Attachment A

# A Search for Fort Louis de la Mobile with Archaeological Geophysics

**Submitted to:**
Gregory A. Waselkov
Center for Archaeological Studies
University of South Alabama

**Prepared by:**
Bryan S. Haley and Jay K. Johnson
Center for Archaeological Research
University of Mississippi

The University of Mississippi

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## 1. ABSTRACT

A geophysical survey of a portion of the Old Mobile site (1MB94) was conducted on December 13-16, 2004 by the University of Mississippi's Center for Archaeological Research under contract with the University of South Alabama's Center for Archaeological Studies. The specific goal of the survey was to delineate features associated with Fort Louis de la Mobile, which stood on or near this site from 1702 to 1711. Survey techniques included electrical resistance and ground penetrating radar. Work was performed by a crew of five made up of faculty, staff, and graduate students from the University of Mississippi. Several features of possible archaeological significance were identified.

# 2. METHODS

## 2.1. Electrical Resistance

Electrical resistance instruments measure how readily current flows through the soil. The goal of a resistance survey in archaeological research is to map the distribution of subsurface differences in resistance by taking readings from the surface (Loke 2000:1). Typically, resistance distribution is closely related to the amount of moisture contained in the subsurface material (Weymouth 1986:319; Clark 1996:27). Differences in relative moisture are a function of grain size for soil and porosity for rocks. Clayey soils will usually have lower resistance values than coarser grained soils because they retain more moisture after a rain. Rocks will usually have even higher resistivity values than sands because they are more moisture resistant than most soils, although this depends on the porosity of the rock (Clark 1996:27). Relative salinity also affects electrical current flow by lowering the resistance of the soil or material (Loke 2000:4). The unit of measure for resistance is the Ohm-m, which ranges from 5 for soils with high salinity to 10,000 for some sandy or gravely soils (Bevan 1998:8).

Electrical instruments operate by introducing a known quantity of current (I) into the soil through an electrode. The resultant voltage (V) is measured at potential electrodes. Using Ohm's Law, $V = I \times R$, resistance (R) can be easily calculated. From the measured resistance values (R), an estimate of the electrical resistance ($\mathbf{r}_a$) can be calculated if needed, by the formula $\mathbf{r}_a = k \times R$, where k is a geometric factor. The conversion takes into consideration the geometry of the array type and removes its effect (Geoscan 1996b:H-1). Because the calculated value is a measurement of resistance over a volume of soil and only an estimate of the actual resistance at a point in the ground, it is termed apparent resistance. The advantage of calculating apparent resistance is that values can be compared in a standardized way (Clark 1996:27).

One beneficial characteristic of the resistance technique for geophysical survey is that the depth of the anomaly can be determined as a function of electrode configuration (Weymouth 1986:326). In simple terms, the separation of the electrodes is directly proportional to the depth of maximum sensitivity. Therefore, two types of surveys are possible.

Electrical profiling, or constant separation traversing (CST), surveys measure the resistance value using a fixed probe separation along the horizontal plane of the ground (Reynolds 1997:446). Therefore, a plan map is created that represents resistance anomalies at a single, fixed ground depth. Because targets can be visible as anomalies in planimetric resistance imagery, it is not essential to convert the readings to apparent resistance.

The other type of survey is vertical electrical sounding (VES), which produces a vertical profile, or pseudosection, of the subsurface (Reynolds 1997:441). The data must be converted to apparent resistivity for pseudosection images to be informative. In addition, a topographic correction must be applied for accurate depth information. Moreover, if the pseudosection is to be an approximate depiction of the subsurface, an inversion must be performed to account for array geometry (Loke 2000:8).

Recent advances have enabled CST or VES to be used to create three dimensional representations of the ground, called resistivity tomography (Clark 1996:62; Loke 2000). Plan or profile images can be placed in correct orientation, interpolation performed, and a three dimensional block of the ground resistivity created. SlicerDicer software by Pixotec is one application suited to this task. Resistivity tomography results are similar to three dimensional ground penetrating radar results and can be performed in finer grained soils. However, the approach is much slower and therefore more expensive than ground penetrating radar.

A typical resistance system is composed of electrodes, battery, meter, and data logger. Although in theory all that is necessary to measure ground resistance is a current and a potential electrode, a two-electrode arrangement is impossible due to the contact resistance found around current electrodes (Aitken 1961:61; Bevan 1998:12). Therefore, electrical resistance instruments use a minimum of four electrodes designed to penetrate the ground enough for current to propagate from the current probes and be sampled by potential probes (Figure 2.1-1).

Electrodes may be arranged in many different configurations to perform geophysical survey. A survey of possible configurations is given by Loke (2000) and is beyond the scope of this report. In general, however, certain methods are more suited to measuring vertical or horizontal changes in ground resistance.

