United States Department of Agriculture | **Natural Resources Conservation Service** | **5 Radnor Corporate Center, Suite 200 Radnor, PA 19087-4585**

Subject: SOI -- Geophysical Assistance -- **Date:** 7 March 1996

To: Mark W. Berkland
State Conservationist
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Purpose:
The purpose of this investigation was to provide requested geophysical field assistance to the South Carolina Department of Parks, Recreation and Tourism. Ground-penetrating radar (GPR) and electromagnetic induction (EM) techniques were used to conduct reconnaissance archaeological surveys at Old Charles Towne Landing and Old Dorchester State Parks. At each site, surveys were designed to map subsurface anomalies. This study demonstrated the value of integrating contemporary geophysical and computer technologies with traditional archaeological techniques to provide more comprehensive site coverage, reduce the number of unsuccessful exploratory pits, and decrease field time and costs.

Participants:
Donnie Barker, State Park Archaeologist, South Carolina Department of Parks, Recreation and Tourism, Columbia, SC
Janson Cox, Superintendent, Old Charles Town Landing State Park, SCDPRT, Charleston, SC
Jim Doolittle, Research Soil Scientist, NRCS, Radnor, PA

Activities:
All field activities were completed during the period of 12 to 15 February 1996.

Equipment:
The radar unit used in this study was the Subsurface Interface Radar (SIR) System-2, manufactured by Geophysical Survey Systems, inc. This unit is backpack portable and requires two people to operate. The use and operation of GPR have been discussed by Morey (1974), Doolittle (1987), and Daniels and others (1988). The SIR System-2 consists of a digital control unit (DC-2) with keypad, VGA video screen, and connector panel. The model 3102 (500 mHz) antenna was used in this investigation. The system was powered by a 12-VDC battery.

The electromagnetic induction meter used in this study was the EM38, manufactured by Geonics Limited*. This meter is portable and requires only one person to operate. Principles of operation have been described by McNeill (1980). No ground contact is required with this meter. This meter provides limited vertical resolution and depth information. Lateral resolution is approximately equal to the intercoil spacing. The EM38 meter has a fixed intercoil spacing of about 40 inches. It operates at a frequency of 13.2 kHz. The EM38 meter has effective observation depths of about 30 and 60

* Trade names are used to provide specific information. Their mention does not constitute endorsement by USDA-NRCS.

inches in the horizontal and vertical dipole orientations, respectively (McNeill, 1986). Values of apparent conductivity are expressed in milliSiemens per meter (mS/m).

To help summarize the results of this study, the SURFER for Windows software program, developed by Golden Software, Inc.,* was used to construct two-dimensional simulations. Grids were created using kriging methods with an octant search. All grids were smoothed using a cubic spline interpolation. In some plots, filled contour lines have been used. Other than showing trends and patterns in values of apparent conductivity (i.e., zones of higher or lower electrical conductivity) or estimated soil depths, no significance should be attached to the colors themselves.

Study Areas:
Old Charles Towne Landing is located within the city of Charleston, South Carolina. Old Dorchester State Park is located about four miles south of the town of Summerville, South Carolina. Both parks are located on the Ashley River. Figure 1 shows the approximate location of these parks in Charleston and Dorchester counties.

Discussion:

Old Charles Towne Landing

Field Procedures:

An irregularly shaped grid (2.5 acres) was established across a portion of Old Charles Towne Landing that was enclosed by palisades. Four, parallel lines provided the foundation for the grid. These lines were oriented in a north-south direction, spaced 100 feet apart, and ranged in length from 200 to 500 feet. Along each of these lines, survey flags were inserted in the ground at intervals of 10 feet. The survey grid was constructed by extending one hundred and thirteen, parallel, profile lines between the north-south lines. Profile lines extended in an east-west direction. Each profile line was 100 feet in length, and spaced about 10 feet apart. Observation points (1243) were measured along each line at intervals of ten feet.

The radar survey was completed by pulling a 500 mHz antenna along each of the parallel, east-west trending, profile lines. This procedure provided about 11300 feet of continuous radar imagery. Each radar profile was reviewed for subsurface features and anomalies. Along each profile line, relative distances and the approximate location of each anomaly were recorded. Interpretations of the depth to finer-textured materials were restricted to the 1243 observation points.

The EM survey was conducted within selected subsections (about 0.7 acres) of the grid. At 352 observation points, measurements were taken with an EM38 meter placed on the ground surface in the horizontal and vertical dipole orientations.

