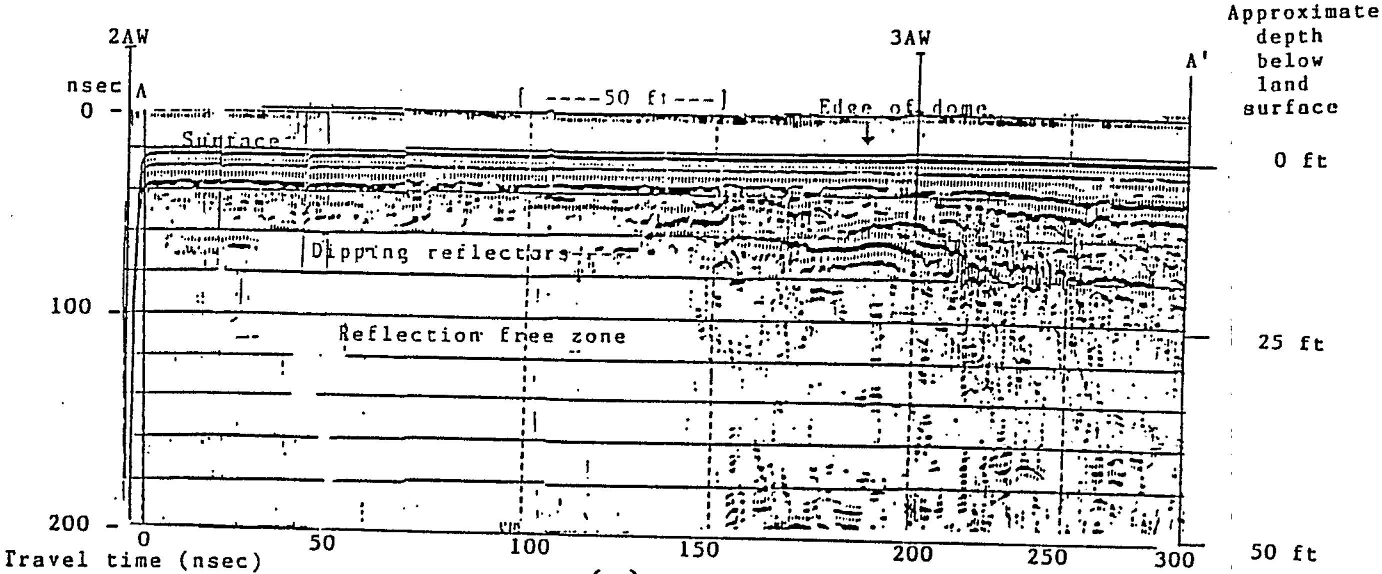
11_b Geologic cross section of EWE showing location of GPR transect A to A'.

most notable features of this line are: the surface at 30 nsec, the reflection-free zone near the center of the dome, the water table at 90 nsec, and the steeply dipping reflectors indicated on figure 11a.

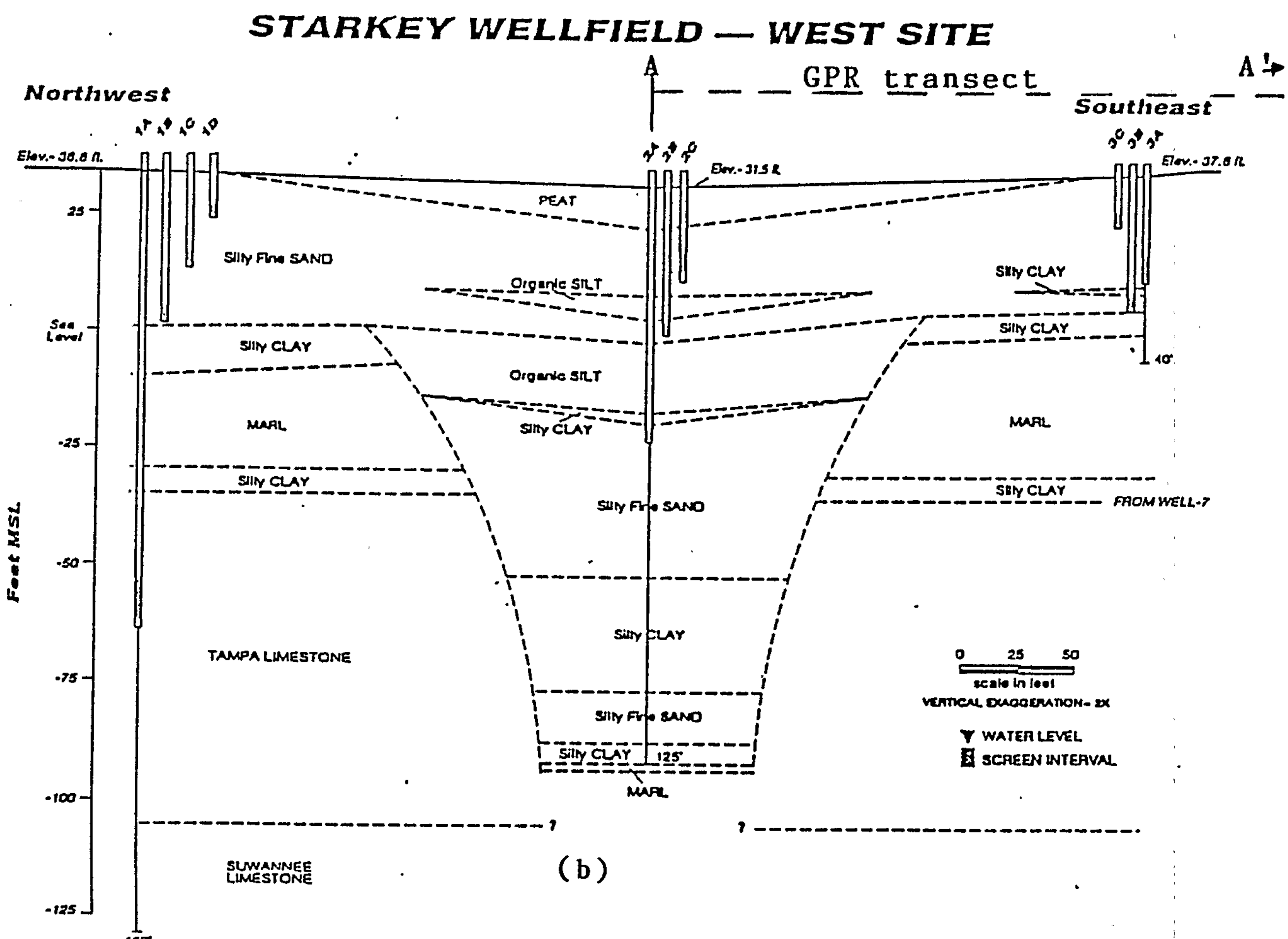
{Important note: the estimates of depth to reflectors contained in the remainder of the GPR section are intended to show approximate time-to-depth conversions and are therefore, only approximations. For studies requiring exact depth conversion, velocity of propagation must be determined directly. This can be done by measuring the dielectric constant in a laboratory or by determining the function (generally non-linear) which describes the changes in the dielectric constant with depth.}

Using 0.20 ft/nsec for conversion indicates that the water table is located at approximately 12 feet below land surface. 0.20 ft/nsec is a good first approximation for depth conversions on radar lines conducted over the types of sediments encountered at Starkey and Eldridge-Wilde wellfields (personal communication Bill Wilson Sinkhole Research Institute, refer to table 2). This correlates well with "true" depth to the water table, 13 feet, calculated from the hydrographs of well 1BE in late May, 1988 (appendix A). Notice the steeply dipping reflectors between 100 and 200 feet east from well 2AE. The dipping layers lie approximately 180 to 240 nsec below the surface. Using the same conversion factor (0.20 ft/nsec), the depths to the upper reflector is approximately 30 feet below the surface and the lower reflector approximately 42 feet below land surface. The well log from 1AE, which is east of the reflectors on figure 11b, indicates that a silty sand/marl interface is located at 33.5 feet below the surface and a marl/silty clay interface is located 48.0 feet below the surface (figure 11a and appendix B). The close correspondence between the interfaces and the reflections on the profile provides a high degree of confidence in this interpretation. Furthermore the depth conversion factor chosen for this dome appears to be within 5 percent of the true average velocity.

Figure 12a is a 200 nsec sweep of STW (an affected site) which starts near well 2AW (also refer to geologic cross-section figure 12b; A to A') and terminates approximately 100 feet outside of the dome. The most obvious features are the ground surface at 20 nsecs, the water table at 50 nsecs, the dipping reflectors that terminate at 100 feet from 2AW and at approximately 80 nsecs, and the zone with no reflections near the center of the dome (below well 2AW). Average resistivity is about 100 ohm-m from the HEP survey which should yield a higher average velocity of about 0.25 ft/nsec. This is slightly faster than EWE because the average resistivity is higher. In late May the water table at well 3AW was approximately 10 feet below the land surface (appendix A). Using an estimated average velocity of 0.25 ft/nsec, the depth to the water table is calculated to be approximately 7.5 feet. The calculated depth is slightly less than the actual depth below land surface, therefore the velocity might be sightly higher in the unsaturated zone. The dipping reflectors, between 60-80 nsecs indicated on figure 12a, do not correspond to any known layers (well log 3AW), and therefore may



(a)



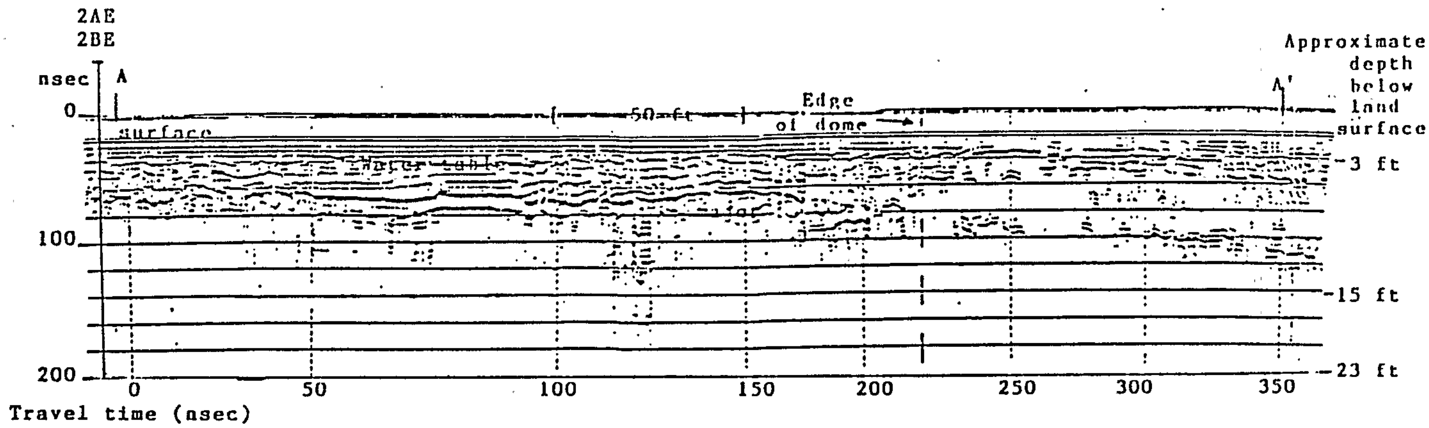
(b)

Figure 12a. 200 nsec sweep of STW with major features indicated.(note: horizontal scale not constant).

12b. Geologic cross section of STW showing location of GPR transect A to A'.

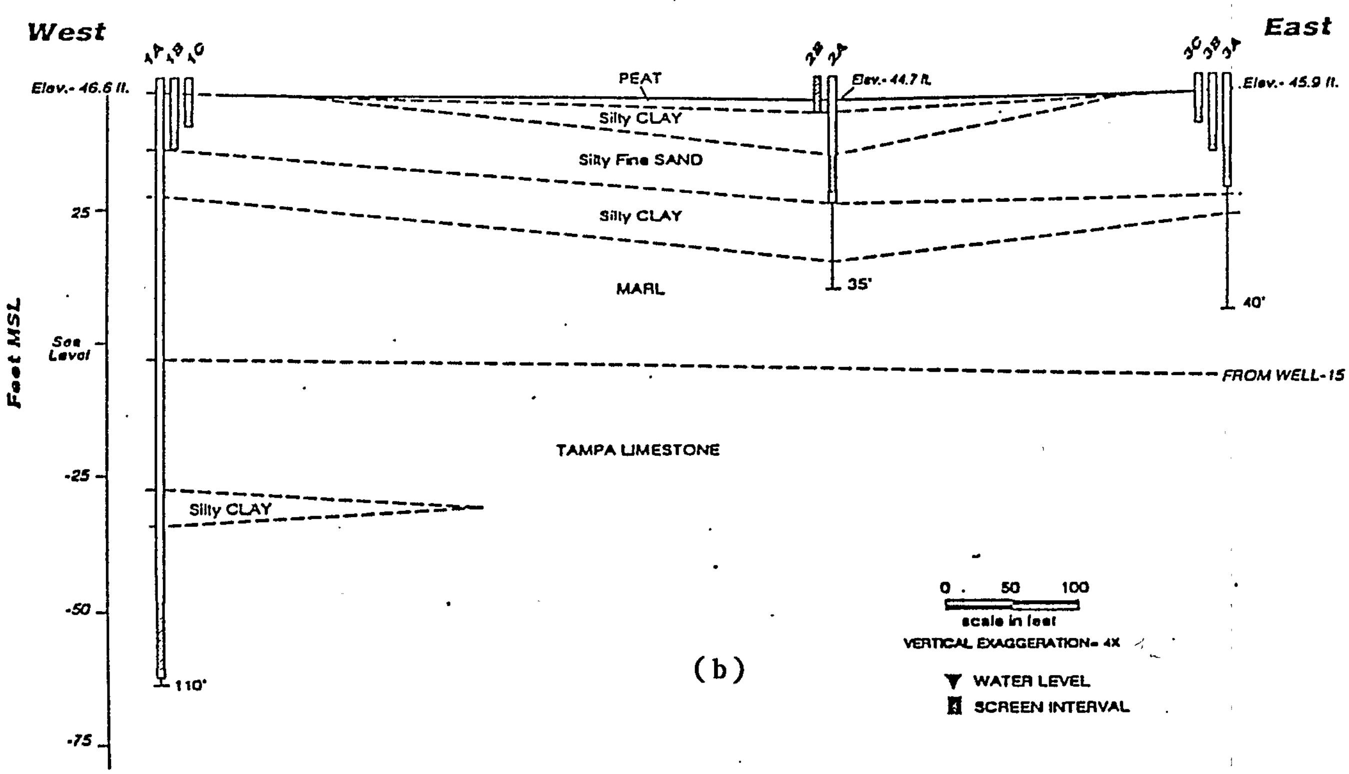
represent thin clay/silt layers which were not detected during well logging. The reflectors at 180 nsecs correspond to the silty clay/marl interface, from well log 3AW, when the velocity is reduced to 0.20 ft/nsec (Figure 12a,b). (Note: The HEP apparent resistivity profiles for STW show a general decrease in resistivity with depth therefore it is reasonable to adjust the velocity accordingly.) Using 0.20 ft/nsec velocity, for depth to time conversion, the depth to the interface is calculated as 32 feet which is very close to the 34 feet below land surface value from well log 3AW. The zone with no reflections near the center may be a reflection-free zone, however no coherent reflections are visible below this zone. The absence of further reflectors suggests that the signal may have been completely attenuated. There are a series of organic silty layers indicated on the well log 2AW (appendix B) that may have caused attenuation of the signal; however, there is no way of determining the cause without further GPR surveys. It is sufficient to note the zone may be an attenuated or reflection free zone for reconnaissance type surveys.

Figure 13a is the 200 nsec profile taken at STE (an unaffected site) from the ET station in the middle to 115 feet outside of the dome. The important features to note are: the surface at 20 nsecs, the water table at 45 nsecs, the strong reflector at 70 nsec, and the attenuated zone below 80 nsecs. The average resistivity of STE is much lower than either EWE or STW and therefore the average velocity is expected to be less. Using an estimated average velocity of 0.125 ft/nsec yields a



(a)

STARKEY WELLFIELD — EAST SITE

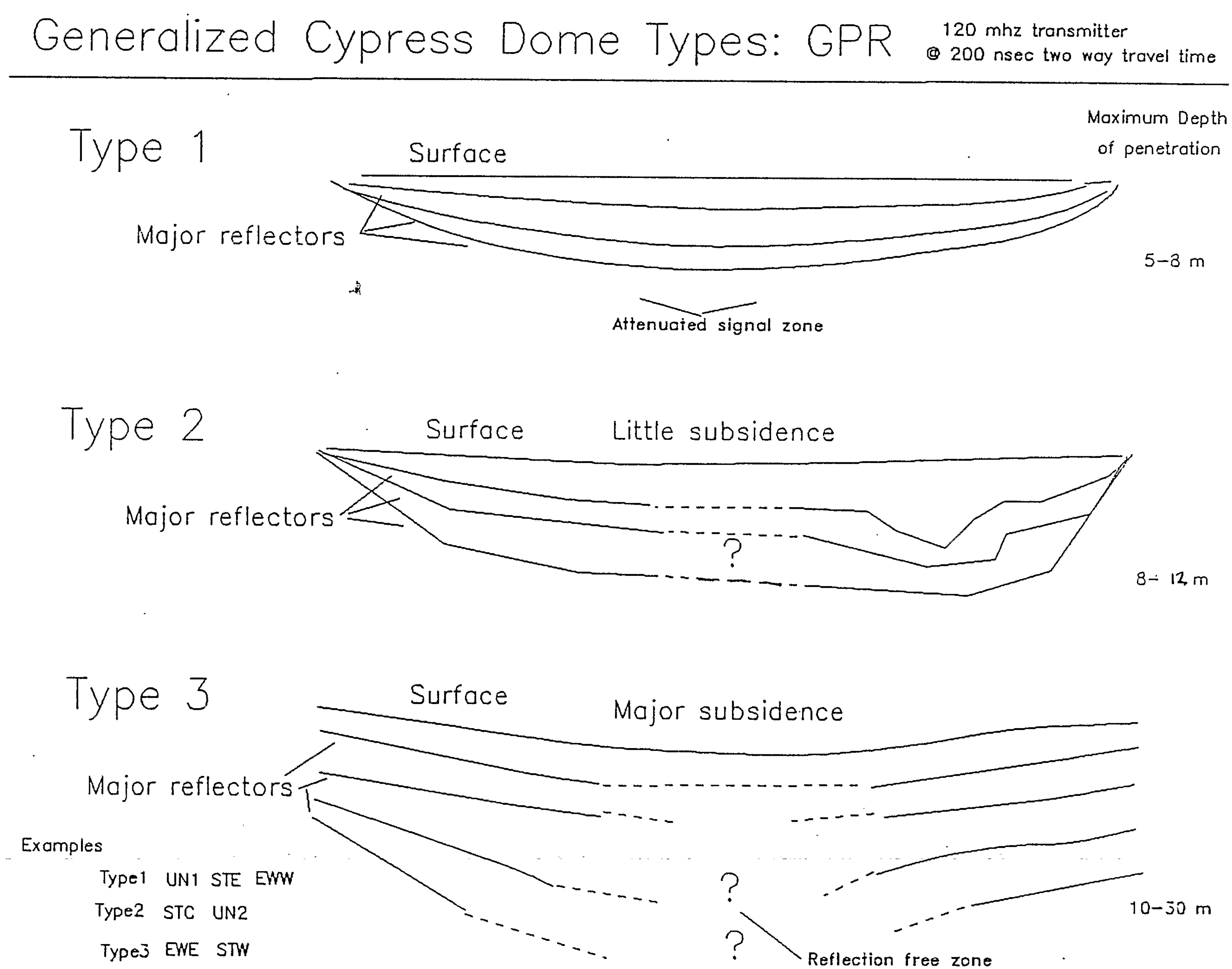


(b)

Figure 13a. 200 nsec sweep of STE with major features indicated. (note: horizontal scale is not constant)

Figure 13b. Geologic cross section of STE with wells indicated. (note: the cross section is not co-planer with the GPR profile) depth of 3 feet below the surface for the water table. The hydrograph for well 2BE in late May indicates that the water table was approximately 2.75 feet below land surface (appendix A). Therefore 0.125 ft/nsec is a good approximation of the average velocity. The depth to the strong reflector at 70 nsecs is calculated to be 6.25 feet. According to well log 2AE the silty clay unit changes from stiff to very stiff at approximately 7.5 feet (refer to figure 13a and appendix B). The interface on the GPR profile, figure 13b, may represent this change in clay compaction. The upper silty clay unit is approximately 6.5 feet thick which would tend to completely attenuate the signal. This is suggested as the reason for the attenuated zone below 80 nsecs.

It is clear from these three sites with known geology that there are significant differences between the two types of domes. Figure 14 shows the relationships that distinguish the affected from unaffected cypress domes on GPR profiles. The differences as noted on the three calibration GPR profiles characterize type 1 and type 3 cypress domes which correspond to unaffected and affected domes respectively. A third type which is distinguishable from the other two (type 2) was discovered during the analysis of the domes with withheld geologic data. It is, however, essentially a type 3 dome. The important features of the type 3 dome (an affected site) include; a reflection-free or attenuated zone near the center which is surrounded by reflections on either side (only on one side if the line did not cross the entire dome), steeply dipping reflections, and a

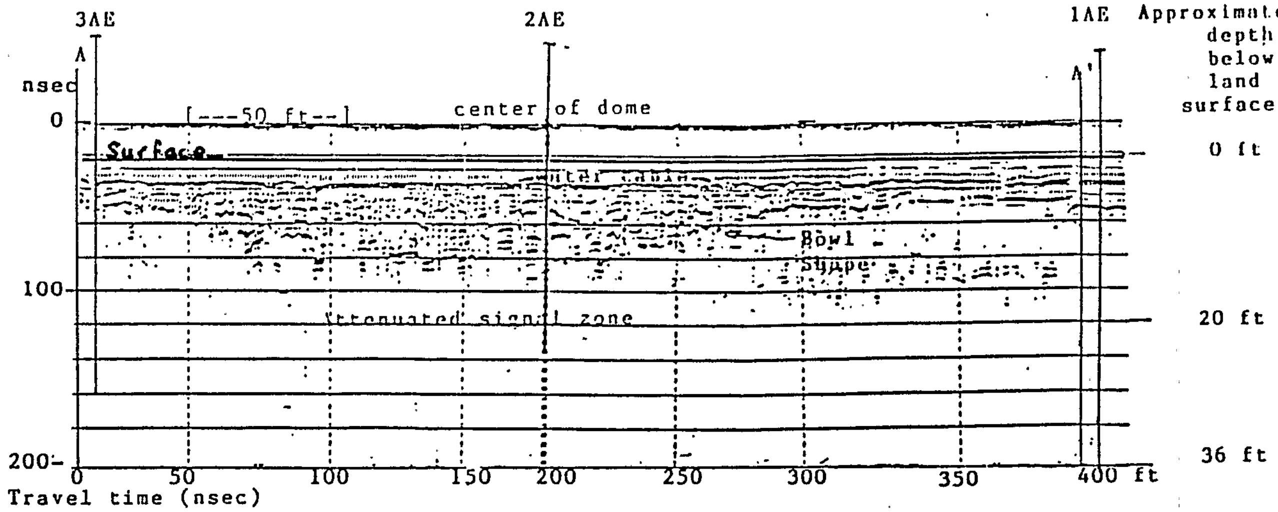

Generalized Cypress Dome Types: GPR
120 mhz transmitter
@ 200 nsec two way travel time
Maximum Depth
of penetration
Type 1
Surface
Major reflectors
5–8 m
Attenuated signal zone
Type 2
Surface
Little subsidence
Major reflectors
?
8– 12 m
Type 3
Surface
Major subsidence
Major reflectors
?
?
Reflection free zone
10–30 m
Examples
Type1 UN1 STE EWW
Type2 STC UN2
Type3 EWE STW

relatively high velocity for the radar signal (as determined from comparison to well log data or hydrographs). The important features of a type 1 dome (an unaffected site) are; generally shallow penetration of the signal which terminates in a bowl shape below the dome, continuous reflections across the entire dome with no abrupt terminations, and a generally lower average velocity for the signal propagation.