The most commonly used setup in archaeological applications is the Twin array, which is particularly suited for revealing narrow features in a profiling type survey and has good depth penetration (Clark 1996:44). For the Twin arrangement, one set of current and potential electrodes are mobile, while another set is fixed, separated by a small distance, and placed a considerable distance from the mobile electrodes. One drawback with the Twin array is difficulty in deriving the geometric factors necessary for conversion to apparent resistivity. Therefore, analysis is performed using the resistance values only. Since the primary application is usually horizontal mapping, this is not a problem.

An alternative to the Twin array is the Pole-Pole array, where one current and potential pair is mobile and the fixed pair is a distance from the mobile pair, but separated from each other by a large distance (Loke 2000:16). The Pole-Pole array has similar properties to the Twin, but can be converted to apparent resistivity fairly easily. The drawback is the greater difficulty in setup.

The Wenner array is usually preferred when pseudosections are being recorded, since it is very sensitive to vertical change in resistance (Bevan 1998:17; Loke 2000:11). With the Wenner array, both sets of electrodes are mobile and all four electrodes are separated by an equal distance (Loke 2000:12). In addition, the geometric factor is a constant and apparent resistivity is therefore easy to calculate (Geoscan 1996b:H-2).

Electrical resistance surveys can be easier to perform and give acceptable results in a wider range of sites than many other geophysical survey techniques (Bevan 1998:7). Although extended periods of rain or drought may adversely affect resistance surveys, the instrument is not subject to interference by metal debris, overhead power lines, and nearby cars, as are magnetic and electromagnetic instruments. Archaeological features detectable with resistance survey include ditches, buried walls, foundations, tombs, voids, compacted floors, humus zones, daub concentrations, mound stratigraphy, and shell deposits (Figure 2.1-2) (Aitken 1961:71; Weymouth 1986:321; Geoscan 1996b:6-8; Thompson et al. 2002).

In their most basic form, electrical resistance instruments are simple and the least expensive of any geophysical instrument. A standard multimeter, batteries, four metal electrodes, and some cables from an electronics store are all that is necessary (Bevan 1998:8). Although the quality of the data may be nearly as good with this setup as a more expensive instrument, the speed will be much slower. More modern systems use multiple probes and elaborate switches to log many readings very quickly and store them electronically.

Interpretation of resistance imagery begins with the identification of strong amplitude anomalies. An examination of high and low values can yield additional information. For example, a low resistance anomaly, if the shape is appropriate, may be a pit because they often trap moisture and create a negative anomaly (Figure 2.1-3). Conversely, a stone wall or foundation will usually produce a positive anomaly (Figure 2.1-3). As with any geophysical survey technique, archaeological targets may only be detected if they contrast with background readings. If data are converted to apparent resistivity, additional information such as soil texture can be gained. The size and shape of a feature a revealed in resistivity imagery is often somewhat broadened, at least with the Twin array setup. An estimate of feature boundaries can be derived by determining the positions at which the signal falls to half of maximum amplitude (Geoscan 1996b:6-4).

The Center for Archaeological Research operates a RM-15 instrument with MPX-15 multiplexor, manufactured by Geoscan Research (Figure 2.1-4). The RM-15 is a British instrument designed specifically for archaeological research. The multiplexor is a data control unit that allows up to six readings at each station and which may be the result of differing electrode separations, differing array types, or high density readings made with the same electrode separation. Readings are often taken every .5 meter along transects of .5 meter or 1 meter spacing. The instrument's data logger can store 30,000 readings. More detailed instrument specifications can be found in Appendix A.

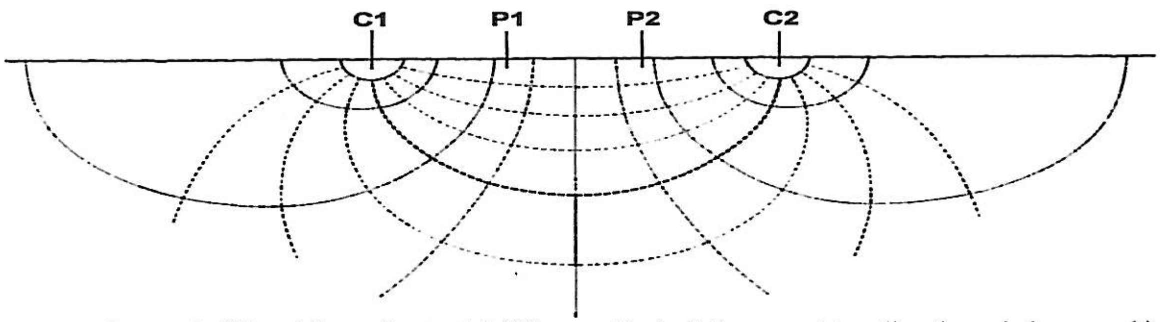


Figure 2.1-1. Current (solid) and lines of potential difference (dashed) for current traveling through the ground in a four-electrode resistance system (from Clark 1996).