Calibration of GPR:

The suitability of GPR was assessed during field trials conducted on a portion of the grid site. The purpose of these trials was to evaluate the depth of observation and resolution of the 500 mHz antenna. In addition, these trials helped to determine the dielectric constant and velocity of propagation of electromagnetic energy through the coarse-textured surface layer, establish a crude depth scale for the radar profiles. These trials also provided an opportunity to optimize control and recording settings.

A short profile line was established within the survey area. A metallic reflector was buried at a depth of 12 inches. The depth to this known, buried metallic reflector was used to scale the radar. Based on the averaged round-trip travel time to this reflector, the velocity of propagation

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through the coarse-textured surface layers was estimated to be 0.24 ft/ns. The dielectric constant was estimated to be 17.

When assessing the appropriateness of using GPR, a major consideration is signal attenuation at the desired antenna operating frequency (Daniels et al., 1988). The maximum depth of observation decreases with increasing antenna frequency. High frequency antennas (>500 mHz) can provide well resolved images of shallow features in soils having low conductivity. However, excessive levels of signal attenuation often preclude the use of high frequency antennas in soil having moderate electrical conductivities (Daniels et al., 1988). In these soils, lower frequency (80, 100, 120, and 300 mHz) antennas can be used to improve the depth of observation. Compared with higher frequency antennas, lower frequency antennas provide poorer resolution of subsurface features. At both Old Charles Towne Landing and Old Dorchester, the electrical conductivity of the soils was low and the 500 mHz antenna provided a suitable balance of observation depth and resolution.

Radar Interpretations:
With the 500 mHz antenna, the depth of observation was restricted to the coarse-textured surface layer and the upper part of the underlying, medium-textured subsoil (argillic horizon). The medium-textured subsoil rapidly attenuated the radar signal and restricted the depth of observation. As most artifacts were assumed to be buried at relatively shallow depths, radar observations below the upper part of the argillic horizon was not required. In addition, disturbances to the upper part of this horizon could indicate the locations of buried post holes or pits.

Figure 2 is a processed radar profile from the study area. This profile has been processed through the RADAN software package. Processing was limited to signal stacking, customizing color transforms and tables, and annotations. In Figure 2, the horizontal scale measures distances along the profile line. This scale is in feet. Along this traverse, at an interval of about 10 feet, the radar operator impressed a segmented line, or distance mark, on the radar profile. The segmented, vertical lines indicate the locations of observation points. At each observation point, the thickness of the surface layer was estimated from the radar imagery.

In Figure 2, the soil surface is represented by the two dark, closely spaced, horizontal lines that extend across the upper part of the profile. Immediately below the surface reflection is the surface layer, a zone of relatively few reflections. In Figure 2, several point reflectors (A) have been identified within the surface layer. The thickness of the surface layer was interpreted to correspond to the depth to the first subsurface, planar reflector.

The only subsurface, planar reflector apparent in this profile is the surface layer/argillic horizon interface. This interface is irregular in depth and expression. In Figure 2, this interface ranges in depth from about 15.8 to 32.6 inches. This interface appears to consist of numerous, irregularly spaced, discrete, point reflectors (see B in Figure 2). These point reflectors were at first believed to represent buried cultural features. However, based on limited ground truth observations, many of these point reflectors are believed to represent undisturbed segments of the argillic horizon. Between the undisturbed segments of the argillic horizon are areas of disturbed soil materials. Areas of disturbed soil materials often appear as depressions (see C)in Figure 2). These depressions are believed to represent buried post holes.

Results:
Within the study area, based on interpretations of the radar profiles taken at the 1243 observation points, the average thickness of the surface layer was 20.2 inches with a range of 9.5 to 42.0 inches. One-half of the observations had surface layers between 18 and 22.3 inches thick. Within the study area, the thickness of the surface layer was estimated to be shallow (0 to 20 inches) at 55 percent and moderately deep (20 to 40 inches) at 45 percent of the observation

points. These data suggest that the site is covered by a relatively thin mantle of coarse-textured materials.

Figure 3 is a two-dimensional plot simulating the thickness of the surface layer (or the depth to the argillic horizon) within the survey area. This simulation was based upon radar interpretations made at the 1243 observation points. In this plot, the contour interval is 3 inches. The approximate location of the converging palisade walls has been indicated with dark blue lines.