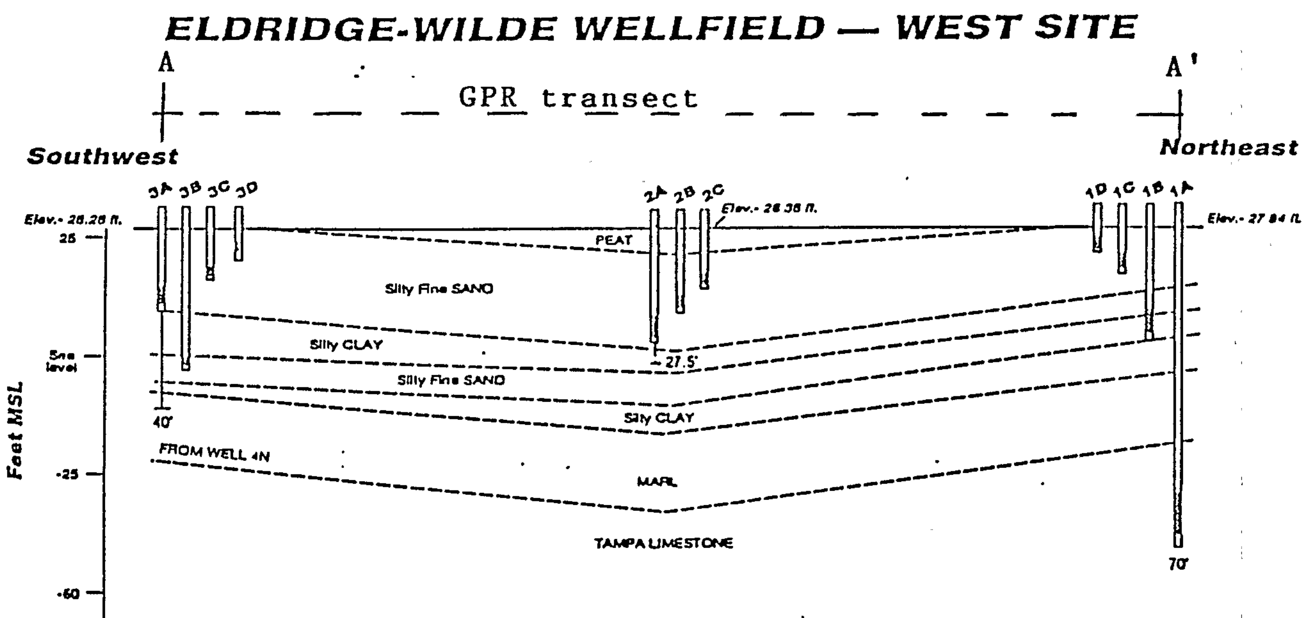
Comparison of GPR types to withheld geologic profiles

Figure 15a shows a 200 nsec sweep of EWW from the southwest near well 3AW to the northeast and well 1AW (also refer to figure 15b). The general features of this profile are the shallow depth of penetration indicated by the termination of reflectors below 80 nsecs, and the bowl shape of the reflection pattern. Also note the generally shallow dip of the reflectors, especially near the center of the dome. These features indicate that this is a type 1 dome.

Following the interim report the previously withheld geologic logs and profiles for site EWW were released (figure 15b and appendix B). Using an estimated approximate velocity of 0.20 ft/nsec to convert to depth, shows that this profile shows no major reflections below approximately 20 feet. Evidently the signal was completely attenuated by the silty clay layer which has an average depth of about 22 feet below the surface. The clay layer is shallower near the edges which may account for the general bowl shape of the reflections. The absence of steeply-dipping or laterally-terminating reflectors is substantiated by the well logs provided in the interim report (appendix B).



(a)



(b)

Figure 15a. 200 nsec sweep of EWW with major features indicated. (note: horizontal scale is not contant)

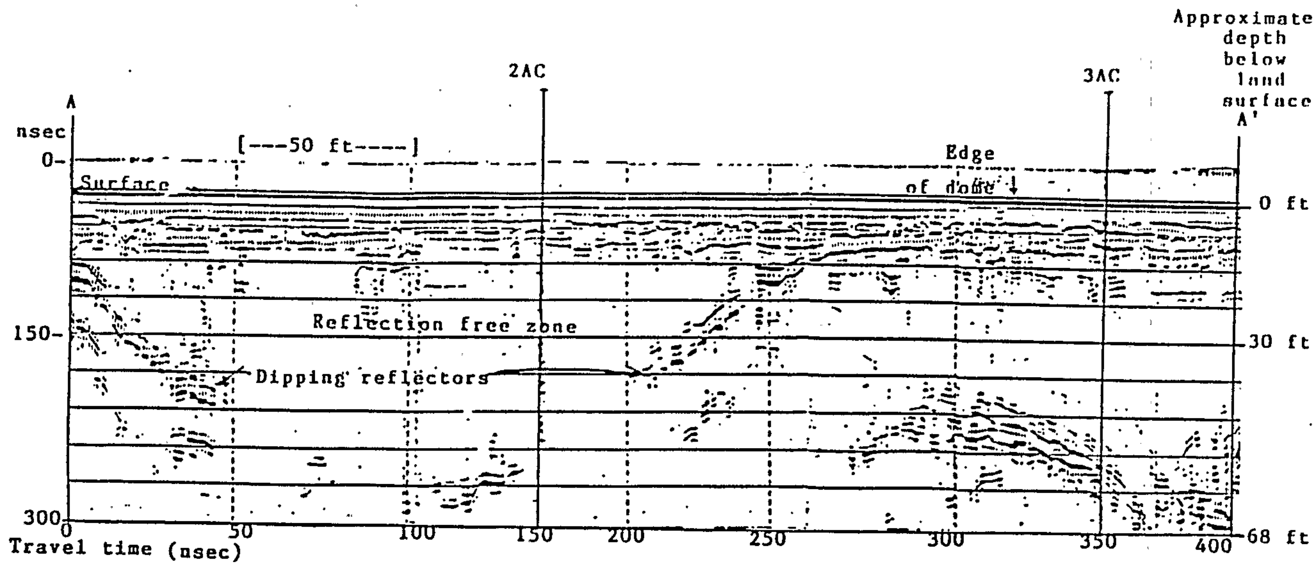
15b. Geologic cross section of EWW with location of GRP transect.

Figure 16a is a 300 nsec sweep of STC. The most notable features are the steeply-dipping reflectors and the reflection-free zone near the center of the dome. These features indicate that this is a type 3 dome, however the reflectors do not terminate near the center as they do in the profiles from STW and EWE. The interim report indicates that this is a sink type dome (figure 16b and appendix B) and the reflection pattern is similar to the type 3 dome, however the presence of continuous reflections below the center of the dome indicates a type 2 GPR signature (refer to figure 14). There are no layers indicated on figure 16b which correlate with the deep reflections because they are below the depth which well 2AC was logged. For the purposes of this report type 2 and 3 are geologically similar cypress domes which appear slightly different on radar lines. Type 2 domes may represent an intermediate stage in the development of fully developed sinkhole systems represented by type 3.

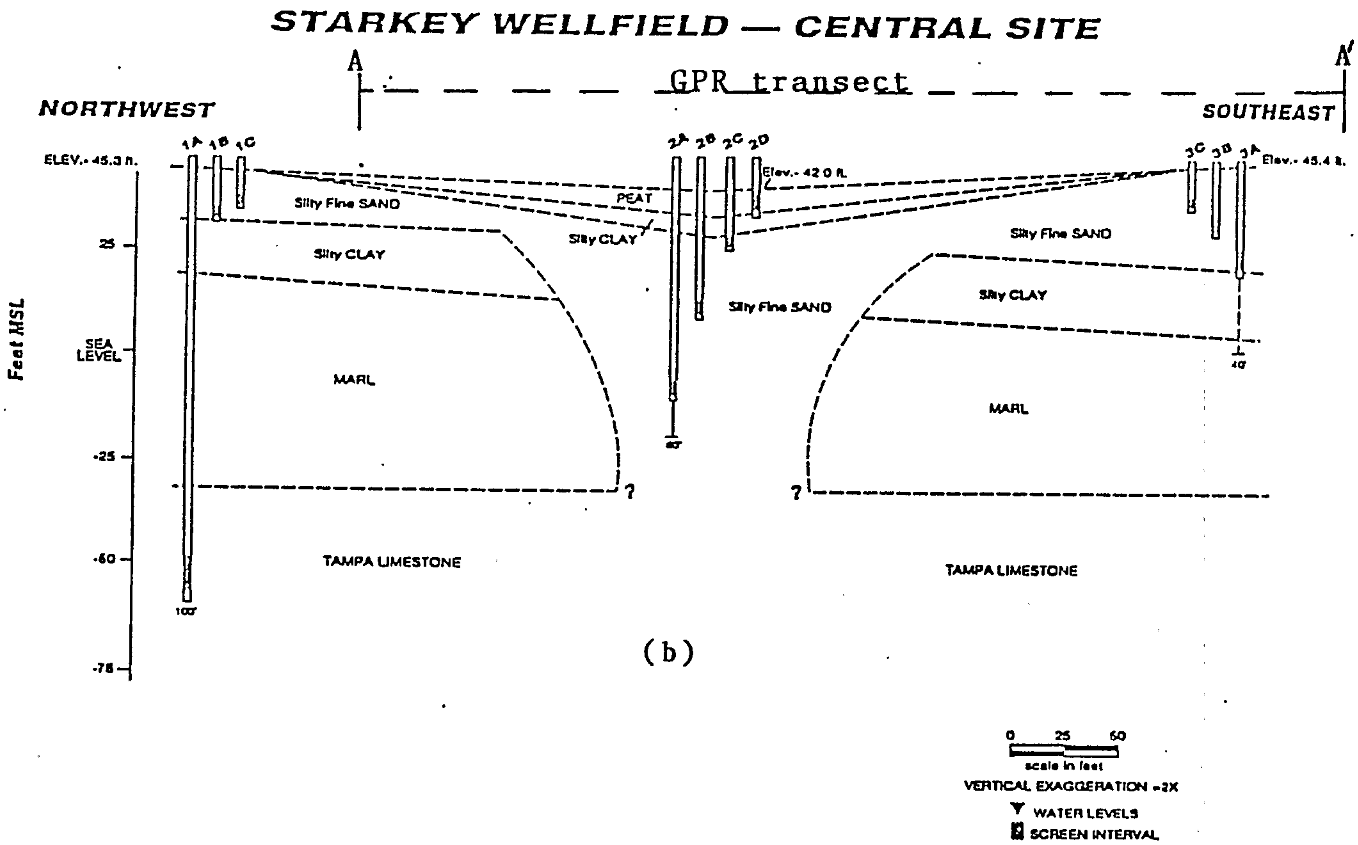
Figure 14 shows the three types of domes as seen on the GPR profiles. Notice that the type 2 appears to be a transitional form between type 1 and type 3. Both the type 2 and type 3 domes are clearly subsidence domes and are easily distinguished from type 1 domes. Type 1 domes are shallow depressions and the profiles graphically display this feature.

GPR interpretation of unknown cypress domes

Figure 17 is a 200 nsec sweep of UN2 from the southwest to the northeast. The most obvious features of this profile are the steeply dipping reflectors and the reflection-free zone near the center. These features along with the presence of reflections



(a)



(b)

Figure 16a. 300 nsec sweep of STC showing major features. (note: horizontal scale is not constant)

16b. Geologic cross section of STC showing location of GPR transect A to A'.

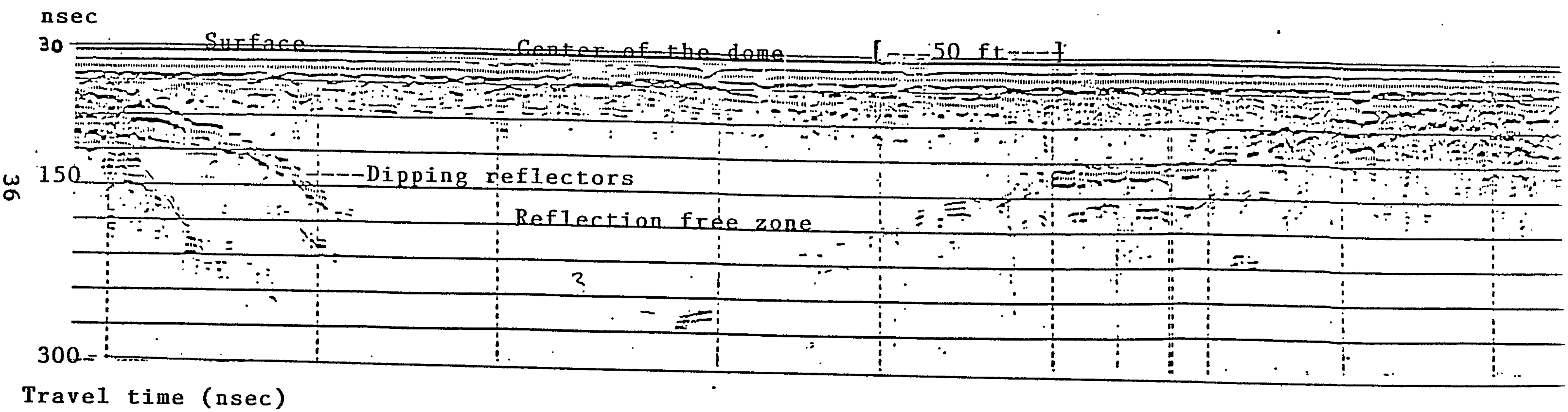


Figure 17. 300 nsec sweep of UN2 cypress dome with major features indicated.

beneath the reflection free zone indicate that this is a type 2 dome. The reduction in hydroperiod that this dome has experienced in recent years seems to support this conclusion.

Figure 18 is the 200 nsec sweep of UN1 from the inside of the dome (northeast) to the outside (southwest). The general reflection pattern is that of a bowl shape with very shallow penetration (using the approximate 5 nsec/ft conversion). These features indicate that this is a type 1 dome. The general health of the dome seems to support this conclusion.

RESULTS: LLEM

The EM-34 surveys of the sites with known geologic conditions (STE,STW, and EWE) resulted in terrain conductivity profiles that lack any unique or distinctive anomalies which could be used to classify the domes. McNeil (1980), modelled EM-34 responses to various geologic settings, however none of the models match the geologic conditions at the affected domes. Therefore, matching the responses to known geologic settings (and the corresponding EM-34 signitures) was not possible. Figures nineteen and twenty are EM-34 profiles of STE (unaffected) and EWE (affected) respectively. Notice the high frequency fluctuations and lack of any distinguishing features which might be correlated with the known geology. While the EM-34 is an excellent tool for many shallow exploration geophysical surveys it may not be suited for use in the well field environment. Probably the greatest problem to plague the surveys was the interference caused by the electromagnetic fields from the large

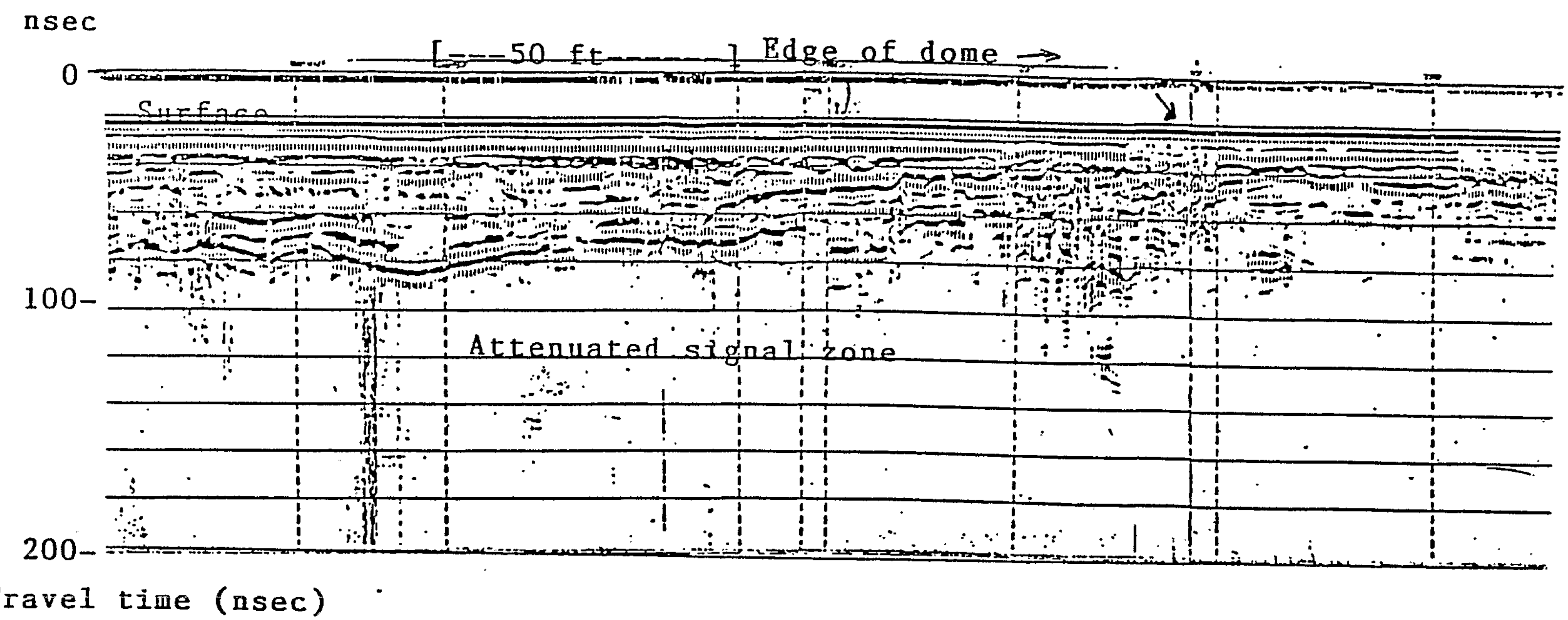


Figure 18. 200 nsec sweep of UN1 cypress dome with major features indicated.

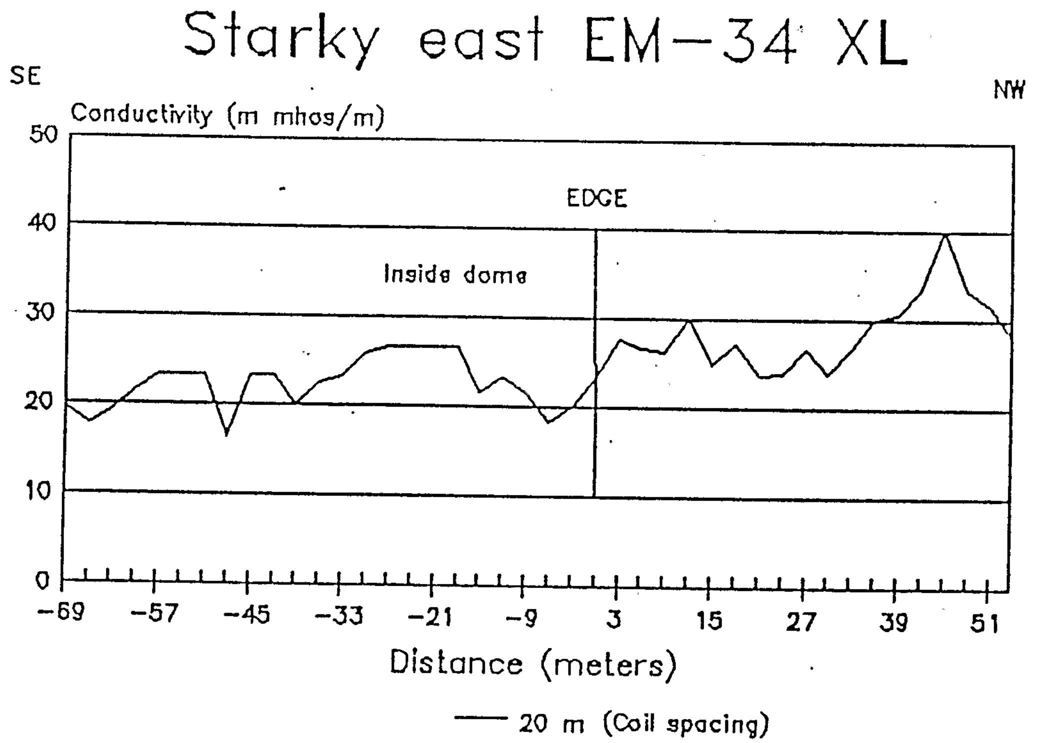


Figure 19. EM-34 profile of STE.

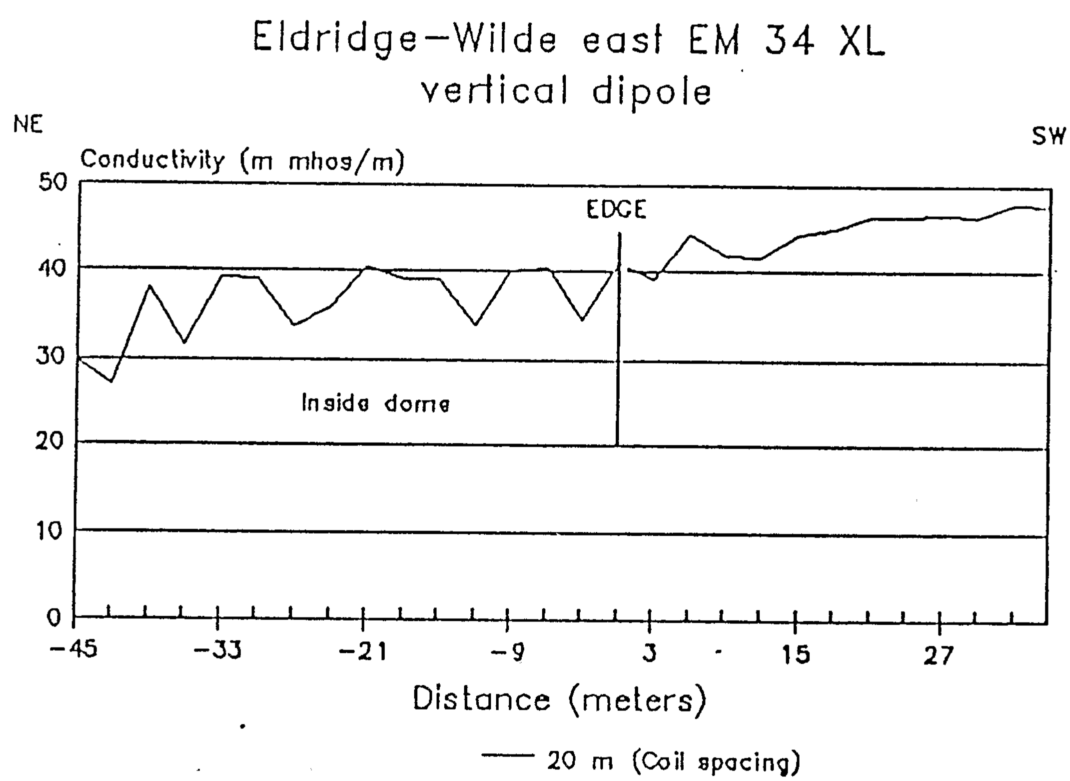


Figure 20. EM-34 profile of EWE.