Although the range in thickness of the surface layer was not considered excessive (32.5 inches), the resulting spatial patterns were complex (see Figure 3). Numerous small, circular, depressions dot the study area. In Figure 3, most discernible depressions range from about 5 to 10 feet in diameter and from 6 to 32 inches in depth. These features may represent former excavations or buried post hole pits.

In general, the thickness of the surface layer thins and becomes less variable towards the east (right-hand side of Figure 3). This portion of the study area was located on the slightly higher-lying summit of a broad low ridge. In Figure 3, a wedge of soils with relatively shallow depths to finer-textured materials appears to extend from the apex of the palisade walls towards the southeast (lower right-hand corner of plot). Within this wedge, depths to finer-textured materials are less variable and depressions are less conspicuous. Along each side of this wedge are sinuous troughs containing soils with greater depths to finer textured materials. The general appearance of these troughs suggests former drainage channel. If these features represent former drainage channels, in-filling with coarser-textured materials is suggested.

A cursory review of the radar profiles revealed 724 identifiable point anomalies. Of these, 251 had appearances that suggested former post holes. These features have been plotted in Figure 4. These anomalies appear to be concentrated in the southwest (lower-left) and east-northeast (right and upper right) portions of the study site. As trees occurred in the southwest and northeast corners of the site, many of the anomalies detected in these portions of the study area probably represent tree roots. In Figure 4, a conspicuous line of interpreted post holes runs parallel with the western palisade wall. These features probably reflect the mound of materials that had been excavated from the trench adjoining the palisade wall.

In Figure 5 all recognized subsurface point anomalies have been plotted with a contour plot of the depths to finer-textured soil materials. This plot can assist archaeologist determine the most appropriate areas for exploratory pits.

EM Survey:

Electromagnetic inductive methods measure vertical and lateral variations in the apparent electrical conductivity of earthen materials. The actual values of apparent conductivity are seldom diagnostic, but lateral and vertical variations in these measurements can be used to infer changes in soils and earthen materials. Interpretations of the EM data are based on the identification of spatial patterns within data sets.

Electromagnetic induction techniques are not suitable for use in all investigations. Generally, the use of EM techniques has been most successful in areas of undisturbed soils where subsurface properties are reasonably homogeneous, the effects of one property (e.g. clay, water, or salt content) dominates over the other properties, and variations in EM response can be related to changes in the dominant property (Cook et al., 1989).

The EM survey was designed to help characterize a portion of the site, identify areas with anomalous electrical conductivity, and suggest the location of buried cultural features and disturbed materials. Variations in values of apparent conductivity were assumed to principally reflect variations in the depth to finer-textured materials (argillic horizon), and the presence of buried artifacts and disturbed soils.

EM Interpretations:
Because of constraints on time and available resources, only a portion (0.7 acres) of the grid site at Old Charles Towne Landing was surveyed with the EM38 meter. At 352 observation points, measurements were taken with an EM38 meter placed on the ground surface in the horizontal and vertical dipole orientations.

Basic statistics for the EM data collected within the study area are displayed in Table 1. These statistics characterize the site as being underlain by comparatively resistive and invariable materials. One-half of the observations had values of apparent conductivity between 5 and 8 mS/m in the horizontal (0 to 30 inches), and between 6 and 9.5 mS/m in the vertical (0 to 60 inches) dipole orientation. In general, values of apparent conductivity were low and increased slightly with increasing observation depths. The low values were assumed to reflect the predominance of resistive sands in the surface layer. Values increased with depth because of moderate concentrations of highly weathered clays in the argillic horizon..

Table 1
Basic Statistics
EM Survey
Old Charles Towne Landing Study Area
(All values are in mS/m)

				Quartiles			
Meter	Orientation	Minimum	Maximum	1st	Median	3rd	Average
EM38	Horizontal	1.0	13.0	5.0	7.0	8.0	6.4
EM38	Vertical	1.0	13.0	6.0	8.0	9.5	7.7

Figures 6 and 7 are two-dimensional plots of data collected with the EM38 meter in the horizontal and vertical dipole orientations, respectively. In each plot, the isoline interval is 2 mS/m. Figures 6 and 7 represents the spatial distribution of apparent conductivity within the upper 30 inches and the upper 60 inches of the soil profile, respectively. The spatial patterns appearing in these figures are presumed to reflect principally the depths to finer-textured materials, disturbances, and buried cultural features.