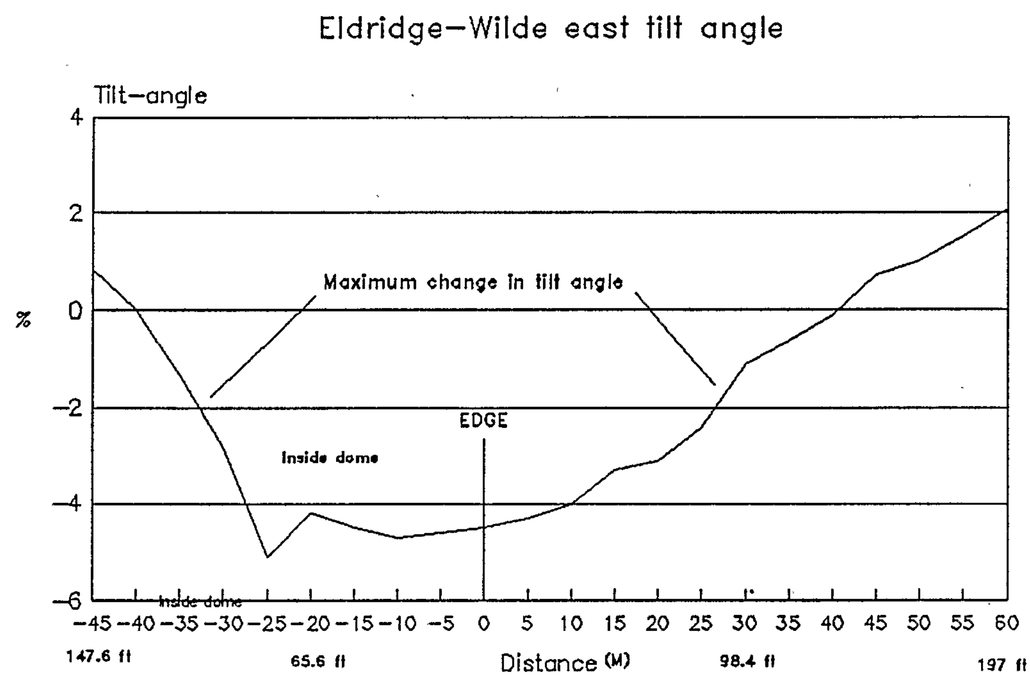
unshielded electric motors used for pumping ground water. The resulting local electromagnetic fields made using the 40 meter coil separation impossible. The 10 and 20 meter separations were less prone to the effects of the electric motors, but resulted in basically uninterpretable data in the context of this study. More specifically, it was not possible to identify distinctive anomalies on the profiles and associate them with any degree of certainty to specific geologic conditions. This is probably due to the complex near surface stratigraphy of the cypress domes which produced many overlapping anomalies. Therefore, the resulting profile represented the average of a number of different anomalies and was not indicative of the overall structure of the dome. It's possible that the 40 meter (131.2 foot) coil separation would have been less prone to this problem because of the increased effective exploration depth, however it was not possible to test this hypothesis.

RESULTS: VLF and HEP

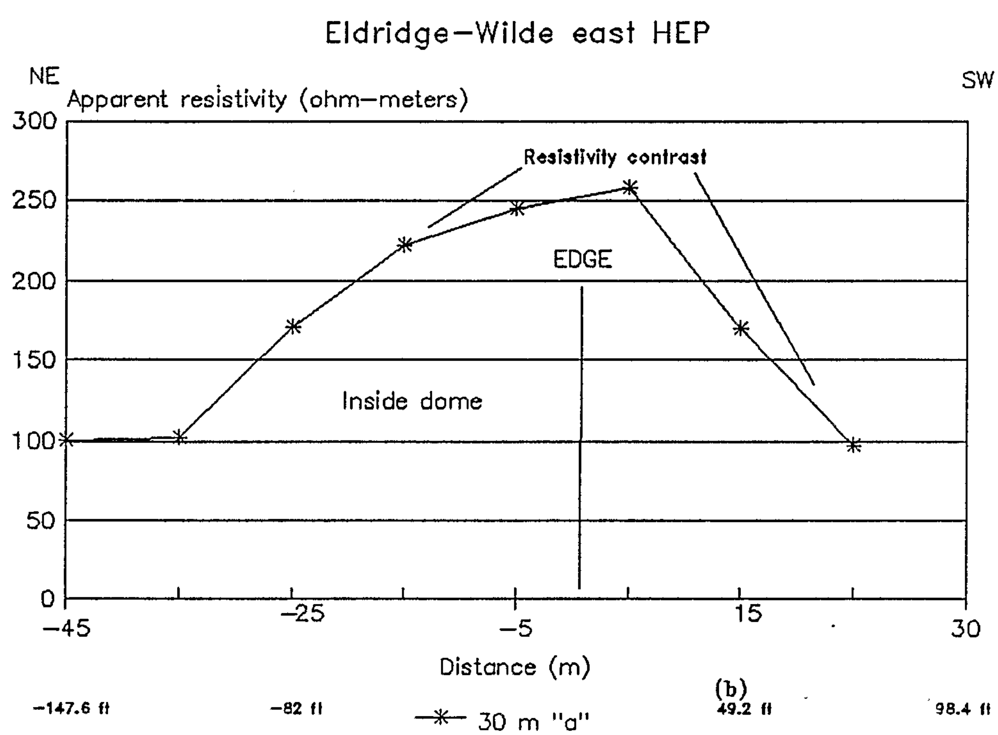
The VLF and HEP surveys are considered together because neither method could be used alone to produce reliable results. The VLF resistivity measurements did not produce recognizable geophysical signatures (possibly due to shallow penetration), and therefore are not considered a plausible method for determining cypress dome type.

An apparent change in resistivity at depth produces the tilt angle anomaly shown in figure 8 of the preceeding section. This figure represents an ideal case in which the change in resistivity is a vertical boundary. Most field conditions are much more complex, and therefore the resulting anomalies are often difficult to interpret. A HEP profile from left to right across the same vertical contact would show a simple increase in apparent resistivity, which would correspond to the subsurface increase in resistivity. To simplify interpretations in this study, sinkhole-type domes are assumed to have an abrupt resistivity contrast with the surrounding undisturbed sediments. Complicating factors that change the shape, or number of anomalies, were simply ignored or removed visually in the interpretation process, and the overall character of the profiles examined. Therefore, the VLF and HEP of the sinkhole type domes should produce recognizable anomalies based on an assumed resistivity contrast. This convention is derived from the geologic cross-sections of the cypress domes which show generally thicker sand columns in the sinkhole-type domes, replacing the collapsed or absent marl/silty clay confining layer, which generally lies just above the Tampa limestone (refer to figures 11a, 12a, and 16a). The depth, thickness, and number of intervening clay/marl/organic silt layers is critical for this assumption because they tend to lower the apparent resistivity measured at the surface (refer to table 1). Where lower resistivity layers are absent, the sand-filled sinkhole represents a higher apparent resistivity target, when compared with the surrounding undisturbed sediments. However, in cases where a number of thin, lower resistivity layers are present in the sand column, the apparent resistivity measured at the surface will be reduced and the contrast with surrounding sediments negated (refer to figure 11a). Therefore, it is possible for some sinkhole-type domes to have no apparent resistivity contrast with the surrounding undisturbed sediments, and thus, appear to be a shallow depression-type domes on either the VLF or HEP surveys. This is known as the problem of equivalence and is the main reason why supporting data from other geophysical methods, and/or drillers log information is necessary for reliable determination of cypress dome type with either VLF or DC resistivity methods.

Figure 21a shows tilt angle and figure 22b the 30 meter (98.4 foot "a" spacing) HEP profiles for EWE an affected site. The 30 meter "a" profile has an effective exploration depth (EED) of 18 meters (59 feet). With this EED, the marl layer or the sand/organic silt layers replacing the marl (near the center of the dome), compose approximately 50% of the total thickness being measured and therefore contribute a significant amount to the apparent resistivity measured at the surface (refer to figure 11a). The HEP profile shows a general increase in apparent resistivity toward the edge of the dome (from the outside and inside), which corresponds with termination of the marl due to karst subsidence. The apparent resistivity drops toward the center of the dome because the organic silty clay layers indicated on the geologic cross section, are thicker and compose a greater percentage of the EED. The tilt angle profile in figure 21a shows a minimum value near the edge, and has maximum relative change in percent tilt on either side of the edge. This



(a)



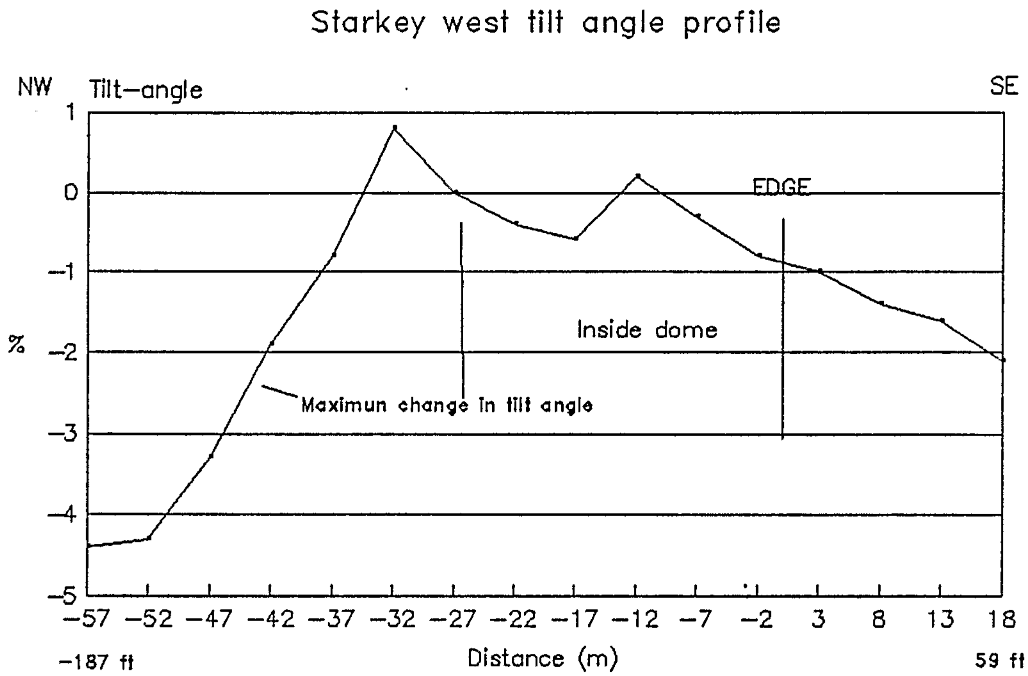
(b)

Figures 21a (upper) and 21b (lower). VLF tilt angle and HEP apparent resistivity profiles.

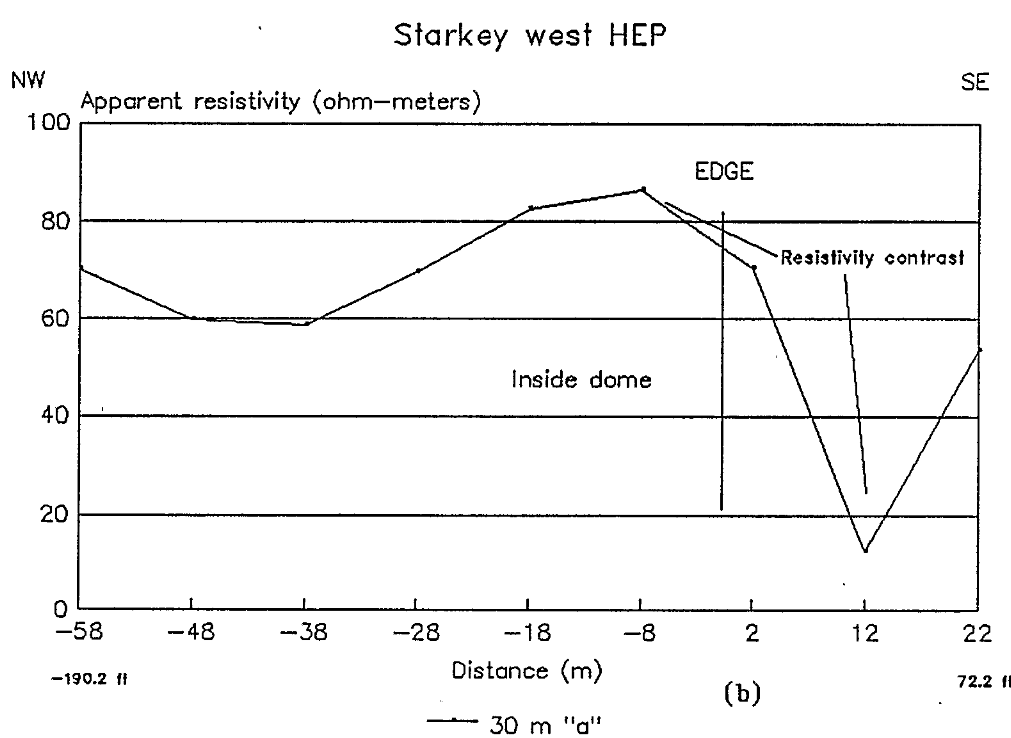
corresponds with figure 8, however the sign of the tilt angle is different because VLF is a directional geophysical method (by directional method we mean that the sign of the tilt angle is dependent on the survey orientation relative to the transmitter and to the vertical structure). Therefore, the sign can be ignored because the general shape and position of the anomaly provides the pertinent information.

Figure 22a shows the tilt angle and figure 22b the apparent resistivity profiles for STW an affected site. The 30 meter "a" HEP profile shows a general increase in resistivity into the dome. This increase corresponds with the termination of the marl/silty clay layer (from the geologic cross section figure 12a) which occurs just east of the edge on figure 22b. Comparing figure 22b with 21b shows the similarities in responses of the affected sites. The only major difference between the HEP responses (21b and 22b) is that the apparent resistivity decreases toward the center of the dome on 21b and not on 22b. This suggests that the organic silty clay layers in-filling the sinkhole at STW are either not as resistive (less clay) as they are at EWE or they represent less of the total EED (figure 12a).

Figure 22a is the tilt angle response at STW. In general, the response corresponds with the tilt angle profile of EWE, which indicates the sediments in-filling the sinkhole display an apparent resistivity contrast with the surrounding undisturbed sediments. As in figure 21a the maximum relative change in tilt angle occurs on either side of the edge of the dome ie. change in resistivity. The tilt angle response of STW approximates the



(a)



(b)

Figure 22a (upper) and 22b (lower). VLF tilt angle and HEP apparent resistivity profiles.

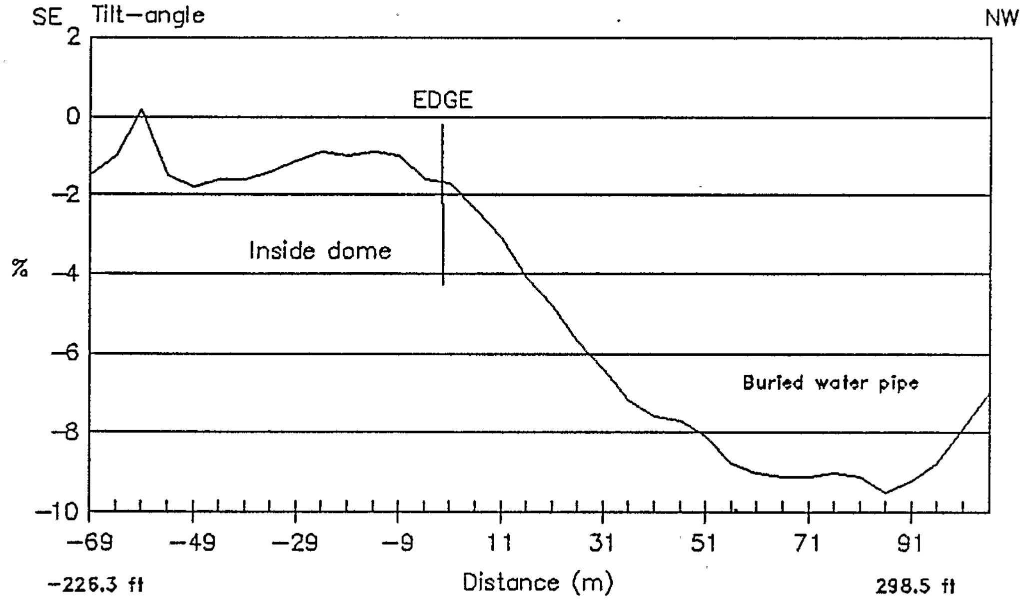
modelled response shown in figure 8. Therefore, comparison of figures 22a and 22b with the expected modelled responses, reveals the presence of a vertical resistivity contrast, which suggests that STW is a sinkhole system. This conclusion is supported by the geologic cross-section of STW, figure 12a.

Figures 23a and 23b are tilt angle and 30 meter "a" HEP profiles of STE an unaffected site. The 30 meter "a" HEP profile shows a strong apparent resistivity contrast between the inside of the dome, approximately 40 ohm-m, and the outside, approximately 80 ohm-m average. The contrast indicated on figure 23b suggests that STE is a sinkhole-type dome, however the geologic cross sections show STE as a simple shallow depression in the surficial sand unit (refer to figure 13a). The increase in resistivity may be due to thickening of the surficial sand unit away from the dome.

Figure 23a is the tilt angle response at STE. The response is generally flat inside the dome, however the tilt angle changes dramatically from 8 to 51 meters (26 to 168 feet) outside of the dome. This change is not entirely due to geologic factors, but rather, represents the tilt angle response to a large steel water pipe buried approximately 90 meters (295 feet) from the edge of the dome. The increase in apparent resistivity indicated by figure 23b probably adds to the response caused by the water pipe. Therefore, the tilt angle response minus the water pipe affects would be relatively flat.

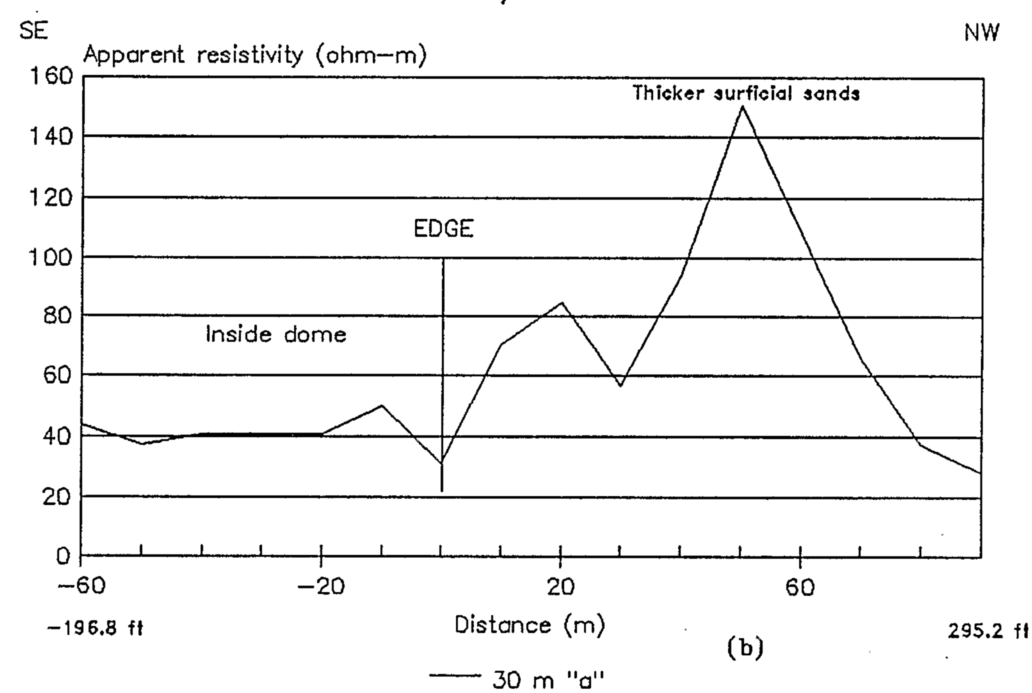
Analysis of the three cypress domes with known geologic cross-sections indicates that neither the VLF tilt angle, or the

Starkey east tilt angle



(a)

Starkey east HEP



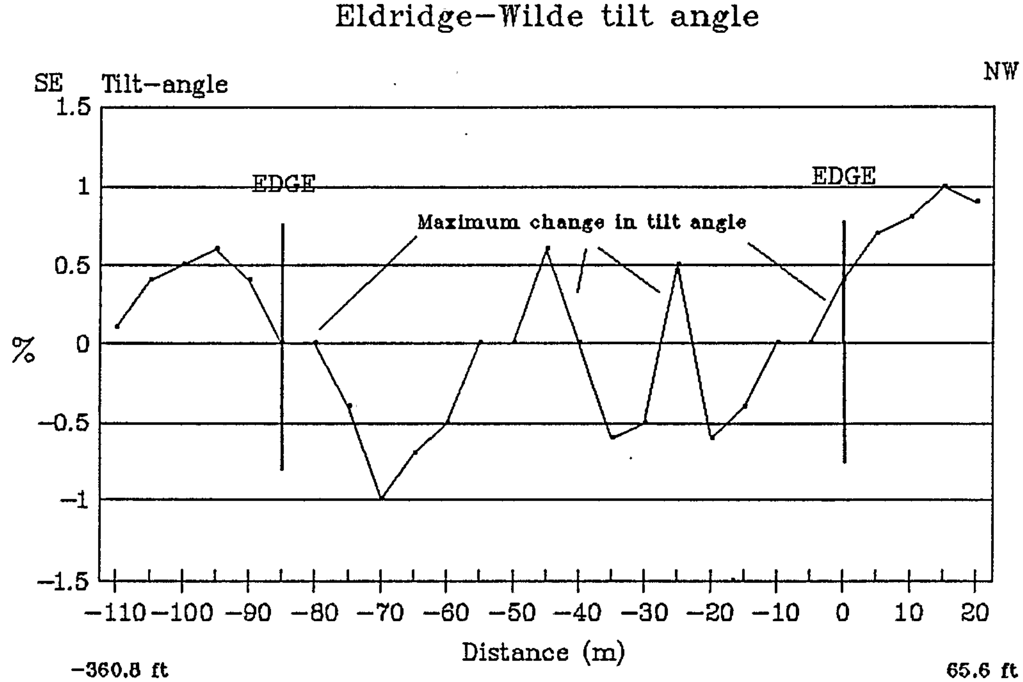
(b)

Figure 23a (upper) and 23b (lower). VLF tilt angle and HEP apparent resistivity profiles.

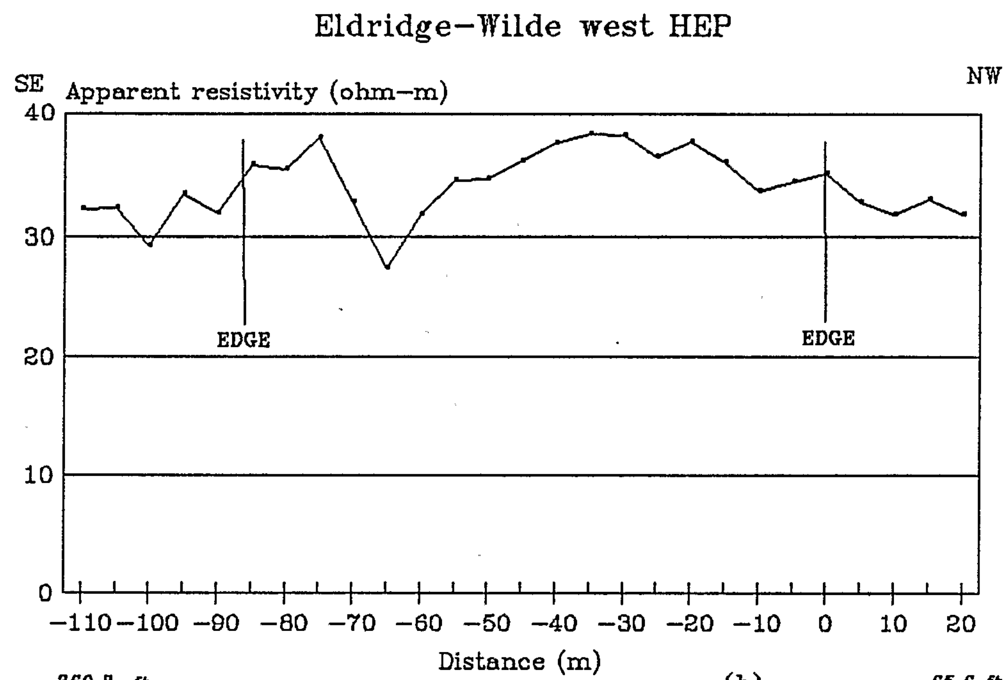
HEP apparent resistivity surveys, when considered alone, provide reliable estimation of cypress dome type. However, further analysis indicates that when a moderate to strong resistivity contrast exists between the sediments in-filling the karst subsidence features (affected domes), and surrounding undisturbed sediments, VLF tilt angle and HEP profiles display characteristic responses. For the tilt angle profiles, the characteristic anomaly is shown in figure 8. The HEP anomaly associated with the affected domes is an abrupt change in apparent resistivity near the edge of the dome. When both, the VLF and HEP, anomalous responses occur, at a site with unknown geology, there is better than a 50% probability that the site is a sinkhole-type system. However, as noted earlier, the problems of equivalence make absolute determination impossible without other constraining data.

Comparison with STC, EWW, UN1, and UN2

Figures 24a and 24b are tilt angle and HEP apparent resistivity profiles of EWW (an unaffected site). Notice how the tilt angle on figure 24a is different from the responses measured over the affected sites. The maximum relative change in tilt angle occurs directly over the edge of the dome on the EWW profile (figure 24a), whereas the maximum change in tilt angle occurs either, inside or outside of the domes on figures 21a and 22a. The shift in the maximum slope of the tilt angle appears to be the only distinguishing characteristic between, the affected and unaffected VLF tilt angle responses. The geologic feature(s) which cause this shift are not readily apparent on either, the



(a)



(b)

30 meter "a"

Figure 24a (upper) and 24b (lower). VLF tilt angle and HEP apparent resistivity profiles.

well logs or the geologic profiles (appendix B and figures 13a and 15a). However, it is probably related to the discontinuance of the conductive marl layer beneath the affected cypress domes.

The HEP profile of EWW, figure 24b, shows no apparent resistivity contrast between the dome and the surrounding sediments. Therefore, the VLF and HEP profiles of EWW are characteristic of an unaffected dome. The interim report supports this conclusion.

Figures 25a and 25b are tilt angle and HEP apparent resistivity profiles of STC (an affected dome). Note that the maximum change in tilt angle is away from the edge of the dome (figure 25a). This correlates well with the response at affected site EWE (figure 21a). However the apparent resistivity profile, figure 25b, does not show a resistivity contrast across the edge of the dome. This suggests the STC is an unaffected dome, which contradicts the tilt angle analysis results. The interim report shows that STC is an affected site (appendix B and figure 16a). It is interesting that STC appeared different on the GPR profiles (figure 16b) and therefore necessitated the creation of the type 2 GPR signature. The lack of resistivity contrast across the edge supports the conclusion that STC is an intermediate stage in the development of sinkhole-type domes.

Figure 26a and 26b are tilt angle and HEP apparent resistivity profiles of UN2. UN2 has experienced a decrease in hydroperiod recently and is therefore classified as an affected site. The tilt angle response has maximum relative change away from the edge of the dome which is an affected dome signature.

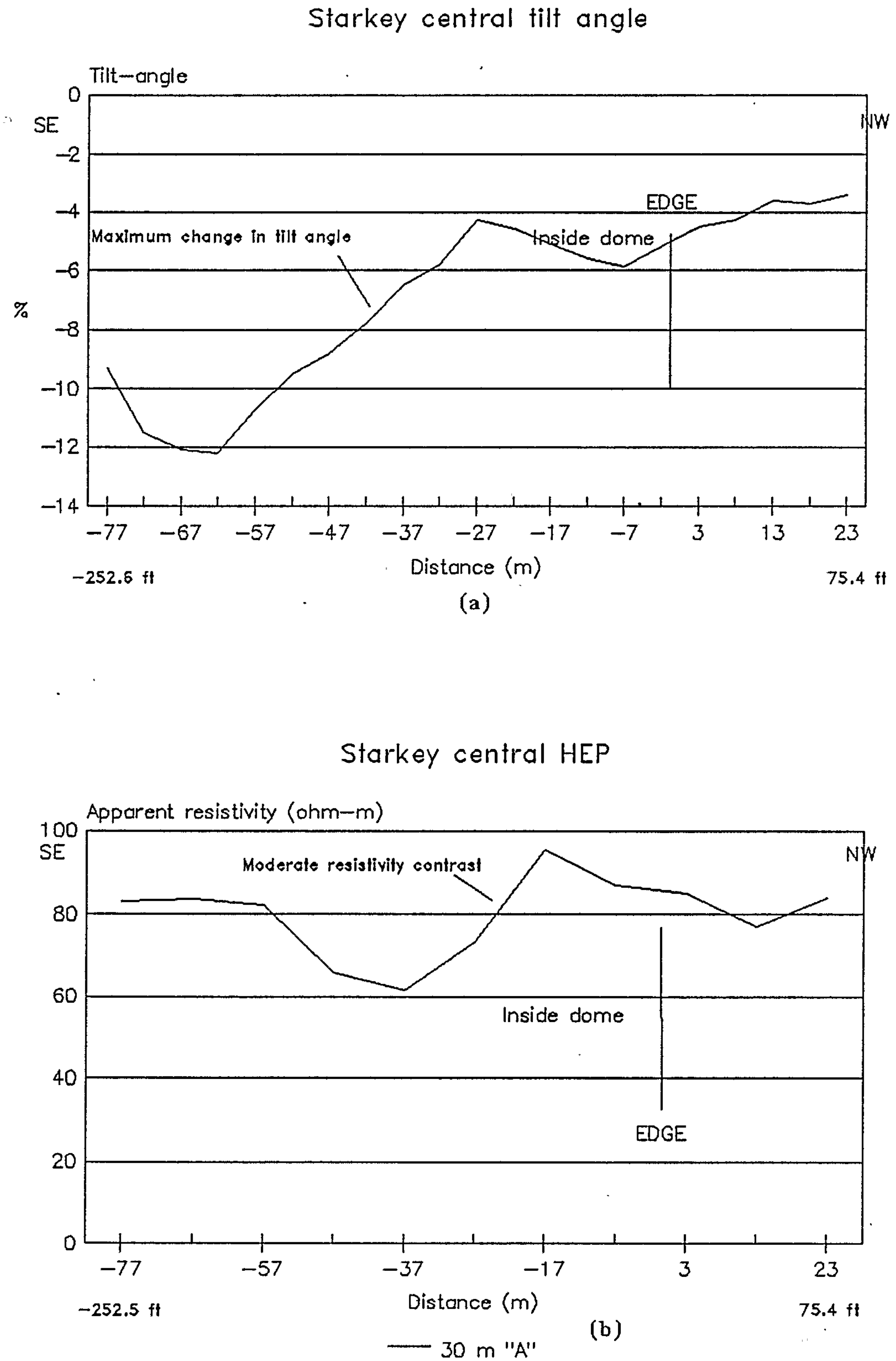
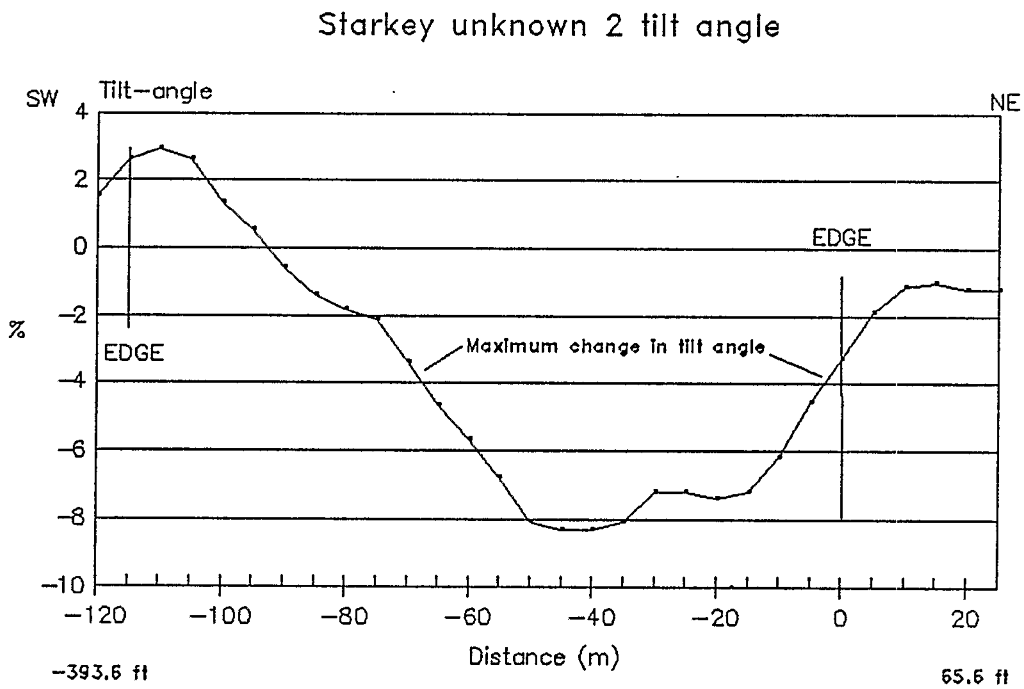
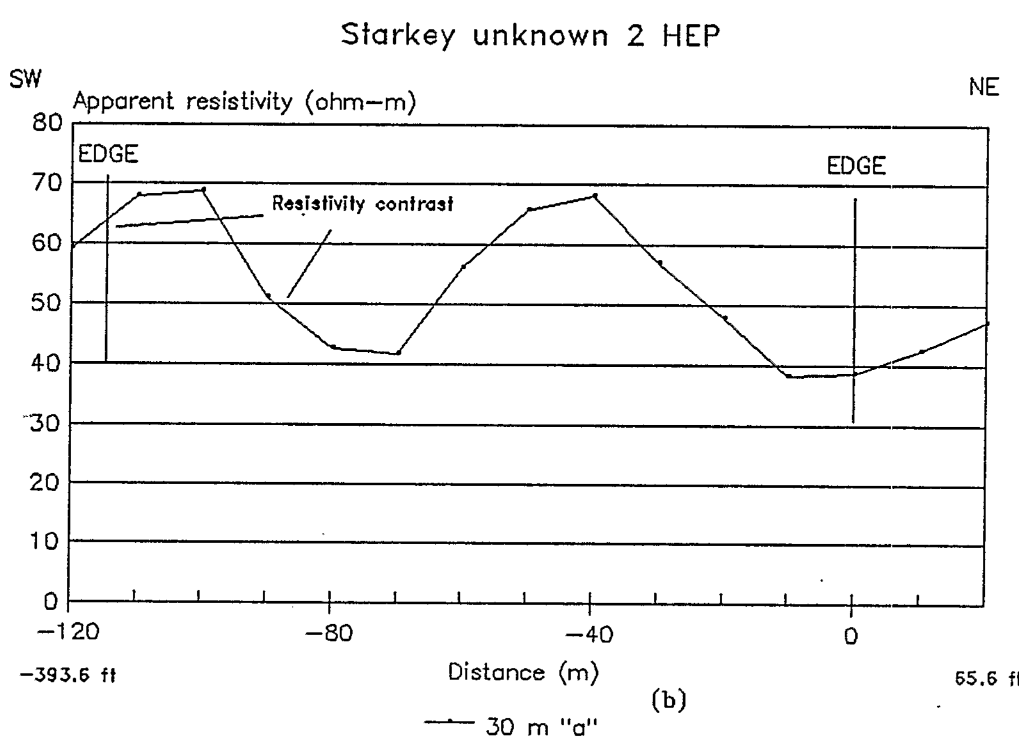


Figure 25a (upper) and 25b (lower). VLF tilt angle and HEP apparent resistivity profiles.



(a)



(b)

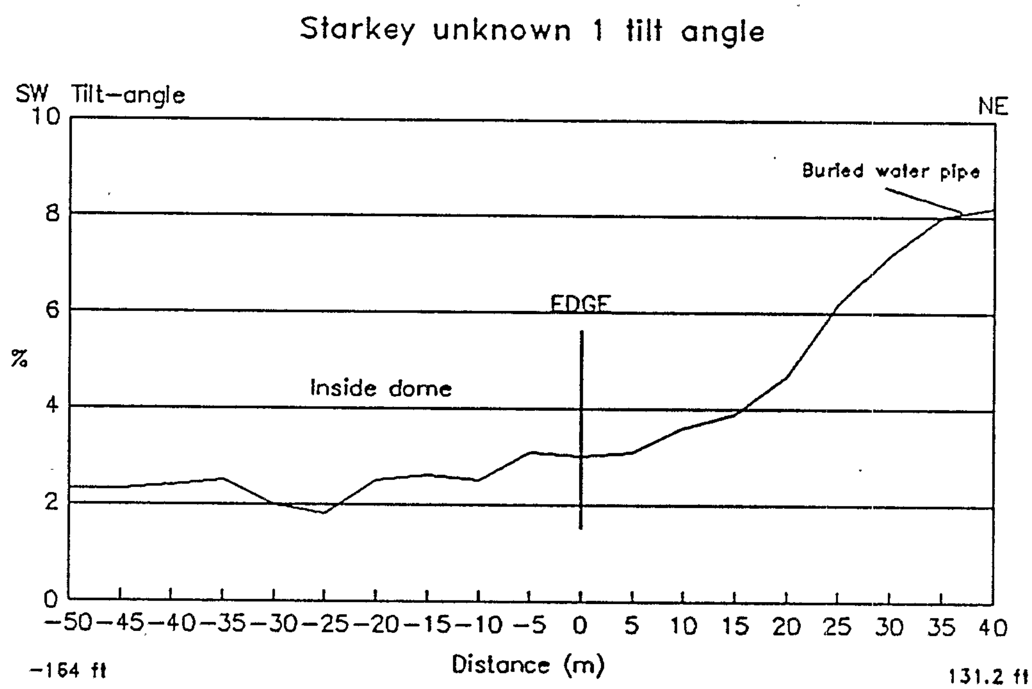
Figure 26a (upper) and 26b (lower). VLF tilt angle and HEP apparent resistivity profiles.

There is an apparent resistivity contrast across the edge of the dome indicated on figure 26b. Therefore, the VLF and HEP surveys seem to support the conclusion that UN2 is an affected site.

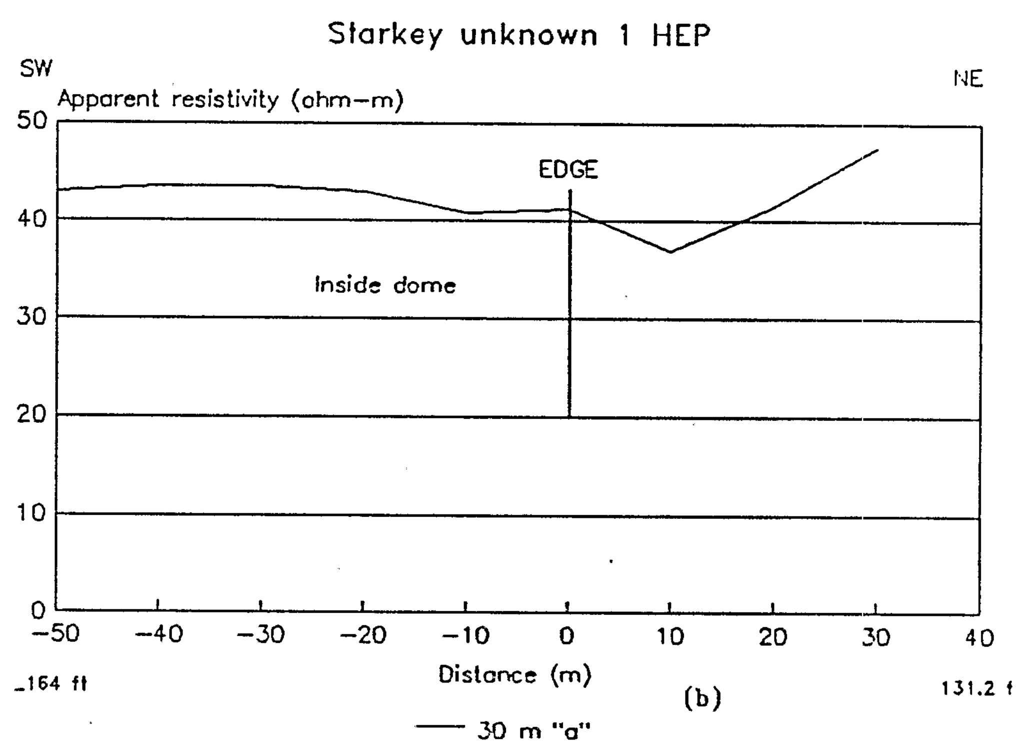
Figures 27a and 27b are tilt angle and HEP apparent resistivity profiles for UN1. The "good" health of UN1, in an area of large drawdown, indicates that UN1 is an unaffected site. The tilt angle response appears to correlate with the responses shown over affected sites; however, there is a large water pipe about 40 meters (122 feet) to the NE of the edge of the dome which probably caused the tilt angle anomaly shown on figure 27a. The apparent resistivity profile, figure 27b, does not show a resistivity contrast across the edge of the dome. Thus, the "apparent" tilt angle anomaly shown on figure 27a is probably not geologically significant. Therefore, the profiles, shown in figures 27a and 27b, support the conclusion that UN1 is an unaffected site.

CONCLUSION:

All four of the geophysical techniques employed in this study have applicability to hydrogeologic investigations. In this study, the four methods were employed to determine the position and/or presence of lateral change in subsurface stratigraphy. The data were interpreted qualitatively as either indicating or not indicating a subsurface change. For each of these methods a variety of "features", both natural and man-made, can cause an anomaly that might be interpreted as a lateral change in stratigraphy. This is known as the problem of



(a)



(b)

Figure 27a (upper) and 27b (lower). VLF tilt angle and HEP apparent resistivity profiles.

equivalence. Therefore developing reliable methods for interpreting the anomalies resulting from most geophysical surveys of this type is very difficult. A large data base is necessary to determine the responses and anomalies associated with complex geologic structures. The VLF, HEP, and LLEM surveys are more prone to equivalence problems and therefore require more time for correct interpretations. Furthermore, without supporting well log data even simple interpretations are often questionable. GPR is less prone to problems of equivalence. However, GPR does have some problems, including near surface clay layers which tend to attenuate the signal, and problems in determining average signal velocity for time to depth conversions. Table 1 summarizes the results of the four methods as to efficiency, cost, time, and reliability.

LLEM has been used in the past to detect vertical geologic structures, however cultural interference (large unshielded electric well pumps) made collecting and interpreting EM data at Starkey and Eldridge-Wilde very difficult.

VLF was also affected by cultural interference such as power lines and underground pipes. These features did not appear to completely degrade the data and therefore some interpretations were possible. It appears that it is possible to distinguish the sink type domes from the shallow depressions on the tilt angle profiles with moderate reliability when correlated with HEP profiles. Without constraints, either HEP or well log information, the tilt-angle profiles of the sink types are not readily distinguished from the shallow depression types.

METHOD	COST	TOTAL TIME	EFFECTIVENESS	RELIABILITY
GPR	125.00 hr	2 hr survey 2 hr analysis	Excellent in resistive areas	Excellent
HEP	50.00 per day	3 hr survey 4 hr analysis	Good with limited well data	Good to fair
VLF	500.0 per week	1.5 hour survey 4 hr analysis	Fair better with well data	Fair to good
VLF resistivity	Same as above	Same as above	Poor too shallow penetration	Not applicable
LLEM	500 per week	2 hr survey 3 hr analysis	Poor for this survey due to cultural interference	not applicable

Table 2. Description of headings:

Cost: rental only does not include man hours.

Total time: represents average time for a 600 foot profile.

Effectiveness: detection of affected cypress domes.

Reliability: confidence in cypress dome type identification

The HEP surveys were very time consuming to conduct in the dense underbrush of the cypress domes. Interpretation of anomalies is not as difficult as the VLF and it is aided greatly by well log information. The larger "a" spacing surveys were effective in delineating some of the sink type domes. Generally a resistivity contrast is associated with the sink type domes. Many conditions can cause resistivity contrast anomalies and therefore it is not possible to determine cypress dome type with great confidence with HEP without additional information.

The GPR surveys provided the best results. The surveys took the least amount time to complete and resulted in a graphic display that was almost immediately interpretable. The profiles showed a graphic display of the subsurface structures and therefore the type of cypress dome could be easily determined in a short period of time. The well data helped in determining depths to reflectors but are not necessary for the reconnaissance surveys.

RECOMMENDATIONS:

For studies of this type in similar geologic environments, we would recommend using ground penetrating radar. GPR appears to be the most efficient and effective method for studying the shallow structural features of cypress domes. Average velocities for the radar signal can be estimated to determine approximate depth to interfaces. The velocity in most saturated sediments ranges from 0.125 to 0.30 ft/nsec. For regional studies a preliminary photolinear analysis should be used to identify possible zones of increased sink development. Furthermore, the transects for the HEP, EM-34, and VLF should be conducted perpedicular to photolinears to detect associated anomalies. Also GPR lines should be conducted next to areas of known geology to calibrate the instrument to well logs. For small-scale studies resistivity surveys can be used in conjunction with the GPR lines for cross correlation. A word of caution: select GPR operators carefully. The quality of the data is dependent on the skill and experience of the person controlling the signal processing unit. Finally, as was alluded to in the preliminary analysis, a stronger correlation of affected sites, type three geologic settings and fracture traces, might be established by studying a greater number of dome sites, using GPR and photolinear analysis.