Patterns appearing in figures 6 and 7, roughly approximate the patterns evident in Figure 3. Areas having more variable and intricate patterns are presumed to reflect disturbances. Highly contrasting patterns over short distances are believed to reflect buried cultural features. These patterns are most apparent in the upper left-hand corner of each plot where the convergence of the two palisade walls occurs. In each plot, small, conspicuous areas having anomously high or low apparent conductivity values are evident. These features are presumed to reflect buried artifacts.

Old Dorchester State Park
Field Procedures:
A small, irregularly shaped grid (about 0.4 acres) was established across a portion of Old Dorchester that overlooked the Ashley River. This site adjoined an area that had been surveyed with GPR in 1991. The grid interval was 10 feet. Along each line, survey flags were inserted in the ground at intervals of 10 feet.

A radar survey was completed by pulling the 500 mHz antenna along nine parallel, north-south trending, grid lines. This procedure provided about 2460 feet of continuous radar imagery.

Discussion:
Unlike the survey conducted in the adjoining area (in 1991), no major subsurface, structural feature was evident on radar profiles. The interpretative results of the radar survey have been plotted in Figure 8. One hundred and forty-two point anomalies and nine planar reflectors were identified on radar profiles and plotted in Figure 8. As the site was located in a forest area, many of the point anomalies are believed to represent tree roots. Some undoubtedly represent artifacts. Most of the planar reflectors are believed to represent cultural features.

Results:

1. Geophysical interpretations are considered preliminary estimates of site conditions. The results of geophysical site investigations do not substitute for direct observations, but rather reduce their number, direct their placement, and supplement their interpretations. Interpretations should be verified by ground-truth observations.

2. At Old Charles Towne Landing, based on GPR interpretations and a ten foot (grid) search strategy, no major subsurface structure was identified within the site. Point anomalies were more numerous in the southwest and northeast portions of the site. While some of these anomalies are suspected to be tree roots, these areas should afford archaeologist with the best opportunities to uncover cultural features and artifacts.

3. At Old Charles Towne Landing, GPR techniques were used to infer the thickness of the surface layer within the study area. Spatial patterns appearing on two-dimensional plots suggest the presence of buried drainage channels near the palisade walls. The accuracy of radar interpretations is based on the adequacy of auger observations. In this study, the number of ground-truth observations was exceedingly small (4). As properties (moisture, clay, and organic matter contents) of the surface layer materials were known to vary, it is anticipated that estimates of the depths to finer-textured materials contain some degree of error.

4. At Old Charles Towne Landing, an EM survey help to characterize a portion of the site. This technique identifies areas with different apparent conductivity values, and provided a method for grouping observation points based on similarities of responses. Variations in values of apparent conductivity were presumed to reflect the depths to finer-textured materials, disturbances, and buried cultural features

5. At Old Dorchester State Park, based on GPR interpretations and a ten foot (grid) search strategy, no major subsurface, structural feature was identified within the survey area. Numerous point and planar reflectors provide hope that the site is underlain by some minor cultural.

6. The investigation process at each site has only begun. All radar profiles have been returned to Donnie Barker under a separate cover letter. These profiles should be maintained, reviewed, and used to guide further investigations at these sites. Base on ground truth verifications, radar interpretations can be improved.

It was my pleasure to work in South Carolina and to provide this technical assistance to the South Carolina Department of Parks, Recreation, and Tourism.