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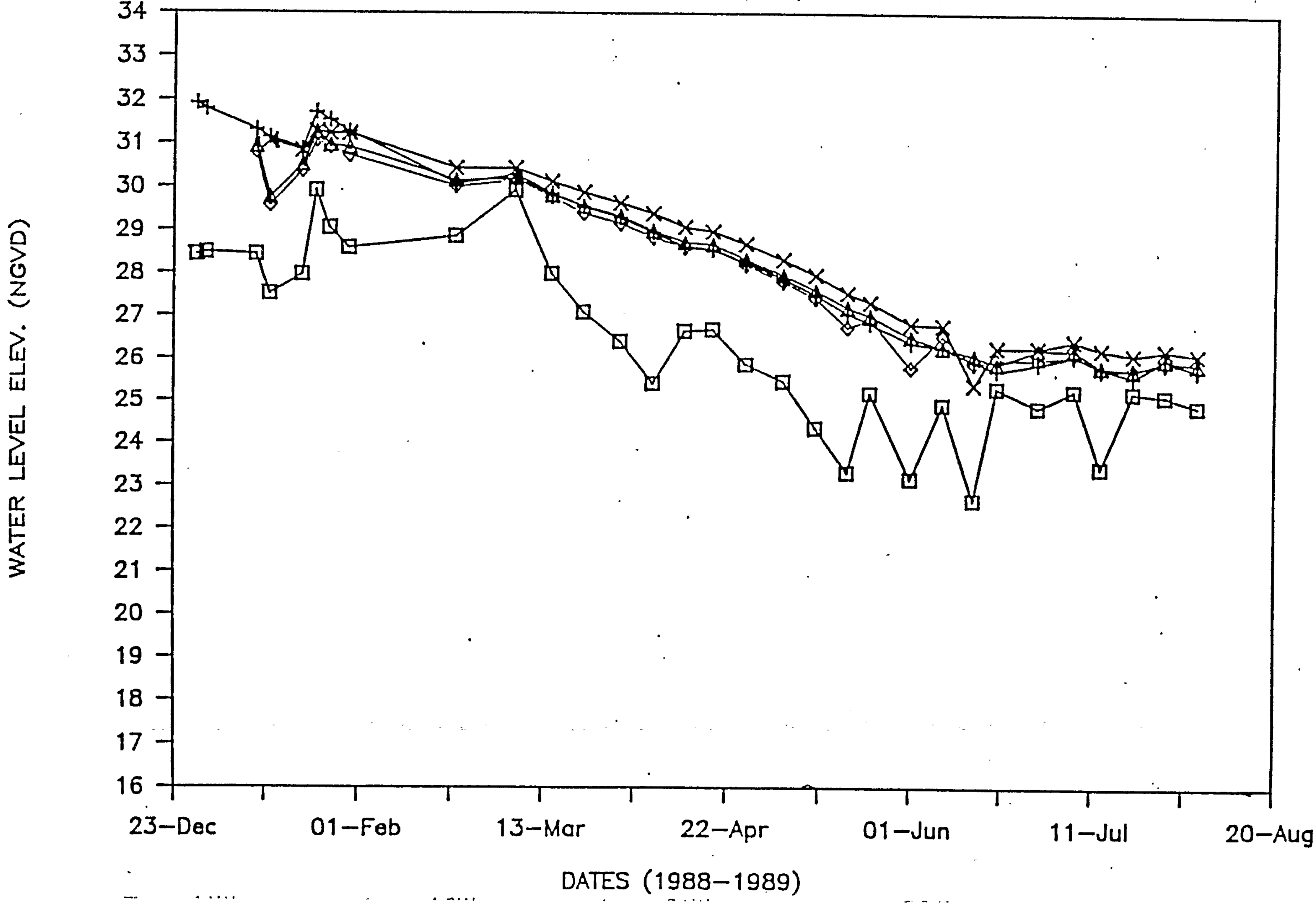
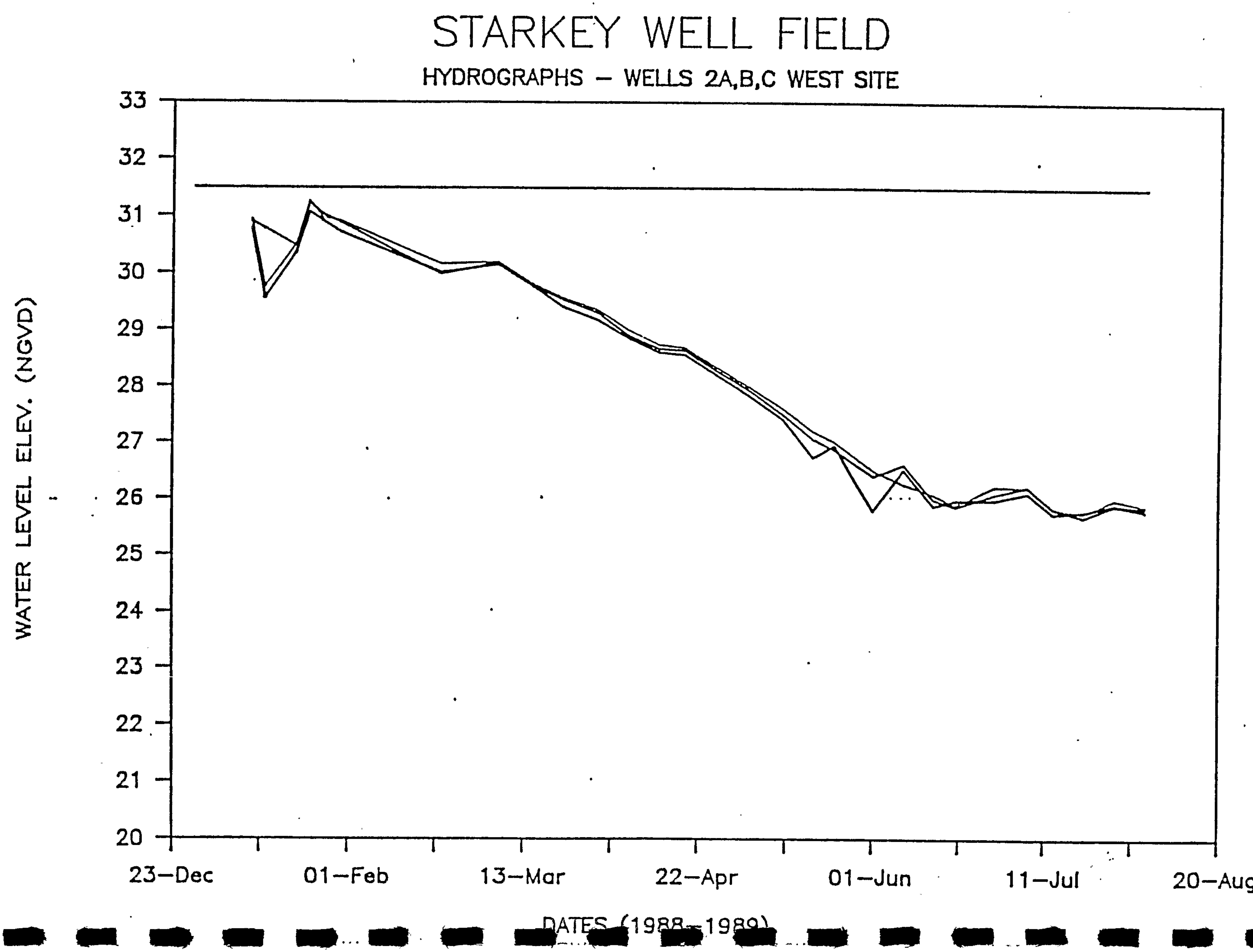
APPENDIX A

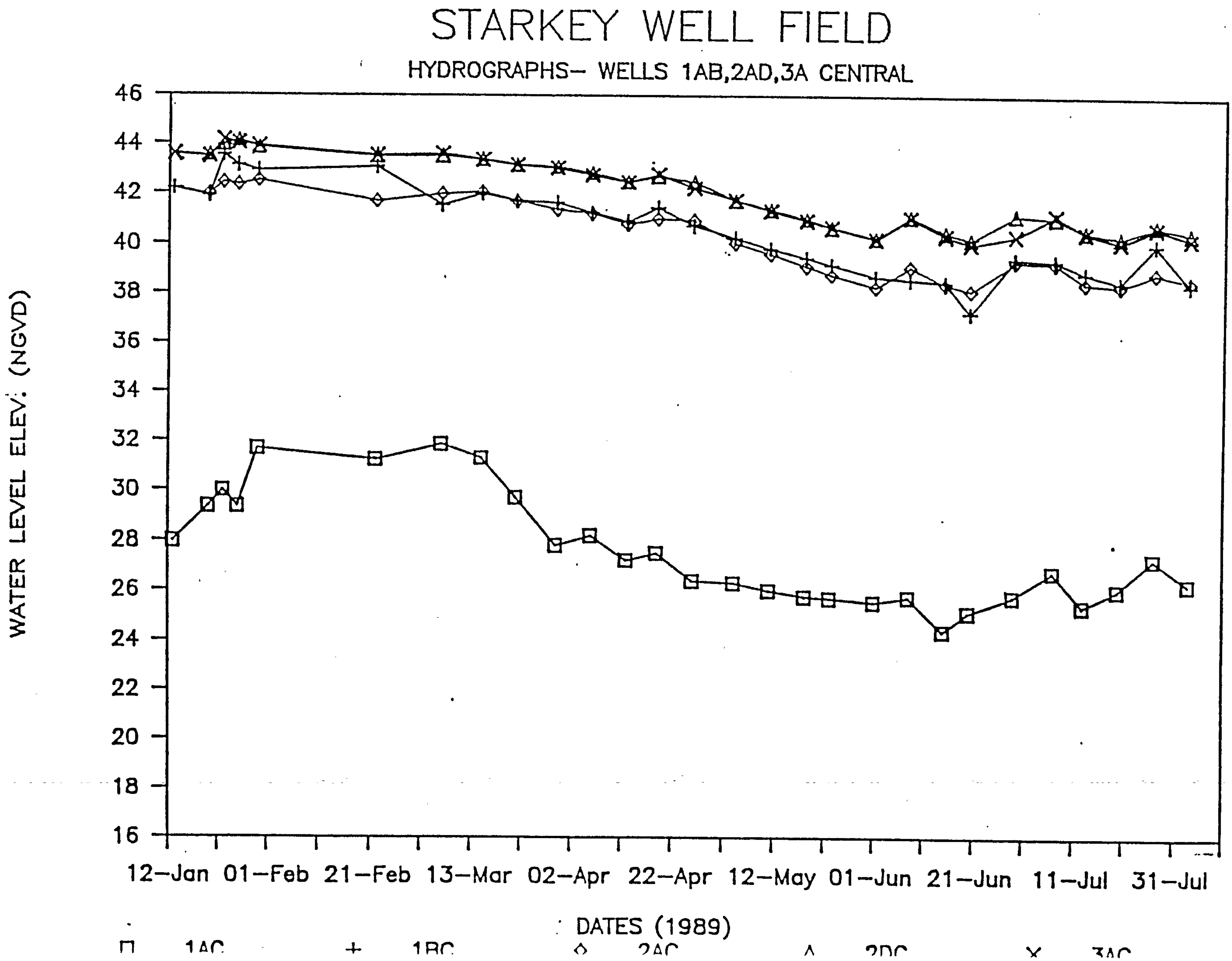
WATER LEVEL HYDROGRAPHS

STARKEY WELL FIELD

HYDROGRAPHS– WELLS 1AC,2AC,3A WEST SITE



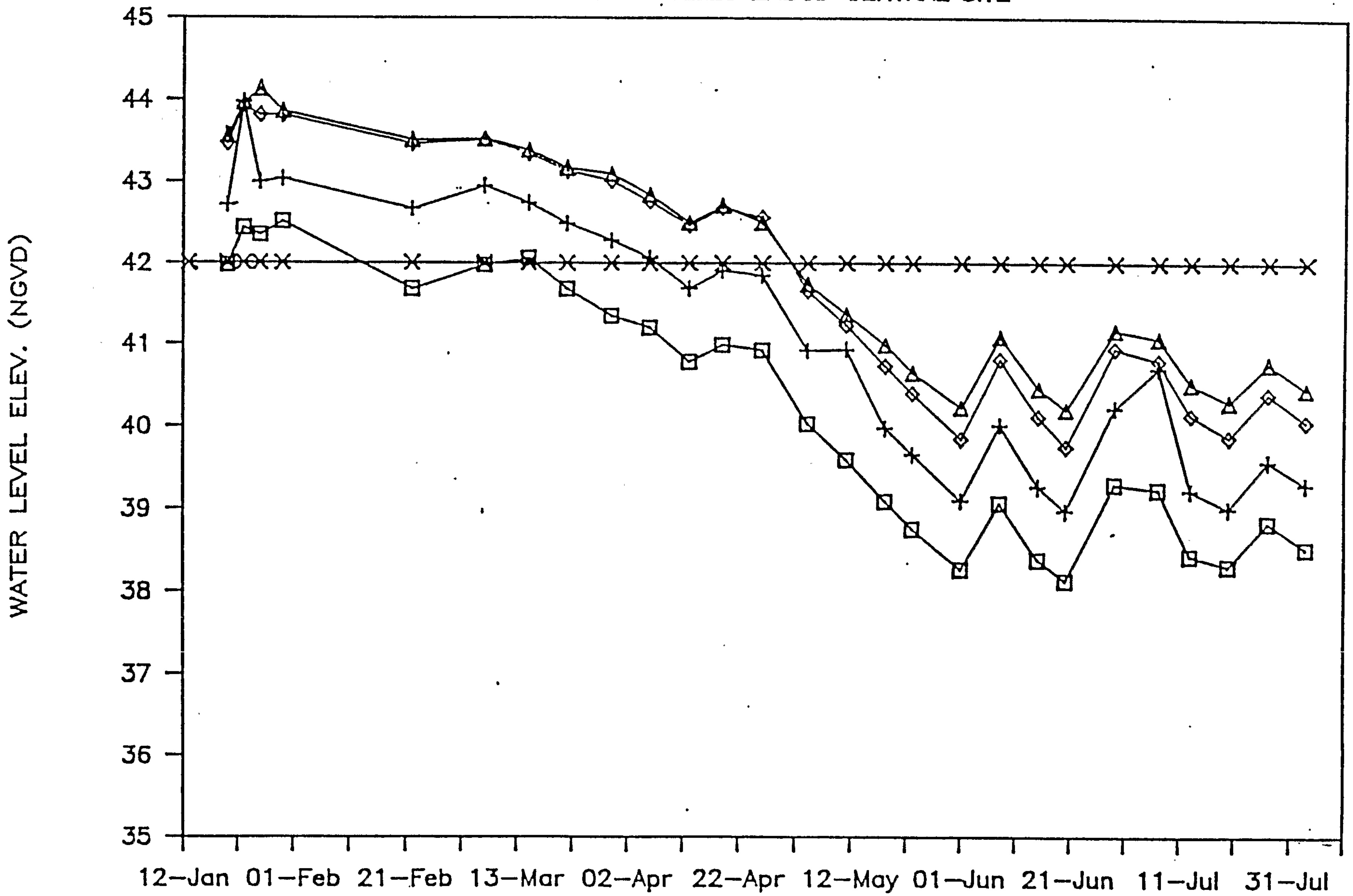

STARKEY WELL FIELD
HYDROGRAPHS – WELLS 2A,B,C WEST SITE
WATER LEVEL ELEV. (NGVD)
33
32
31
30
29
28
27
26
25
24
23
22
21
20
23–Dec
01–Feb
13–Mar
22–Apr
01–Jun
11–Jul
20–Aug
DATES (1988–1989)



STARKEY WELL FIELD
HYDROGRAPHS– WELLS 1AB,2AD,3A CENTRAL
WATER LEVEL ELEV. (NGVD)
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
12–Jan 01–Feb 21–Feb 13–Mar 02–Apr 22–Apr 12–May 01–Jun 21–Jun 11–Jul 31–Jul
DATES (1989)

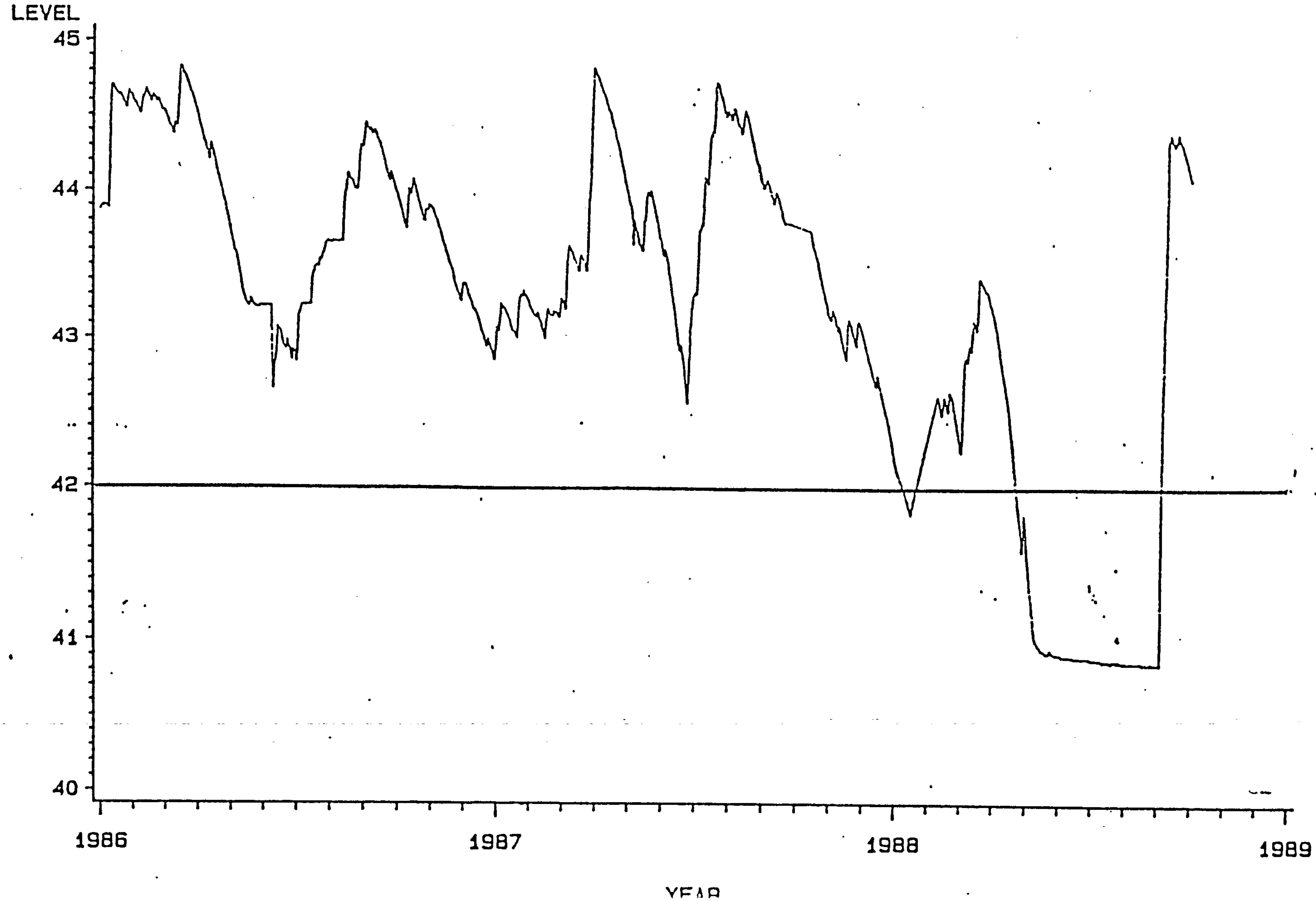
STARKEY WELL FIELD

HYDROGRAPHS — WELLS 2ABCD CENTRAL SITE



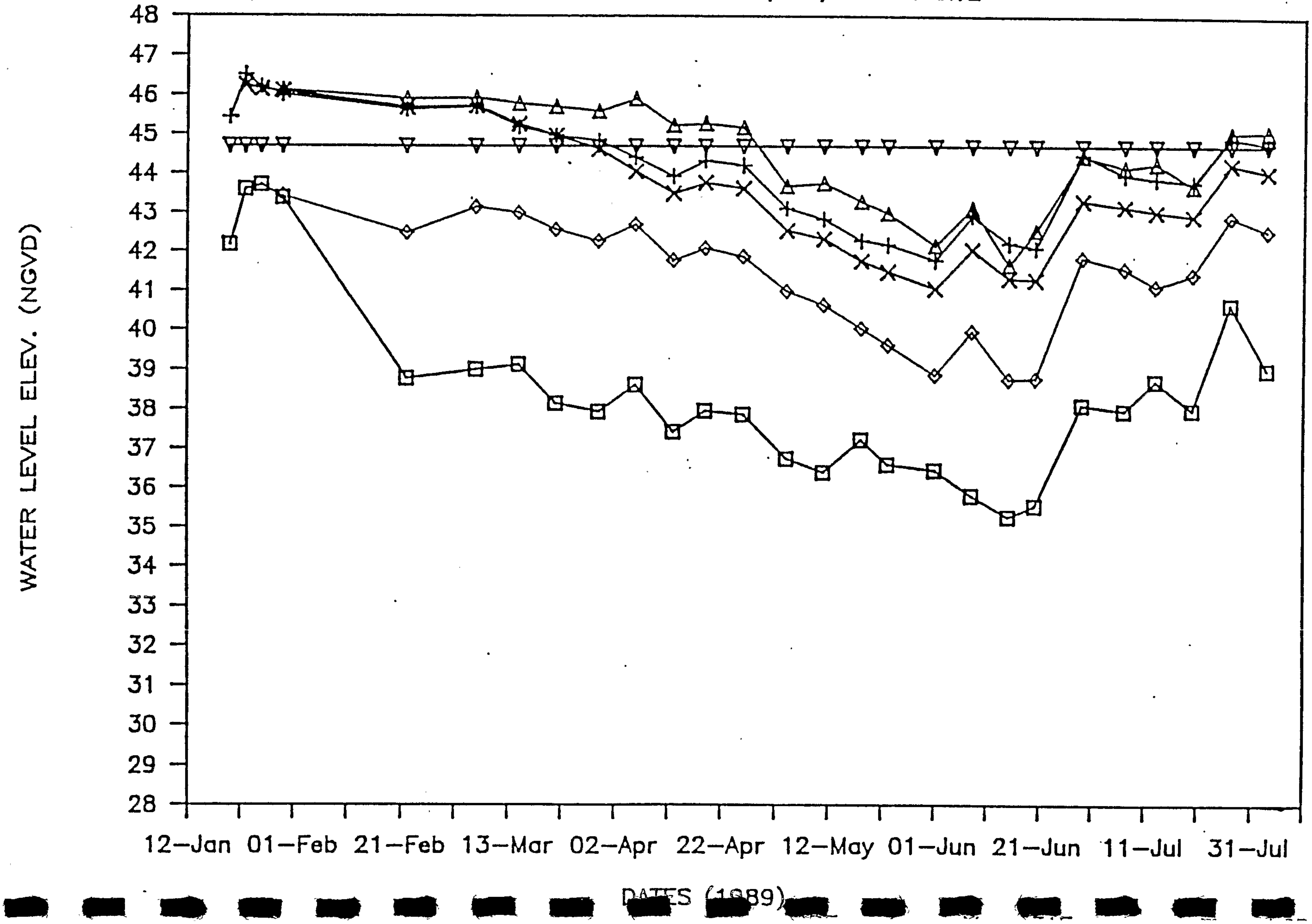
[redacted]

HYDROGRAPH OF STARKEY CENTRAL #1



STARKEY WELL FIELD

HYDROGRAPHS– WELLS 1AB,2AB,3A EAST SITE



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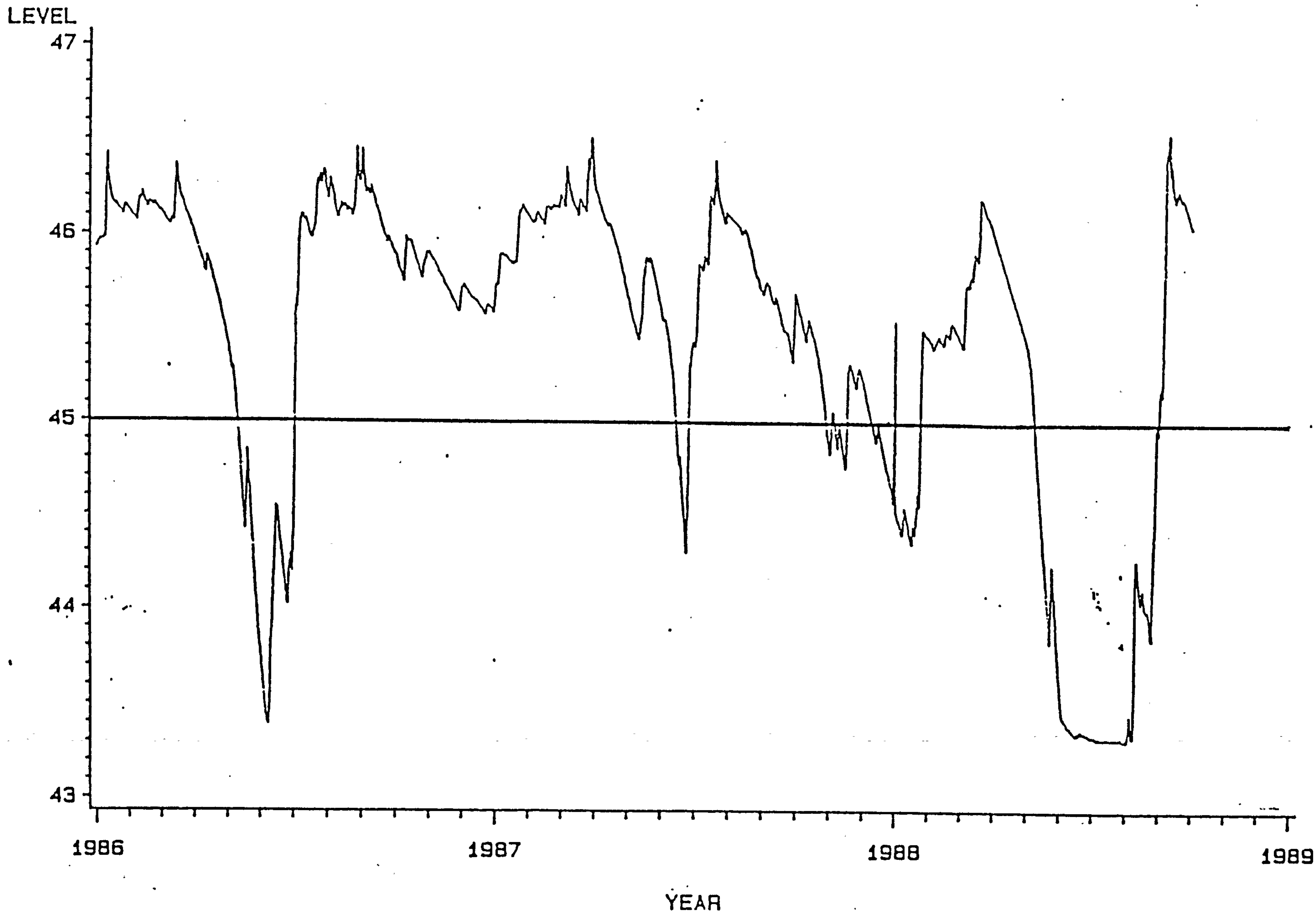
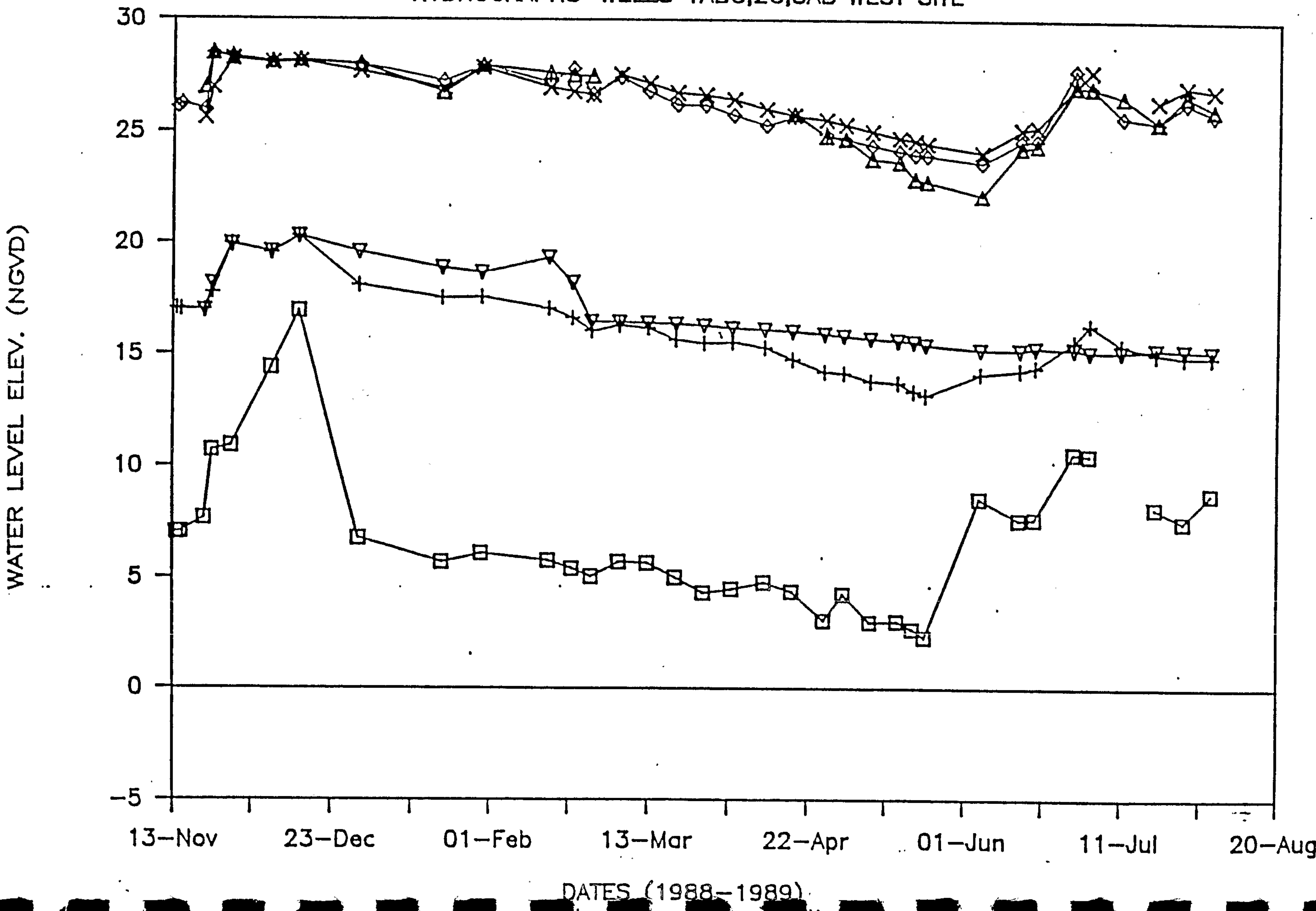
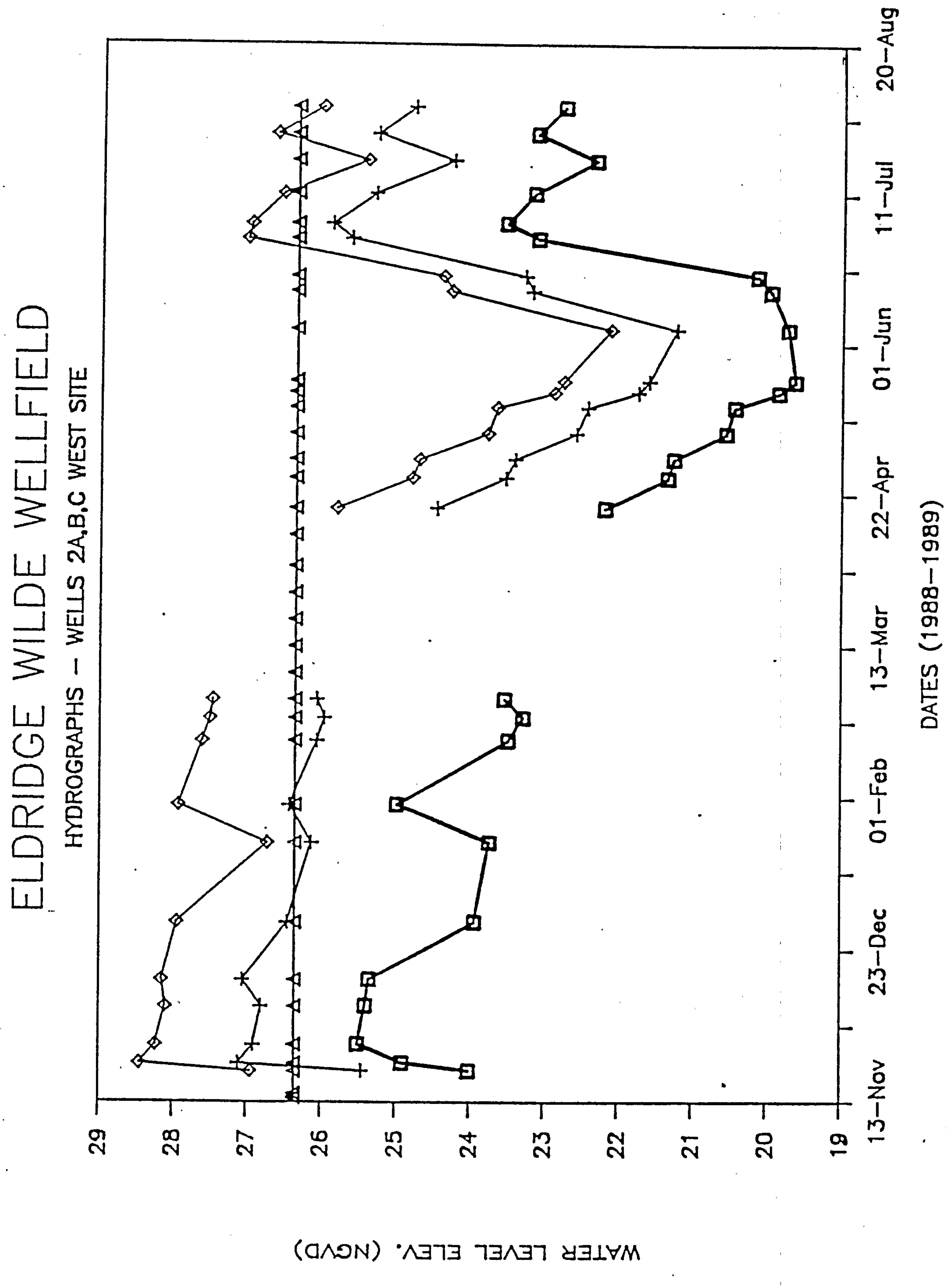


ELDRIDGE WILDE WELL FIELD

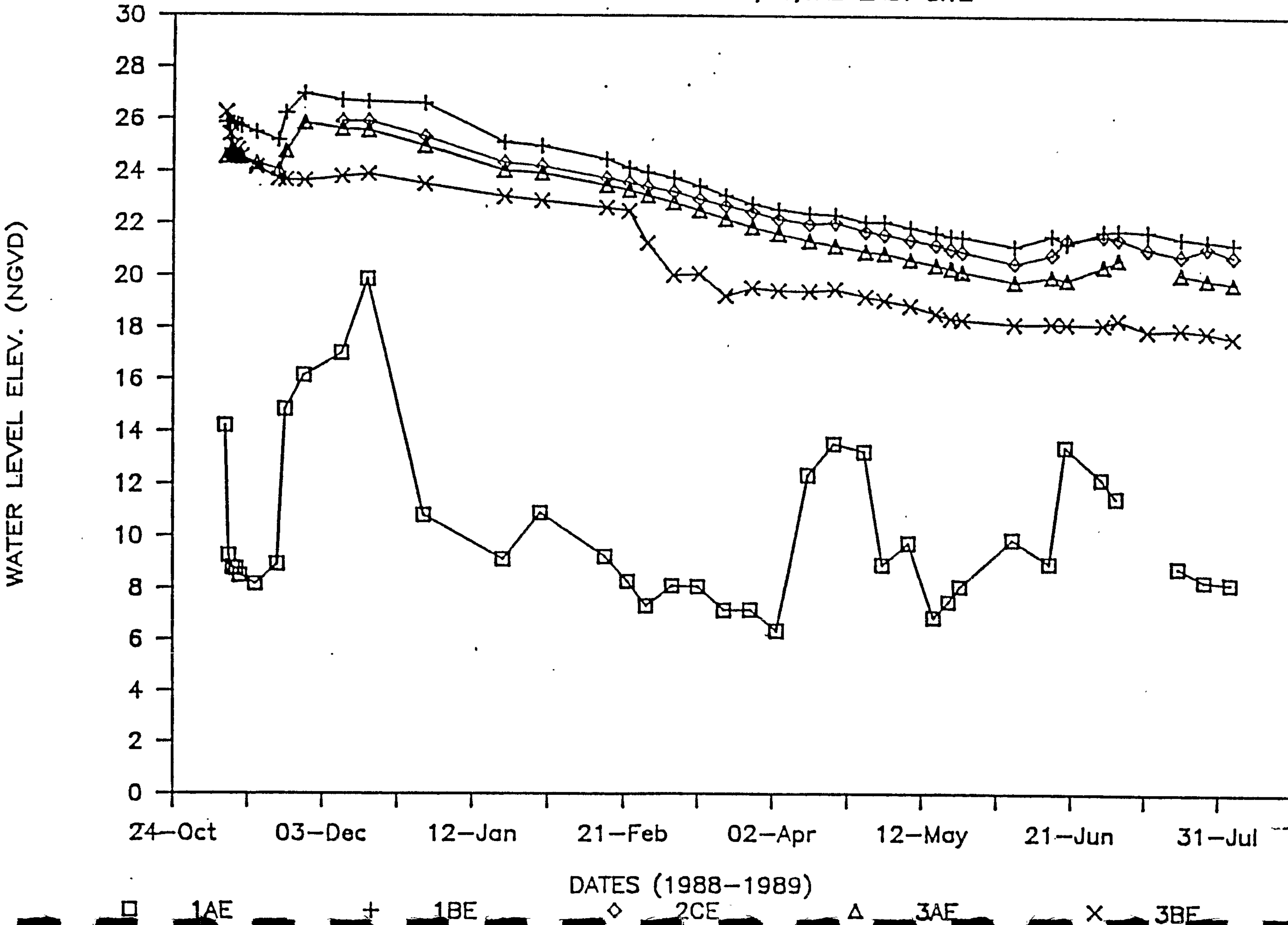
HYDROGRAPHS—WELLS 1ABC,2C,3AB WEST SITE




ELDRIDGE WILDE WELLFIELD
HYDROGRAPHS — WELLS 2A,B,C WEST SITE
WATER LEVEL ELEV. (NGVD)
29
28
27
26
25
24
23
22
21
20
19
13-Nov
23-Dec
01-Feb
13-Mar
22-Apr
01-Jun
11-Jul
20-Aug
DATES (1988-1989)

ELDRIDGE WILDE WELL FIELD

HYDROGRAPHS— WELLS 1AB,2C,3AB EAST SITE



APPENDIX B

DRILLING LOGS

SWFWMD
WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa

Report of Boring Number: 1A West
Sheet 1 of 3
Date 12/20/88 File P07620

Boring Co. American Drilling, Inc.
Foreman George DeGroot
SWFWMD Engineer John Watson

Boring Location Starkey Wellfield
Ground Elevation 36.8' Well Elevation 40.12
Date Started 12/12/88 Date ended 12/20/88

CASING
Size: Mud Rotary
Hammer: ______ lb.
Fall: ______

SAMPLER
Type: Split Spoon Other:
Hammer: 140 lb.
Fall: 30 inch

Groundwater Readings: Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	PEN./REC	SAMPLE DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	18/16	1-2.5	7-4-6	Medium dense, brown, fine SAND, little Silt, root fibers.				
3		2	18/16	3-4.5	6-9-9	Medium dense, brown, fine SAND, little (+) Silt.				
5		3	18/16	5-6.5	3-6-6	Similar to above.		Grout		
7		4	18/10	7-8.5	3-5-9	Medium dense, dark brown, fine SAND, little (+) Silt.	Silty fine SAND			
10		5	18/10	10-11.5	3-4-4	Loose, dark brown, fine SAND, little (+) Silt.				
13.5		6	18/10	13.5-15	3-5-5	Medium dense, dark brown, fine SAND, little (+) Silt.		6-inch PVC Well		
18.5		7	18/10	18.5-20	2-4-6	Similar to above.				
23.5		8	18/12	23.5-25	4-7-7	Similar to above.				
28.5		9	18/13	28.5-30	3-7-10	Medium dense, brown, fine SAND, little Silt.	33.5'			
33.5		10	18/18	33.5-35	3-2-4	Medium stiff, grey-brown, CLAY & SILT, little fine Sand, medium (-) plasticity.	Silty Sandy CLAY 35'			

REMARKS:

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa

Report of Boring Number: IA West
Sheet 2 of 3
Date ______ File P07620

Boring Co. ______
Foreman ______
SWFWMD Engineer ______
Boring Location: Starkey Wellfield
Ground Elevation ______ Well Elevation ______
Date Started ______ Date ended ______

CASING — Size: ______ Hammer: ______ lb. Fall: ______

SAMPLER — Type: ______ Other: ______ Hammer: ______ lb. Fall: ______

Groundwater Readings: Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	PEN./REC	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
38.5		11A	18/18	38.5-39.5	WOH/18"	Very soft, grey-green, Silty CLAY, high plasticity.	Silty CLAY			
		11B		39.5-40		Very soft, white, Silty CLAY, high plasticity.		Grout		
43.5		12	6/6	43.5-44	50/6"	Very dense, brown-grey, CLAY & SILT, little (-) limestone fragments, medium plasticity.	43.5 / MARL			
48.5		13	3/3	48.5-48.7	50/3"	Similar to above.				
53.5		14	3/3	53.5-53.7	50/3"	Similar to above.		6-inch PVC Well		1.
58.5							57' / VOID			
63.5		15	18/18	63.5-65	3-5-6	Stiff, green, Silty CLAY, high plasticity.	63' / Silty CLAY			
68.5		16	18/10	68.5-70	28-32-38	Grey-White, Silty, Sandy, LIMESTONE.	68.6			2.
73.5		17	18/15	73.5-75	22-18-32	Similar to above.	TAMPA LIMESTONE			
78.5		18	12/8	78.5-79.5	23-27	Similar to above.		30-65 Silica Sand		
83.5		19	18/12	83.5-85	10-14-24	Similar to above.	85'	20-30 Silica Sand; Screen Interval		

REMARKS:
1. Encountered a void from 57' to 63 feet below land surface. Installed 4 inch diameter steel casing to 64 feet below land surface and continued drilling.
2. Top of Tampa Limestone is approximately 68.5 feet below land surface.

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Swamps in Wellfields near Tampa

Report of Boring Number: 1A West
Sheet 3 of 3
Date
File P07620

Boring Co.
Foreman
SWFWMD Engineer

Boring Location: Starkey Wellfield
Ground Elevation
Well Elevation
Date Started
Date ended

CASING
Size:
Hammer: lb.
Fall:

SAMPLER
Type:
Other:
Hammer: lb.
Fall:

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	PEN./REC.	SAMPLE DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
88.5		20	15/12	88.5-89.7	17-18-50/3"	Grey-white, Silty, Sandy, LIMESTONE.		20-30 Silica Sand; Screen Interval		
93.5		21	18/10	93.5-95	36-40-38	Similar to above		95'; Sump		
98.5		22	9/8	98.5-99.3	28-50/4"	Similar to above	Tampa Limestone			3.
119		23	18/8	119-120.5	23-24-28	Similar to above				
139		24	7/3	139-139.5	48-50/1"	Fragments of Suwannee Limestone, Shell fossils.	139.5' Suwannee Limestone			4.
160						Bottom of boring at 160'				

REMARKS:

3. Monitor well 1A West installed at completion of boring.

4. Top of Suwannee Limestone is approximately 139.5 feet below land surface. Drilling bit responded with more resistance and a grinding noise from 139.5 to 160 feet below land surface.

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number: 2A West
Sheet 1 of 3
Date 1/5/89 File P07620

Boring Co. American Drilling, Inc.
Foreman Wade Thompson
SWFWMD Engineer John Watson

Boring Location Starkey Wellfield
Ground Elevation 31.5' Well Elevation 34.77'
Date Started 12/28/88 Date ended 1/5/89

CASING
Size: Mud Rotary
Hammer: ___ lb.
Fall: ___

SAMPLER
Type: Split Spoon Other:
Hammer: 140 lb.
Fall: 30 inch

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL /FT.	SAMPLE NO.	PEN./REC	SAMPLE DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	18/6	1-2.5	WOR	PEAT, fibrous.				
3		2	18/8	3-4.5	WOH	Similar to above.				
5		3	18/8	5-6.5	WOH	Similar to above.	PEAT	Grout		
7		4	18/10	7-8.5	WOH	Similar to above.				
10		5	18/12	10-11.5	4-4-2	Loose, grey-brown, fine SAND little (+) Silt.	10.0'	2-inch PVC Well		
13.5		6	18/14	13.5-15	7-9-7	Medium dense, grey-brown, fine SAND, little (+) Silt.	Silty fine SAND			1.
18.5		7	18/10	18.5-20	7-4-1	Loose, dark brown, fine SAND and (-) Silt.				
23.5		8	18/12	23.5-25	1-1/12"	Very loose, black-brown, SILT, organic.	23.5' Organic SILT			
28.5		9	18/10	28.5-30	5-4-4	Loose, black-brown, fine SAND, some Silt.	28.5' Silty fine SAND			1.
33.5		10	18/12	33.5-35	1-2-2	Very loose, black-brown, SILT, organic.	33.5' Organic SILT			

REMARKS:

1. Conducted a falling head permeability test at 13 to 15 feet in borehole 2C and at 28 to 30 feet in borehole 2B.

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number 2A West
Sheet 2 of 3
Date
File P07620

Boring Co.
Foreman
SWFWMD Engineer
Boring Location
Ground Elevation
Well Elevation
Date Started
Date ended

CASING: Size: Hammer: lb. Fall:

SAMPLER: Type: Other: Hammer: lb. Fall:

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL /FT.	SAMPLE NO.	PEN./REC.	SAMPLE DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
38.5		11	18/16	38.5-40	2-2-4	Loose, black-brown, SILT, trace (-) fine Sand, organic.	Organic SILT	Grout		
43.5		12	18/14	43.5-45	1-1-1	Very loose, black-brown, SILT, organic, pieces of wood, 1/2 to 1 inch.		2-inch PVC Well		
48.5		13A	18/16	48.5-50	1-1-1	Very soft, dark brown, Silty CLAY, high plasticity.	48.5' Silty CLAY 51.5'	30-65 Silica Sand		2.
		13B	24/8	50-52	WOH					
53.5		14	18/12	53.5-55	10-9-9	Medium dense, light-brown, fine SAND, little Silt.	54' Screen Interval 56'	20-30 Silica Sand		3.
58.5		15	18/10	58.5-60	3-5-6	Medium dense, dark brown, fine SAND, littl Silt.		Sump		
63.5		16	18/10	63.5-65	2-2-4	Loose, dark brown, fine SAND, little Silt.	Silty fine SAND			
68.5		17	18/10	68.5-70	1-1/12"	Very loose, dark brown, fine SAND, little Silt.		Formation Material		
73.5		18	18/10	73.5-75	1-2-3	Loose, dark brown, fine SAND, little Silt.				
78.5		19	18/12	78.5-80	2-2-2	Similar to above.				
83.5		20	18/18	83.5-85	2-3-4	Medium stiff, black-brown, Silty CLAY, high plasticity.	83.5' Silty CLAY	Grout		

REMARKS:
2. Obtained a sample for laboratory permeameter testing at 50 to 52 feet in borehole 2A.
3. Monitor well 2A West installed at completion of boring.