With kind regards,

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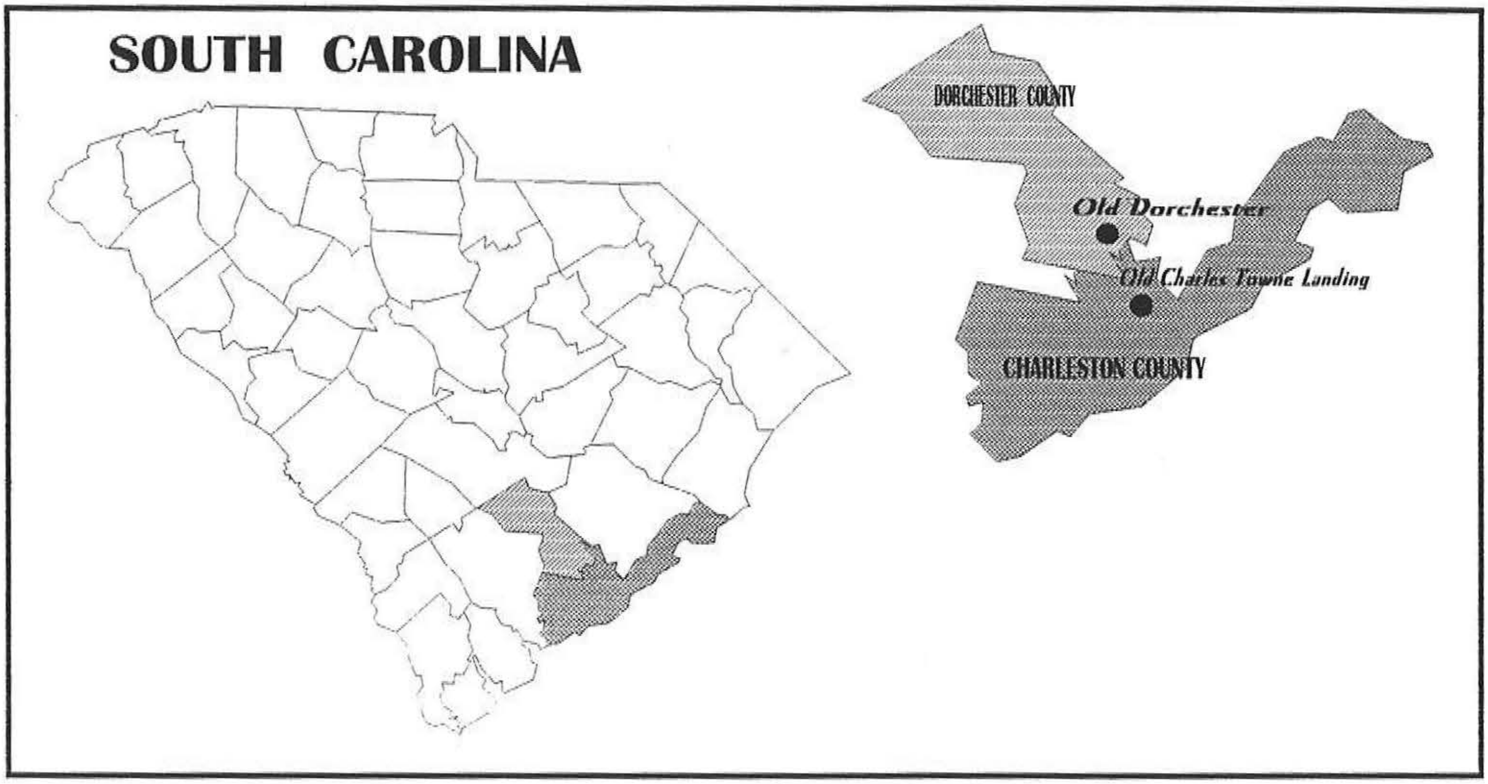
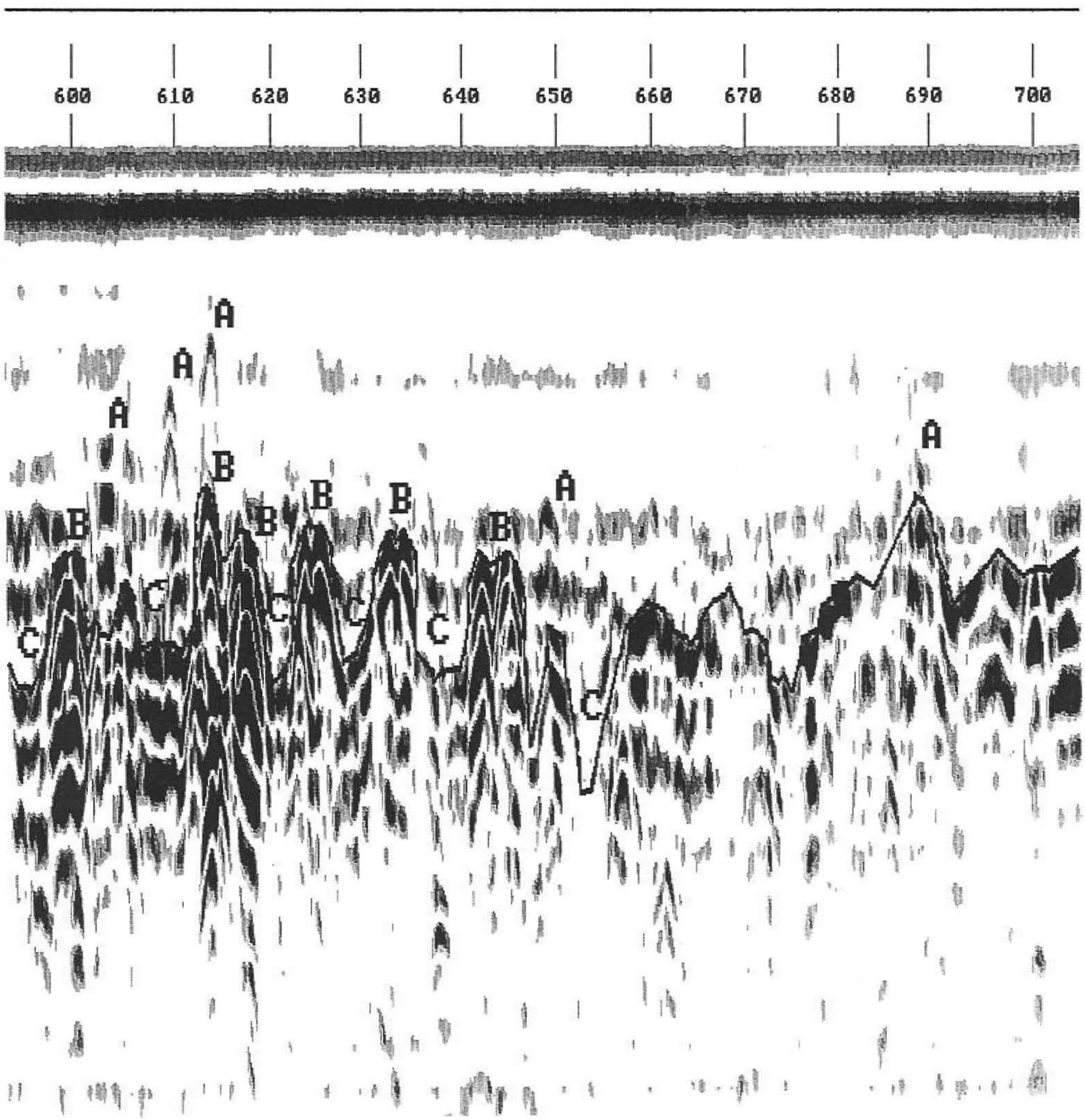