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number 2A West
Sheet 3 of 3
Date ______ File P07620

Boring Co. ______
Foreman ______
SWFWMD Engineer ______

Boring Location Starkey Wellfield
Ground Elevation ______ Well Elevation ______
Date Started ______ Date ended ______

CASING
Size: ______
Hammer: ______ lb.
Fall: ______

SAMPLER
Type: ______ Other:
Hammer: ______ lb.
Fall: ______

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	PEN./REC	SAMPLE DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRTA. CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
88.5		21	24/20	88.5-90.5	Pushed	Black-brown, Silty CLAY, high plasticity, pieces of wood 1/2" to 1".				4.
93.5		22	18/16	93.5-95	2-4-6	Medium stiff, black-brown, Silty CLAY, trace fine Sand, high plasticity.	Silty CLAY			
98.5		23	18/16	98.5-100	4-3-3	Similar to above.				
103.5		24	18/16	103.5-105	2-2-3	Medium stiff, black-brown, Silty CLAY, trace fine Sand, high plasticity, pieces of wood 1/2" to 1".		Grout		
108.5		25	18/14	108.5-110	4-8-7	Medium dense, black-brown, fine SAND, little (+) Silt.	108.5' Silty fine SAND			
113.5		26	18/14	113.5-115	5-8-13	Medium dense, dark brown, fine SAND, little Silt.				
118.5		27	24/24	118.5-120	5 Pushed	Dark-brown, Silty CLAY, trace, fine Sand, high plasticity.	118.5' Silty CLAY			
123.5		28	18/10	123.5-124	5 12-12	Very stiff, green, Silty CLAY.	124.3'			
				124.5-125	42	Hard, white, CLAY & SILT, and Limestone fragments, medium plasticity.	MARL			
						Bottom of boring at 125'				

REMARKS: 4. Obtained a sample for laboratory permeameter testing at 88.5 to 90.5 feet in borehole 2A.

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number 3A West
Sheet 1 of 2
Date 12/29/88 File P07620

Boring Co. American Drilling, Inc.
Foreman George DeGroot
SWFWMD Engineer John Watson

Boring Location Starkey Wellfield
Ground Elevation 37.6'
Well Elevation 40.38'
Date Started 12/28/88
Date ended 12/29/88

CASING
Size:
Hammer: lb.
Fall:

SAMPLER
Type: Split Spoon
Hammer: 140 lb.
Fall: 30 inch
Other:

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL./FT.	SAMPLE NO.	PEN./REC.	SAMPLE DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	18/10	1-2.5	2-5-9	Medium dense, brown, fine SAND, little Silt, root fibers.				
3		2	18/12	3-4.5	7-8-8	Medium dense, light brown, fine SAND, little Silt.		6-inch PVC Well		
5		3	18/12	5-6.5	3-3-9	Similar to above.				
7		4	18/12	7-8.5	5-8-8	Similar to above.	Silty fine SAND	Grout		
10		5	18/10	10-11.5	4-9-17	Similar to above.				1.
13.5			18/0	13.5-15	11-32-40	No Recovery.		30-65 Silica Sand		2.
18.5		6	18/10	18.5-20	6-15-18	Dense, brown, fine SAND, little (+) Silt.		17' Screen Interval; 20-30 Silica Sand; 22'		
23.5		7A	18/14	23.5-25	7-20-7	Very stiff grey, Silty CLAY, high plasticity.	Silty 24' CLAY 25'	Sump		3.
		7B	24/14	25-27	3-6-8	Medium dense, brown, fine SAND, little Silt.	Silty fine SAND 28.5'	Bentonite Hole Plug		
28.5		8	24/20	28.5-30.5	1-1-1-3	Soft, brown-grey, Silty CLAY, high plasticity.	Silty CLAY			4.
33.5		9A	13/10	33.5-34	4	Green-grey, Silty CLAY, high plasticity.	34.0'	Formation Material		
		9B		34-34.6	28-50.2"	Hard, grey-white, SILT & CLAY, little Limestone fragments, low plasticity.	MARL			

REMARKS:
1. Conducted a falling head permeability test at 10 to 12 feet in bore hole 3A.
2. The density and recovery attempt at 13.5 to 15 feet was probably affected by the gravel used for the previous permeability test.
3. Monitor well 3A West installed at completion of boring. Used bentonite hole plug from 23-40 feet.
4. Obtained a sample for laboratory permeameter testing at 28.5-30.5 feet in borehole 3A.

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD
WELL DRILLING LOG

PROJECT

Report of Boring Number 3A West
Sheet 2 of 2
Date File P07620

Boring Co.
Foreman
SWFWMD Engineer

Boring Location Starkey Wellfield
Ground Elevation Well Elevation
Date Started Date ended

CASING
Size:
Hammer: lb.
Fall:

SAMPLER
Type: Other:
Hammer: lb.
Fall:

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	PEN./REC	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
38.5		10	4/4	38.5-38.8	50/4"	Hard, grey-white, SILT & CLAY and Limestone fragments, low plasticity.	MARL	Formation Material		
						Bottom of boring at 38.8'				

REMARKS:

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD
WELL DRILLING LOG

Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Sheet 1 of 3

Date 1-5-89 File P07620

Boring Co. American Drilling, Inc.
Foreman George DeGroot
SWFWMD Engineer John Watson

Boring Location Starkey Wellfield
Ground Elevation 45.3 Well Elevation 47.98
Date Started 1-3-89 Date ended 1-5-89

CASING	
Size:	Mud Rotary
Hammer:	lb.
Fall:	

SAMPLER	
Type:	Split Spoon
Hammer:	140 lb.
Fall:	30 inch
Other:	

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	PEN./REC	SAMPLE DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	18/12	1-2.5	3-7-12	Medium dense, dark brown, fine SAND, little Silt, root fibers.				
3		2	18/14	3-4.5	3-9-9	Medium dense, brown, fine SAND and Silt	Silty fine SAND			
5		3	18/10	5-6.5	2-4-2	Loose, light brown, fine SAND, and Silt.				
7		4	18/12	7-8.5	3-3-3	Similar to above		Grout		
10		5	18/14	10-11.5	6-9-10	Very stiff, grey-green, Silty CLAY, high plasticity	10'			
13.5		6	18/15	13.5-15	2-2-3	Medium stiff, white, Silty CLAY, high plasticity	Silty CLAY			
18.5		7	18/12	18.5-20	7-12-23	Hard, grey-green, Silty CLAY, high plasticity.		6-inch PVC Well		
23.5		8	14/8	23.5-24.8	10-20-50/4"	Hard, white, CLAY & SILT, little Limestone Fragments, medium plasticity	23.5			
28.5		9	3/3	28.5-28.7	50/3"	Similar to above	MARL			
33.5		10	2/1	33.5-33.6	50/2"	Similar to above				

REMARKS:

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number: 1A Central
Sheet 2 of 3
Date ____ File P07620

Boring Co. ____
Foreman ____
SWFWMD Engineer ____

Boring Location: Starkey Wellfield
Ground Elevation ____ Well Elevation ____
Date Started ____ Date ended ____

CASING — Size: ____ Hammer: ____ lb. Fall: ____

SAMPLER — Type: ____ Other: ____ Hammer: ____ lb. Fall: ____

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	PEN./REC	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
38.5		11	1/1"	38.5-38.6	50/1"	Limestone fragments				1
43.5		12	3/1	43.5-43.7	50/3"	Limestone fragments				
48.5		13	3/3	48.5-48.7	50/3"	Hard, white-green, SILT & CLAY and Limestone fragments, low plasticity.		6-inch PVC Well		
53.5		14	4/4	53.5-53.8	50/4"	Similar to above				
58.5		15	4/4	58.5-58.8	50/4"	Hard, white-green, CLAY & SILT little Limestone fragments, medium plasticity.	MARL			
63.5		16	1/1	63.5-63.6	50/1"	Similar to above				
								Grout		
68.5		17	2/2	68.5-68.6	50/2"	Similar to above				
73.5		18	1/1	73.5-73.6	50/1"	Limestone fragments	73.5'			2
78.5		19	4/1	78.5-78.8	50/4"	Limestone fragments	TAMPA LIMESTONE			
83.5		20	6/4	83.5-84	50/6"	White, Silty, Sandy LIMESTONE		30-65 Silica Sand		
88.5		21	18/14	88.5-90	25-30-33	Similar to above	88'	20-30 Silica Sand		

REMARKS:

1. Drilling bit responded with resistance and a grinding noise 38 to 45 feet below land surface.
2. Top of Tampa limestone is approximately 73.5 feet below land surface.

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT	
Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.	Report of Boring Number 1A Central Sheet 3 of 3 Date ____ File ____

Boring Co. ____
Foreman ____
SWFWMD Engineer ____

Boring Location ~~Starkey Wellfield~~
Ground Elevation ____ Well Elevation ____
Date Started ____ Date ended ____

CASING
Size: ____
Hammer: ____ lb.
Fall: ____

SAMPLER
Type: ____ Other:
Hammer: ____ lb.
Fall: ____

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	PEN./REC.	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
93.5		22	18/12	93.5-95	29-47-43	White, Silty, Sandy, LIMESTONE	TAMPA LIMESTONE 98	Screen Interval; 20-30 Silica Sand		
98.5		23	18/12	98.5-100	13-16-23	~~Similar to above~~				
						Bottom of boring at 100'		Sump		3

REMARKS:

3. Monitor well 1A Central was installed at completion of boring.

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT	
Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.	Report of Boring Number 2A Central; Sheet 1 of 2; Date 1-11-89; File P07620

Boring Co. American Drilling, Inc.
Foreman Wade Thompson
SWFWMD Engineer John Watson

Boring Location Starkey Wellfield
Ground Elevation 42.0' Well Elevation 46.73'
Date Started 1-9-89 Date ended 1-11-89

CASING
Size: HW and Mud Rotary
Hammer: ______ lb.
Fall: ______

SAMPLER
Type: Split Spoon Other:
Hammer: 140 lb.
Fall: 30 inch

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL/FT.	SAMPLE NO.	PEN./REC	SAMPLE DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	18/6	1-2.5	WOH	PEAT, fibrous.				
3		2	18/0	3-4.5	WOH	No Recovery	PEAT			
5		3	18/8	5-6.5	WOH	PEAT, Fibrous.		Grout		
7		4A	18/14	7-8.5	-	Grey-brown, fine SAND, little Silt.	7' SAND 8'			1
		4B	24/12	8-10	4-3-3-9	Medium stiff, grey-brown Silty CLAY, trace fine Sand, high plasticity.	Silty CLAY 10'			2
10		5	18/14	10-11.5	14-18-16	Dense, white-brown, fine SAND, some silt.				3
13.5		6	18/14	13.5-15	15-12-2	Medium dense, brown, fine SAND, some Silt.		2-inch PVC Well		
18.5		7	18/10	18.5-20	1-1-1	Very loose, black-brown, fine SAND, some (+) Silt.				3
23.5		8	18/10	23.5-25	4-2-6	Loose, brown, fine SAND, some (-) Silt.	Silty fine SAND			
28.5		9	18/14	28.5-30	7-20-21	Dense, white-brown, fine SAND little Silt.				
33.5		10	18/14	33.5-35	10-16-17	Dense, dark brown, fine SAND, some Silt				

REMARKS:

1. Hammer fall was less than 30 inches, blow counts were not recorded.
2. Obtained a sample for laboratory permeameter testing at 8-10 feet below land surface in borehole 2C.
3. Conducted a falling head permeability test at 10-12 feet in borehole 2C and at 20-22 feet in borehole 2B.

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD
WELL DRILLING LOG

PROJECT	Report of Boring Number 2A Central
	Sheet 2 of 2
	Date ______ File P07620

Boring Co.________________ Boring Location ________________
Foreman ________________ Ground Elevation ________ Well Elevation ________
SWFWMD Engineer ________________ Date Started ________ Date ended ________

CASING
Size: ________
Hammer: ________ lb.
Fall: ________

SAMPLER
Type: ________ Other:
Hammer: ________ lb.
Fall: ________

Groundwater Readings:			
Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	SAMPLE PEN./REC.	SAMPLE DEPTH	SAMPLE BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
38.5		11	18/10	38.5-40	8-10-15	Medium dense, dark brown fine SAND, some Silt		Grout		
43.5		12	18/12	43.5-45	14-20-26	Dense, brown, fine SAND, some Silt	Silty fine SAND	30-65 Silica Sand; 20-30 Silica Sand		
48.5		13	18/10	48.5-50	11-14-17	Similar to above		48' – 50' Screen Interval; Sump		
53.5		14	18/12	53.5-55	6-6-6	Medium dense, brown, fine SAND some Silt.				4
58.5		15	18/12	58.5-60	15-15-13	Similar to above		Formation Material		
						Bottom of boring at 60'				5

REMARKS:
4. Monitor well 2A Central installed at completion of the boring.
5. Terminated boring at 60 feet due to the limitations of the tri-pod drill rig.

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD
WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number 3A Central
Sheet 1 of 2
Date 1/9/89 File P07620

Boring Co. American Drilling, Inc.
Foreman George DeGroot
SWFWMD Engineer John Watson

Boring Location Starkey Wellfield
Ground Elevation ______ Well Elevation ______
Date Started 1-6-89 Date ended 1-9-89

CASING
Size: HW then Mud Rotary
Hammer: ______ lb.
Fall: ______

SAMPLER
Type: Split Spoon Other:
Hammer: 140 lb.
Fall: 30 inch

Groundwater Readings:			
Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	PEN./REC	SAMPLE DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	18/12	1-2.5	1-6-7	Medium dense, dark brown, fine SAND, some Silt.				
3		2	18/14	3-4.5	4-11-12	Medium dense, brown, fine SAND, some Silt.		Grout		
5		3	18/10	5-6.5	3-3-5	Loose, light brown, fine SAND and (+) Silt.	Silty fine SAND			
7										1
								6-inch PVC Well		
10		4	18/10	10-11.5	2-4-7	Medium dense, black-brown, fine SAND, some Silt.		30-65 Silica Sand		
13.5		5	18/10	13.5-15	5-8-9	Medium dense, brown, fine SAND, some Silt.	15'	20-30 Silica Sand		
18.5		6	18/12	18.5-20	5-6-7	Medium dense, light brown, fine SAND, some (+) Silt.	20'	Screen Interval; Sump		2
23.5		7A	24/20	23.5-24.5	Pushed	Green, Silty CLAY, high plasticity.	23.5'			3
		7B		24.5-25.5		White, CLAY and SILT, some Limestone fragments, medium plasticity.				
28.5		8	18/12	28.5-30	9-19-10	Very stiff white-green Silty CLAY, high plasticity.	Silty CLAY	Formation Material		
33.5		9	24/18	32-34	PUSHED	Green, Silty CLAY, high plasticity.		Grout		3
							38.5'			

REMARKS:
1. Conducted a falling head permeability test at 5 to 7 feet below land surface in borehole 3A. No sample was obtained from 7 to 8.5 feet due to gravel used for previous permeability test.
2. Monitor well 2A-Central installed at completion of boring.
3. Obtained a sample for laboratory permeameter testing at 23.5-25.5 feet and at 32 to 34 feet in borehole 3A Central.

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD
WELL DRILLING LOG

PROJECT	Report of Boring Number 3A Central
	Sheet 2 of 2
	Date File

Boring Co.
Foreman
SWFWMD Engineer
Boring Location
Ground Elevation Well Elevation
Date Started Date ended

CASING
Size:
Hammer: lb.
Fall:

SAMPLER
Type: Other:
Hammer: lb.
Fall:

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL /FT.	SAMPLE NO.	PEN./REC.	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRTA. CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
38.5		10	10/10	38.5-39.2	46-50/3"	Hard, white, CLAY & SILT, some Limestone fragments	MARL	Grout		
						Bottom of boring at 39.2'				

REMARKS:

MICROFILMED

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number: 1A East
Sheet 1 of 3
Date 1-16-89 File P07620

Boring Co. American Drilling, Inc.
Foreman George DeGroot
SWFWMD Engineer John Watson

Boring Location Starkey Wellfield
Ground Elevation 46.6' Well Elevation 49.67'
Date Started 1-10-89 Date ended 1-16-89

CASING
Size: Mud Rotary
Hammer: lb.
Fall:

SAMPLER
Type: Split Spoon Other:
Hammer: 140 lb.
Fall: 30 inch

Groundwater Readings:			
Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL /FT.	SAMPLE NO.	PEN./REC	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	18/14	1-2.5	2-3-5	Loose, light brown, fine SAND, some Silt, root fibers.				
3		2	18/14	3-4.5	5-8-10	Medium dense, brown, fine SAND, some Silt.	Silty fine SAND			
5		3	18/16	5-6.5	9-7-11	Medium dense, grey-brown fine SAND, and Silt.				
7		4	18/14	7-8.5	12-12-16	Similar to above.		Grout		
10		5	18/16	10-11.5	14-12-11	Very stiff, white-green, Silty CLAY, high plasticity.	10' Silty CLAY			
13.5		6	18/16	13.5-15	2-3-3	Medium stiff, white-green, Silty CLAY, high plasticity.		6-inch PVC Well		
18.5		7	18/16	18.5-20	3-2-1	Soft, white, CLAY & SILT, trace, Limestone fragments.	18.5'			
23.5		8	18/17	23.5-25	7-5-7	Stiff, white, CLAY & SILT, little Limestone fragments, medium plasticity.	MARL			
28.5		9	18/14	28.5-30	2-4-4	Similar to above.				
33.5		10	2/2	33.5-33.6	50/2"	Hard white, CLAY & SILT, some (+) Limestone fragments, medium plasticity.				

REMARKS:

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number 1A East
Sheet 2 of 3
Date ______ File P07620

Boring Co. ______
Foreman ______
SWFWMD Engineer ______
Boring Location ______
Ground Elevation ______ Well Elevation ______
Date Started ______ Date ended ______

CASING
Size: ______
Hammer: ______ lb.
Fall: ______

SAMPLER
Type: ______ Other:
Hammer: ______ lb.
Fall: ______

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL./FT.	SAMPLE NO.	PEN./REC.	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRTA. CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
38.5		11	12/12	38.5-39.5	17-50/6"	Hard, white, CLAY & SILT, some (+) Limestone fragments, medium plasticity.				
43.5		12	18/6	43.5-45	43-27-24	LIMESTONE FRAGMENTS, little Clay & Silt.				
48.5		13	3/3	48.5-48.7	50/3"	Limestone fragments.		Grout		
53.5		14	1/1	52.5-52.6	50/1"	Limestone fragments.	MARL			
58.5		15	12/8	58.5-59.5	37-50/6"	White, Silty, Sandy, LIMESTONE				
63.5		16	2/2	63.5-63.6	50/2"	Similar to above.		6-inch PVC Well		
68.5		17	2/2	68.5-68.6	50/2"	Hard, CLAY & SILT, some Limestone fragments, medium plasticity.				
73.5		18	10/10	73.5-74.3	27/50/4"	Hard, green, Silty CLAY, high plasticity.	73.5 Silty CLAY			
78.5		19	18/14	78.5-80	40-20-40	Similar to above.				
83.5		20	6/6	83.5-84	50/6"	White, Silty, Sandy, LIMESTONE	83.5' TAMPA LIMESTONE			

REMARKS:

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD
WELL DRILLING LOG

PROJECT	
	Report of Boring Number 1A East
	Sheet 3 of 3
	Date ______ File ______

Boring Co. ____________________ Boring Location Starkey Wellfield
Foreman ____________________ Ground Elevation ______ Well Elevation ______
SWFWMD Engineer ____________________ Date Started ______ Date ended ______

CASING
Size: ______
Hammer: ______ lb.
Fall: ______

SAMPLER
Type: ______ Other:
Hammer: ______ lb.
Fall: ______

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	SAMPLE PEN./REC.	SAMPLE DEPTH	SAMPLE BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
88.5		21	5/4	88.5-88.9	50/5"	Hard, white-green, CLAY & SILT, some Limestone fragments.		Grout 30-65 Silica Sand		
93.5		22	2/1	93.5-93.4	50/2"	Limestone fragments.	95'	20-30 Silica Sand		
98.5		23	17/10	98.5-99.9	17-40-50/5"	White, Silty, Sandy, LIMESTONE	TAMPA LIMESTONE	Screen Interval		
103.5		24	18/10	103.5-105	24-37-17	Similar to above.	105'	Sump		1
108.5		25	18/12	108.5-110	20-17-20	Similar to above.				
						Bottom of boring at 110'				

REMARKS:

1- Monitor well 1A East installed at completion of boring.

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

WELL DRILLING LOG

Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number 2A East
Sheet 1 of 2
Date 1/26/89 File P07620

Boring Co. American Drilling, Inc.
Foreman George DeGroot
SWFWMD Engineer John Watson

Boring Location Starkey Wellfield
Ground Elevation 44.7' Well Elevation 48.64
Date Started 1/24/89 Date ended 1/26/89

CASING
Size: HW and Mud Rotary
Hammer: lb.
Fall:

SAMPLER
Type: Split Spoon Other:
Hammer: 140 lb.
Fall: 30 inch

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL./FT.	SAMPLE NO.	PEN./REC.	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	24/8	0-2	1-3-4-5	PEAT, fibrous.	PEAT			
2		2	24/8	2-3	1-5	Similar to above.		Grout		
				3-4	5-5	Stiff, grey, Silty CLAY, high plasticity.	3'			
4		3	24/6	4-6	4-6-4	Similar to above.				
6		4	24/6	6-8	3-4-5-7	Similar to above.	Silty CLAY	2-inch PVC Well		
8		5	24/16	8-10	4-8-15-21	Very stiff, grey-brown, Silty CLAY, high plasticity.				1.
10		6	18/12	10-11.5	7-21-22	Dense, grey-white, fine SAND, little Silt.	10'	30-65 Silica Sand		2.
13.5		7	18/12	13.5-15	5-6-5	Medium dense, light brown, fine SAND, some (+) Silt.	11' Silty fine SAND 16'	20-30 Silica Sand; Screen Interval		3.
18.5		8	18/14	18.5-20	3-4-6	Stiff, brown-grey, Silty CLAY, trace fine Sand, high plasticity.	18.5'	Sump; Bentonite Hole Plug		
23.5		9	24/18	23.5-25.5	1/12"-1/12"	Very soft, grey-green, Silty CLAY, high plasticity.	Silty CLAY	Formation Material		
28.5		10	18/10	28.5-30	3/18"	Very soft, white, CLAY & SILT, little Limestone fragments, medium plasticity.	28.5' MARL			

REMARKS:
1. Obtained a sample for laboratory permeameter testing at 8 to 10 feet and at 23.5 - 25.5 feet below land surface in borehole 2A.
2. Conducted a falling head permeability test at 11 to 13 feet below land surface.
3. Monitor well 2A East installed at completion of the boring.