SOUTH CAROLINA
DORCHESTER COUNTY
Old Dorchester
Old Charles Towne Landing
CHARLESTON COUNTY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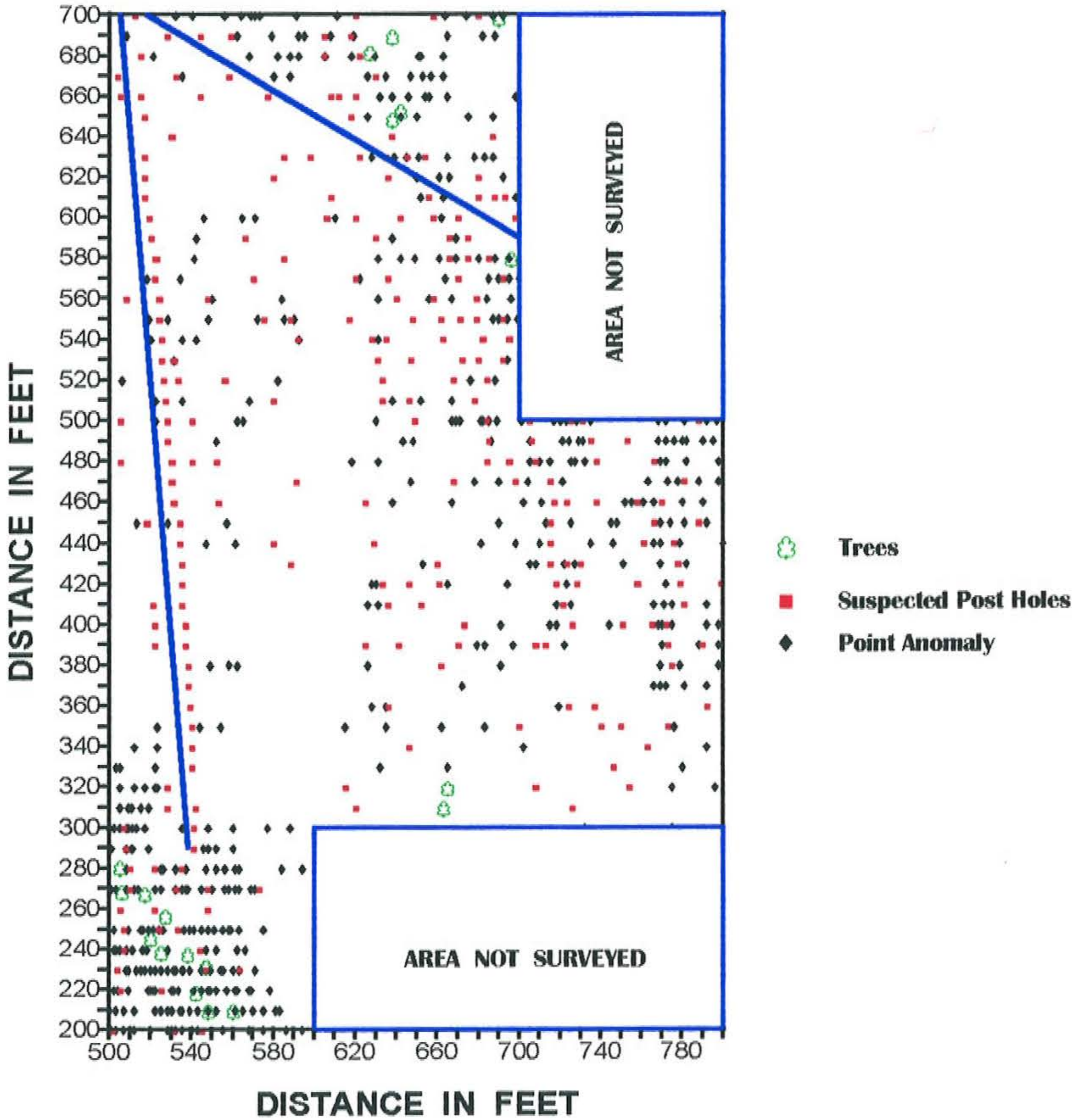
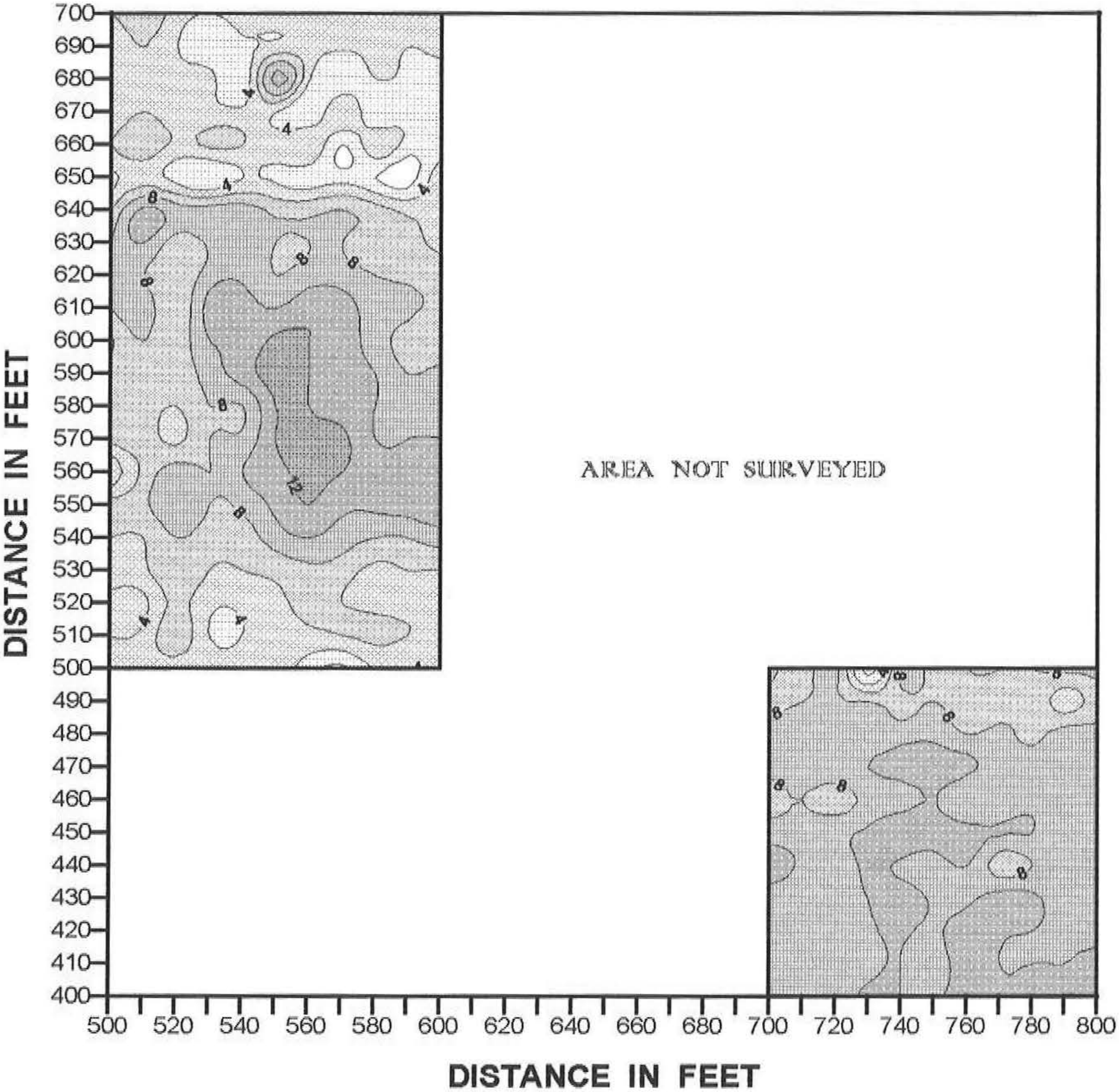
OLD CHARLES TOWNE LANDING
CHARLESTON, SOUTH CAROLINA

LOCATIONS OF DETECTED ANOMALIES



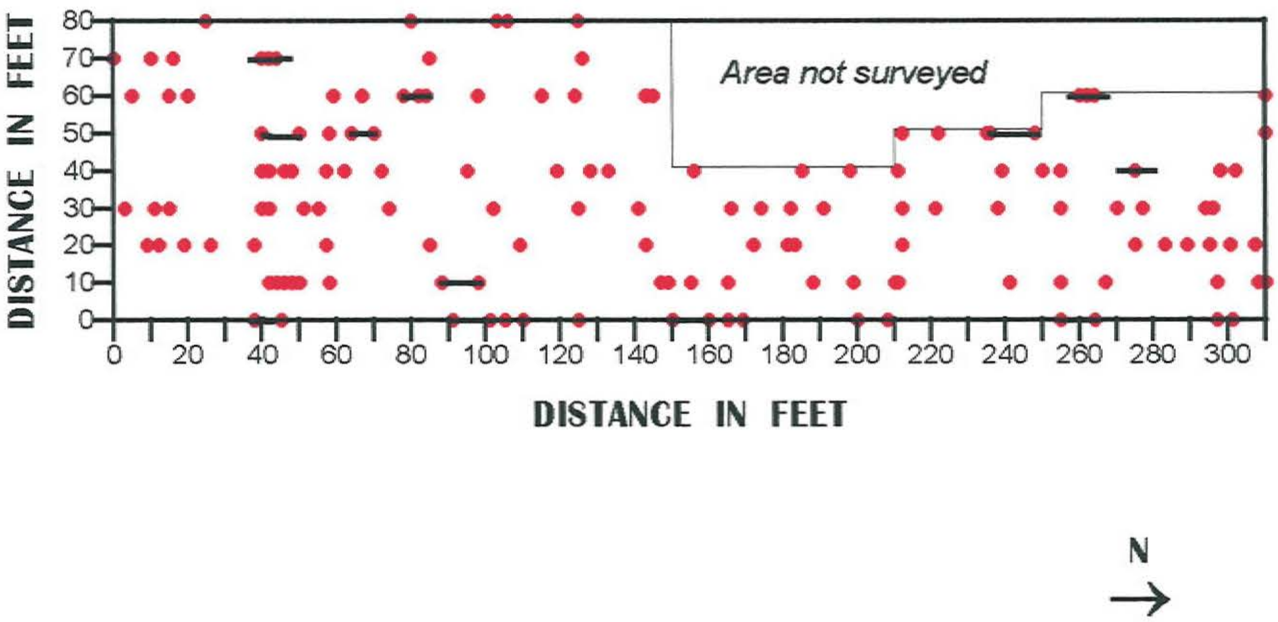
OLD CHARLES TOWNE LANDING
CHARLESTON, SOUTH CAROLINA

EM38 METER
VERTICAL DIPOLE ORIENTATION



OLD DORCHESTER STATE PARK

ANOMALIES DETECTED WITH GPR



● POINT REFLECTORS

— PLANAR REFLECTORS