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) *The stratification lines represent the approximate boundary between soil types and the transition may be gradual.*

SWFWMD
WELL DRILLING LOG

PROJECT

Report of Boring Number 2A East
Sheet 2 of 2
Date ______ File ______

Boring Co. ______
Foreman ______
SWFWMD Engineer ______

Boring Location ______
Ground Elevation ______ Well Elevation ______
Date Started ______ Date ended ______

CASING
Size: ______
Hammer: ______ lb.
Fall: ______

SAMPLER
Type: ______ Other:
Hammer: ______ lb.
Fall: ______

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. / FT.	SAMPLE NO.	SAMPLE PEN./REC	SAMPLE DEPTH	SAMPLE BLOWS / 6"	SAMPLE DESCRIPTION	STRTA. CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
33.5		11	18/10	33.5-35	20-17-8	Very Stiff, white, CLAY & SILT, some Limestone fragments.	MARL	Formation Material		
						Bottom of boring at 35'				

REMARKS:

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number 3A East
Sheet 1 of 2
Date 1/19/89 File P07620

Boring Co. American Drilling, Inc.
Foreman George DeGroot
SWFWMD Engineer John Watson

Boring Location Starkey Wellfield
Ground Elevation 45.9 Well Elevation 48.84'
Date Started 1-18-89 Date ended 1-19-89

CASING
Size: HW then Mud Rotary
Hammer: lb.
Fall:

SAMPLER
Type: Split Spoon Other:
Hammer: 140 lb.
Fall: 30 inch

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	PEN./REC	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	18/12	1-2.5	5-7-9	Medium dense, brown, fine SAND, some (-) Silt.				
3		2	18/12	3-4.5	7-11-11	Similar to above.		Grout		
5		3	18/12	5-6.5	6-4-8	Similar to above.		6-inch PVC Well		1.
7		4	18/12	7-8.5	39-44-33	Very dense, brown, fine SAND, and (+) Silt.	Silty fine SAND	30-65 Silica Sand		
10		5	18/10	10-11.5	6-6-8	Medium dense, light brown, fine SAND, some (-) Silt.	10'	20-30 Silica Sand; Screen Interval		
13.5		6	18/6	13.5-15	10-13-13	Medium, dense, brown-grey, SILT, little fine Sand.	15'	Sump		
18.5		7 A	18/10	18.5-20	4-3-3	Medium,stiff,grey-brown,CLAY & SILT,and fine Sand,trace limestone fragments,low plasticity.	20.5'	Bentonite Hole Plug		2.
		7B	24/10	20.5-22.5	Pushed	Green, Silty CLAY, high plasticity.	Silty CLAY			
23.5		8	18/12	23.5-25	5-8-5	Stiff,white,CLAY & SILT,some Limestone fragments,medium plasticity.	23.5'			3.
28.5		9	18/12	28.5-30	10-26-24	Hard, white, CLAY & SILT, little, Limestone fragments, medium (-) plasticity.	MARL	Formation Material		
33.5		10	11/10	33.5-34.4	24/50/5"	Similar to above.				

REMARKS:
1. Conducted a falling head permeability test at 5 to 7 feet and at 10 to 12 ft. in borehole 3A.
2. Monitor well 1A East installed at completion of boring.
3. Obtained a sample for laboratory permeameter testing at 20.5-22.5 feet in borehole 3A.

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT ______

Report of Boring Number 3A East
Sheet 2 of 2
Date ______ File ______

Boring Co. ______
Foreman ______
SWFWMD Engineer ______

Boring Location ______
Ground Elevation ______ Well Elevation ______
Date Started ______ Date ended ______

CASING
Size: ______
Hammer: ______ lb.
Fall: ______

SAMPLER
Type: ______ Other:
Hammer: ______ lb.
Fall: ______

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	PEN./REC	SAMPLE DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
38.5		11	18/14	38.5-40	48-38-36	Hard, white, CLAY & SILT, little Limestone fragments.	MARL	Formation Material		
						Bottom of boring at 40'				

REMARKS:

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

WELL DRILLING LOG

Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Date ______ File P07620

Boring Co. ______
Foreman ______
SWFWMD Engineer ______
Boring Location ______
Ground Elevation ______ Well Elevation ______
Date Started ______ Date ended ______

CASING
Size: ______
Hammer: ______ lb.
Fall: ______

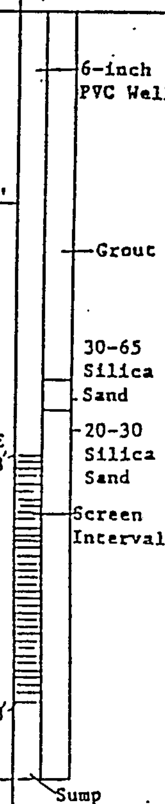
SAMPLER
Type: ______ Other:
Hammer: ______ lb.
Fall: ______

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL /FT.	SAMPLE NO.	PEN./REC.	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	FIELD TESTING	RMKS.
38.5		11	6/6	38.5-39	50/6"	Hard, grey-white, SILT & CLAY, low plasticity, some Limestone Fragments. MARL	MARL		
43.5		12	4/4	43.5-43.8	50/4"	Similar to above	46'		3
48.5		13	2/1	48.5-49.6	50/2"	Limestone fragment	TAMPA LIMESTONE		
55									
60		14		± 60'	WASH	Limestone Cuttings	58'		
65									
70		15		± 70'	WASH	Limestone Cuttings Bottom of boring at 70'	68'		4

WELL INSTALLATION



REMARKS:
3. Top of Tampa Limestone is approximately 46 feet below land surface. Drilling bit responded with resistance and a grinding noise from 46 to 70 feet below land surface.
4. Monitor well 1A West installed at completion of boring.

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

WELL DRILLING LOG

Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Sheet 1 of 2
Date 11/10/88 File P07620

Boring Co. American Drilling, Inc.
Foreman George DeGroot
SWFWMD Engineer John Watson

Boring Location Eldridge-Wilde Wellfield
Ground Elevation 27.84' Well Elevation 31.97'
Date Started 11/9/88 Date ended 11/10/88

CASING
Size: Mud rotary - open hole
Hammer: ______ lb.
Fall: ______

SAMPLER
Type: Split Spoon Other:
Hammer: 140 lb.
Fall: 30 inch

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	PEN./REC	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	18/12	1-2.5	4-4-8	Loose, light brown, fine SAND trace (+) Silt.				
3		2	18/10	3-4.5	4-8-8	Medium dense, grey-brown, fine SAND, little Silt, root fibers.	Silty fine SAND			
5		3	18/10	5-5.5	3	Stiff, grey-brown, CLAY & SILT medium plasticity.	5.0' CLAY & SILT 5.5'			
				5.5-6.5	6-8	Medium dense, black-brown fine SAND, little Silt.				
7		4	18/10	7-8.5	6-6-6	Medium dense, dark brown, fine SAND, little (+) Silt.	Silty fine SAND	Grout		
10		5	18/12	10-11.5	7-14-21	Dense, dark brown, fine SAND, little (+) Silt.				
13.5		6	18/16	13.5-15	9-2-5	Medium stiff, black-brown, Silty CLAY, high plasticity.	13.5' Silty CLAY			
18.5		7A	18/12	18.5-19	15	Similar to above.	19'	6-inch PVC Well		
		7B		19-20	12-8	Medium dense, light brown, fine SAND, little (-) Silt.	Silty fine Sand 23.5			
23.5		8	18/12	23.5-25	9-8-5	Stiff, black-brown, mottled, Silty CLAY and fine SAND, medium plasticity.	Silty CLAY and fine SAND 27			
28.5							VOID			1
		9	4/4	31.5-31.8	50/4"	Hard, grey-white, SILT & CLAY, low plasticity, some Limestone fragments. MARL.	31.5'			
33.5		10	6/6	33.5-34	50/6"	Similar to above.	MARL			
							38.5'			2

REMARKS:
1. Encountered a void from 27 to 31.5 feet below land surface. Installed a 10 inch diameter steel casing to 15 feet below land surface and added several bags of stone to fill the void in the borehole.
2. Observed 1 to 3 inch chunks of organic matter rising in wash from about 35 feet below land surface.

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number ________ Sheet 1 of 1
Date 11-16-88 File P07620

Boring Co. American Drilling, Inc.
Foreman: George DeGroot
SWFWMD Engineer John Watson

Boring Location Eldridge-Wilde Wellfield
Ground Elevation 26.36 Well Elevation 31.19
Date Started 11-16-88 Date ended 11-16-88

CASING
Size: HW
Hammer: ________ lb.
Fall: ________

SAMPLER
Type: Split Spoon Other:
Hammer: 140 lb.
Fall: 30 inch

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL./FT.	SAMPLE NO.	PEN./REC.	SAMPLE DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	18/4	1-2.5	1/12"-1	PEAT	PEAT			
3		2A	18/16	3-3.5		Similar to above	3.5'			
		2B		3.5-4.5	12-25	Dense, grey-brown, fine SAND, trace Silt.				
5		3	18/16	5-6.5	9-15-15	Similar to above		2-inch PVC Well		1
7		4	18/16	7-8.5	4-15-12	Medium dense, brown, fine SAND, little Silt	Silty fine SAND			
10		5	18/12	10-11.5	9-9-7	Similar to above		Grout		
13.5		6	18/12	13.5-15	2-4-6	Medium dense, dark brown, fine SAND, little (+) Silt.		30-65 Silica Sand		1
18.5		7	18/16	18.5-20	4-5-6	Similar to above	18'	20-30 Silica Sand; Screen Interval		
23.5		8	24/18	23.5-25	1-1-3	Loose, brown, fine SAND, little Silt.	23'			
				25-25.5	4	Black-brown, Silty CLAY, high plasticity.	25'	Sump		2
		9	24/18	25.5-27	3-4-8-15	Stiff, black-brown, Silty CLAY high plasticity.	Silty CLAY	Grout		
				27-27.5		Dark brown, Organic Matter				
						Bottom of boring at 27.5'				3

REMARKS:
1. Conducted a falling head permeability test at 5 to 7 feet in borehole 2C and at 13 to 15 feet in borehole 2B.
2. Monitor well 2A West installed at completion of the boring.
3. Obtained a sample for laboratory permeameter testing at 25.5 to 27.5 feet in borehole 2A.

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

WELL DRILLING LOG

Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number 3A West
Sheet 1 of 2
Date 11-14-88 File P07620

Boring Co. American Drilling, Inc.
Foreman George DeGroot
SWFWMD Engineer John Watson

Boring Location Eldridge-Wilde Wellfield
Ground Elevation 28.28 Well Elevation 31.92
Date Started 11-11-88 Date ended 11-14-88

CASING
Size: HW then Mud Rotary
Hammer: ______ lb.
Fall: ______

SAMPLER
Type: Split Spoon Other:
Hammer: 140 lb.
Fall: 30 inch

Groundwater Readings:			
Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	PEN./REC.	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	18/8	1-2.5	4-6-8	Medium dense, brown, fine SAND, little Silt.				
3		2	18/8	3-4.5	7-11-11	Medium dense, light brown, fine SAND, little Silt.		6-inch PVC Well		
5		3	18/16	5-6.5	6-7-10	Similar to above.	Silty fine SAND	Grout		
7		4	18/10	7-8.5	8-6-7	Medium dense, brown, fine SAND, little (+) Silt.				1
10		5	18/12	10-11.5	9-19-15	Dense, brown, fine SAND, little Silt.		30-65 Silica Sand		2
13.5		6	18/10	13.5-15	5-3-3	Loose, brown, fine SAND, little Silt.	12'	20-30 Silica Sand; Screen Interval		
18.5		7A	24/14	18.5-20	1-3-4	Medium stiff, black-brown Silty CLAY; high plasticity	17'; 18.5'	Sump		3 4
		7B		20-20.5	7	Dark brown, Organic Matter.	Silty CLAY			
23.5		8	18/12	23.5-25	3-4-4	Medium stiff, black-brown, Silty CLAY, high plasticity.		Grout		
28.5		9	18/10	28.5-30	3-8-7	Medium dense, dark brown, fine SAND, little (+) Silt.	28.5'; Silty fine SAND			
33.5		10A	24/16	33.5-34	2	Loose, light brown, fine SAND, little Silt.	34'			
		10B		34-35	2-2	Medium Stiff, green-grey Silty, high plasticity.	Silty CLAY 35'			
		10C		35-35.5	3	Medium stiff, grey-white, SILT & CLAY, low plasticity, some Limestone fragments.	MARL			

REMARKS:

1. Conducted a falling head permeability test at 18.5-20.5 feet in borehole 3A.
2. The density of sample 5 may be affected by gravel used in the falling head test.
3. Monitor well 3A West was installed at completion of boring.
4. Obtained a sample for laboratory permeameter testing at 18.5-20.5 feet in borehole 3A.

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT

Report of Boring Number 3A West
Sheet 2 of 2
Date ______ File P07620

Boring Co. ______
Foreman ______
SWFWMD Engineer ______

Boring Location Eldridge-Wilde Wellfield
Ground Elevation ______ Well Elevation ______
Date Started ______ Date ended ______

CASING
Size: ______
Hammer: ______ lb.
Fall: ______

SAMPLER
Type: ______ Other:
Hammer: ______ lb.
Fall: ______

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	PEN/REC	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
38.5		11	18/10	38.5-40	11-16-11	Very stiff, grey-white, SILT & CLAY, low plasticity, some Limestone fragements.	MARL	Grout		
						Bottom of boring at 40'				

REMARKS:

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number: 1A East
Sheet 1 of 2
Date 11/2/88 File P07620

Boring Co. American Drilling, Inc.
Foreman George DeGroot
SWFWMD Engineer John Watson

Boring Location Eldridge-Wilde Wellfield
Ground Elevation 34.70 Well Elevation 38.63
Date Started 10-31-88 Date ended 11-2-88

CASING
Size: Mud rotary-open hole
Hammer: lb.
Fall:

SAMPLER
Type: Split Spoon Other:
Hammer: 140 lb.
Fall: 30 inch

Groundwater Readings: Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL /FT.	SAMPLE NO.	PEN./REC	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	18/10	1-2.5	6-7-9	Medium dense, brown, fine SAND, trace (+) Silt.				
3		2	18/10	3-4.5	4-5-5	Medium dense, light brown, fine SAND, trace (+) Silt.				
5		3	18/8	5-6.5	2-2-1	Very loose, brown, fine SAND, little Silt.		Grout		
7		4	18/10	7-8.5	3-4-7	Medium dense, dark brown, fine SAND, little (+) Silt.	Silty fine SAND			
10		5	18/10	10-11.5	5-6-8	Similar to above.				
13.5		6	18/10	13.5-15	3-6-8	Similar to above.		6-inch PVC Well		
18.5		7	18/8	18.5-20	6-16-28	Dense, dark brown, fine SAND, little (+) Silt.				
23.5		8	18/8	23.5-25	8-8-16	Medium dense, dark brown, fine SAND, little (+) Silt.				
28.5		9	18/12	28.5-30	10-20-21	Dense, dark brown, fine SAND, little (+) Silt.				
33.5		10 A	18/18	33.5-34.5	2-3	Medium stiff, mottled, brown CLAY & SILT with dark brown Silty CLAY, medium (+) plasticity.	33.5'			
		10B		34.5-35	3	Brown, CLAY & SILT, medium plasticity, little (-) Limestone fragments.	MARL			

REMARKS:

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number: 1A East
Sheet: 2 of 2
Date:
File: P07620

Boring Co.:
Foreman:
SWFWMD Engineer:

Boring Location: Eldridge-Wilde Wellfield
Ground Elevation: Well Elevation:
Date Started: Date ended:

CASING	SAMPLER
Size:	Type: Other:
Hammer: lb.	Hammer: lb.
Fall:	Fall:

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL./FT.	SAMPLE NO.	PEN/REC	SAMPLE DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
38.5		11A	18/6	38.5-39.5	WOH-3-3	Soft, green-grey, Silty CLAY, high plasticity.				
		11B		39.5-40		Grey-white, CLAY & SILT, little Limestone fragments, medium plasticity.				
43.5		12	18/16	43.5-45	7-4-5	Stiff, grey-white, CLAY & SILT, little Limestone fragments, medium plasticity.	MARL	6-inch PVC Well		
48.5		13	18/16	48.5-50	13-24-31	Hard, green, Silty CLAY, high (-) plasticity.	48.5' Silty CLAY			
53.5		14	18/16	53.5-55	14-18-16	Similar to above		Grout		
58.5		15	4/2	58.5-58.8	50/4"	Limestone fragments	56.5'			
65								30-65 Silica Sand		
70							TAMPA LIMESTONE 68'	20-30 Silica Sand		
75				± 75'	WASH	Limestone cuttings		Screen Interval		
80						Bottom of boring at 80'.	78'	Sump		

REMARKS: 1. Top of limestone is approximately 56.5 feet below land surface. Drilling bit responded with resistance and a grinding noise from 56.5 to 80 feet below land surface.
2. Monitor well 1A East installed at completion of boring.

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Swamps in Wellfields near Tampa

Report of Boring Number: 2A East
Sheet 1 of 1
Date 11/22/88 File P07620

Boring Co. American Drilling, Inc.
Foreman George DeGroot
SWFWMD Engineer John Watson

Boring Location Eldridge-Wilde Wellfield
Ground Elevation 23.90 Well Elevation
Date Started 11-21-88 Date ended 11-22-88

CASING
Size: HW
Hammer: lb.
Fall:

SAMPLER
Type: Split Spoon Other:
Hammer: 140 lb.
Fall: 30 inch

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL /FT.	SAMPLE NO.	PEN./REC	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	18/16	1-2.5	1/18"	PEAT, fibrous.				
3		2	18/0	3-4.5	WOH/18"					1.
5		3	18/16	5-6.5	WOH/18"	Similar to Above.	PEAT			2.
7		4	18/12	7-8.5	1/18"	Similar to above.				
10		5A	18/12	10-11.1	1/18"	Similar to above.	11.1'	2-inch PVC Well		
		5B		11.1-11.5		Very soft, black-brown, Silty CLAY, organic, high(-)plasticity	Silty CLAY			3.
13.5		6A	18/16	13.5-15	1/18"	Similar to above.				
18.5		7	18/10	18.5-20	1-4-4	Loose, grey-brown, fine SAND, little (+) Silt.	18.5' Silty fine SAND	Grout		2.
23.5		8	18/16	23.5-25	WOH-1-1	Very soft, black-brown, Silty CLAY, organic, high plasticity.	23.5' Silty CLAY			
28.5		9	18/16	28.5-30	1/12"-1	Similar to above.		30-65 Silica Sand		
		10	24/16	30.5-31.5	WOH/12"	Similar to above				
				31.5-32.5	3-4	Loose, grey-brown, fine SAND, little Silt.	31.5' Silty fine SAND	20-30 Silica Sand		3.
33.5								Screen Interval		4.
						Bottom of boring at 35'.		Sump		

REMARKS:
1. No recovery within split spoon sampler.
2. Conducted a falling head permeability test at 5 to 7 feet and 18 to 20 feet below land surface in borehole 2B.
3. Obtained a sample for laboratory permeameter testing at 11.5 to 13.5 feet in borehole 2B and from 30.5 to 32.5 feet in borehole 2A.
4. Monitor well 2A East was installed at completion of the boring.

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD WELL DRILLING LOG

PROJECT: Hydrogeologic Investigation of Cypress Domes in Wellfields near Tampa.

Report of Boring Number: 3A East
Sheet 1 of 2
Date 11-4-88 File P07620

Boring Co. American Drilling, Inc.
Foreman George DeGroot
SWFWMD Engineer John Watson

Boring Location Eldridge-Wilde Wellfield
Ground Elevation 35.85 Well Elevation 39.57
Date Started 11-3-88 Date ended 11-4-88

CASING
Size: HW then Mud Rotary
Hammer: lb.
Fall:

SAMPLER
Type: Split Spoon Other:
Hammer: 140 lb.
Fall: 30 inch

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL /FT.	SAMPLE NO.	PEN./REC	DEPTH	BLOWS/6"	SAMPLE DESCRIPTION	STRATA CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
1		1	18/12	1-2.5	3-4-5	Loose, brown, fine SAND, trace Silt, root fibers.				
3		2	18/10	3-4.5	4-9-10	Medium dense, light brown, fine SAND, trace Silt.				
5		3	18/12	5-6.5	3-4-6	Similar to above.		6-inch PVC Well		
7		4	18/12	7-8.5	3-3-3	Loose, dark brown, fine SAND, little (+) Silt.				
10		5	18/10	10-11.5	2-2-4	Similar to above.	Silty fine SAND			
13.5		6	18/10	13.5-15	2-4-5	Similar to above.		Grout		1.
18.5		7	18/6	18.5-20	1-2-4	Similar to above.				
23.5		8	18/10	23.5-25	10-6-9	Medium dense, brown, fine SAND, little Silt.	25'	30-65 Silica Sand; 20-30 Silica Sand		1.
28.5		9	18/0	28.5-30			30'	Screen Interval		2.
			18/0	30-31.5				Sump		
33.5		9	18/16	33.5-35	1-2-2	Soft, mottled, grey-brown CLAY & SILT with white-grey, CLAY & SILT, medium plasticity, little Limestone Fragments.	33.5' MARL	Bentonite Hole Plug		3.
		10	24/10	35-37	WOH-1-2-2	Similar to above.				

REMARKS:
1. Conducted a falling head permeability test at 13.5 to 17 feet and 25 to 27 feet below land surface at borehole 3A.
2. No recovery in split spoon sampler at 28.5 - 31.5 feet which may be due to gravel used for the permeability test.
3. Obtained a sample for laboratory permeameter testing at 35-37 feet in borehole 3A.

GRANULAR SOILS BLOWS/FT.	DENSITY	COHESIVE SOILS BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

SWFWMD
WELL DRILLING LOG

PROJECT

Report of Boring Number 3A East
Sheet 2 of 2
Date ______ File ______

Boring Co. ______
Foreman ______
SWFWMD Engineer ______

Boring Location Eldridge-Wilde Wellfield
Ground Elevation ______ Well Elevation ______
Date Started ______ Date ended ______

CASING

Size: ______
Hammer: ______ lb.
Fall: ______

SAMPLER

Type: ______ Other:
Hammer: ______ lb.
Fall: ______

Groundwater Readings:

Date	Depth	Casing at	Stabilization Time

DEPTH	CAS. BL. /FT.	SAMPLE NO.	SAMPLE PEN./REC.	SAMPLE DEPTH	SAMPLE BLOWS/6"	SAMPLE DESCRIPTION	STRTA. CHG. and GEN. DESC.	WELL INSTALLATION	FIELD TESTING	RMKS.
38.5		11	18/6	38.5-40	1-2-2	Soft, white-grey, CLAY & SILT, medium plasticity, little Limestone Fragments.	MARL			
45		12	24/10	45-46.5	WOH/18	Very loose, brown, fine SAND, trace Silt.	45' fine SAND 46.5'	Formation Material		
				46.5-47	10	Grey-white CLAY & SILT, some Limestone fragments, medium plasticity.	MARL			
						Bottom of Boring at 47'				

REMARKS:

GRANULAR SOILS		COHESIVE SOILS	
BLOWS/FT.	DENSITY	BLOWS/FT.	DENSITY
0-4	V. LOOSE	<2	V. SOFT
4-10	LOOSE	2-4	SOFT
10-30	M. DENSE	4-8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES: 1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

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(108 PGS)

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