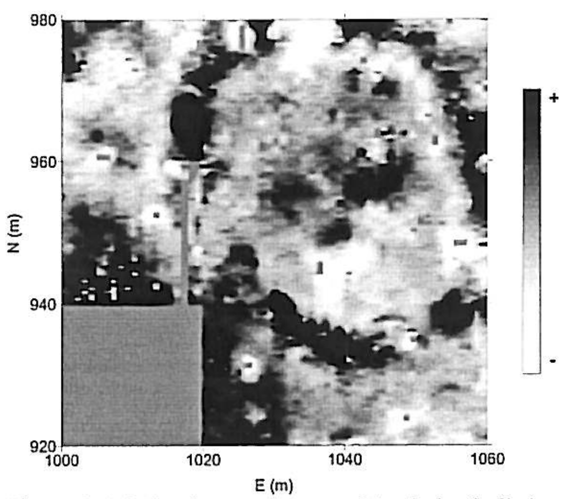


Figure 2.1-2. Resistance image of Archaic shell ring at Sapelo Island, Georgia (from Thompson et al. 2002).

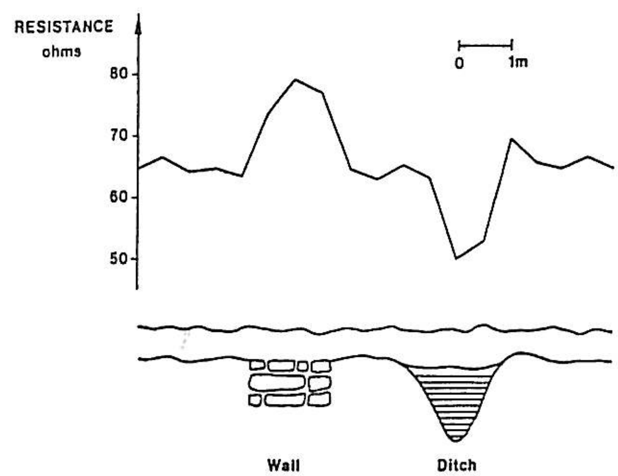


Figure 2.1-3. Resistance amplitude over wall and ditch features (from Geoscan 1996b).

Figure 2.1-4. Resistance survey with the Geoscan RM15 and 2.0-meter frame.

## 2.2. Ground Penetrating Radar

Ground penetrating radar (GPR) operates by sending an electromagnetic wave pulse into the ground that reflects off materials with contrasting electrical properties (Figure 2.2-1) (Weymouth 1986:371; Conyers and Goodman 1997:23). Reflectance is related primarily to the electrical conductivity and magnetic permeability of the materials (Conyers and Goodman 1997:32). Relative dielectric permittivity (RDP), the ability of a material to store and pass a magnetic field, is the accepted property used to describe the materials. RDP (K) ranges from 1 for air to 81 for water and is expressed by $K = c^2 / V^2$, where c is the velocity of light and V is the velocity of the wave (Conyers and Goodman 1997:33; Reynolds 1997:689). For soils, RDP ranges from 3 from the driest sand to 40 for saturated clay. The strength of the reflection is proportional to the difference in RDP of the two materials and relies on an abrupt change between materials (Conyers and Goodman 1997:34; GSSI 1999:36). A contrast in RDP as small as 1 can cause a reflection in some cases (GSSI 1999:31).

Furthermore, the travel time of the interaction is recorded as a matter of course in GPR surveys and this can be related to the depth of the target. When a radar wave bounces off a subsurface reflector, total travel time is recorded in nanoseconds (ns) and is directly proportional to the depth of that target. If RDP is known for the medium, target depth can be calculated. RDP is difficult to determine accurately in the field, but can be estimated by several methods (Conyers and Goodman 1997:32; GSSI 1999:79). One commonly used technique is geometric scaling in which a curve is fit to the properties of a hyperbolic reflections in the data generated by strong reflectors. Because of the geometry of reflectance, as the antenna passes over a target, the reflection will be expressed as a hyperbola and the width of that hyperbola is determined by the dielectric permittivity of the soil (GSSI 199:83).

An interface is visible if the electrical properties of two substances contrast enough to produce a reflection. The magnitude of the reflection depends on the amount of contrast in the dielectric properties of the materials at an interface. This characteristic of GPR can contribute substantially to the study of stratigraphy. For example, a sand layer overlying a packed clay floor, a buried stone wall, or an air filled cavity will likely produce a measurable reflection.

GPR antennas are available in various center frequencies, usually between 100 and 1500 MHz. Choice is determined by optimum depth of propagation and resolution of the signal (GSSI 1999:51). In general, lower frequency antennas propagate energy to greater depths. However, the vertical resolution also decreases (GSSI 1999:56). For example, low frequency antennas penetrate as far as 50 meters in ideal circumstances. In contrast, a 1000 MHz antenna may only penetrate to 0.5 meters, but can resolve features 1.0 centimeter thick (GSSI 1999:52). A 400 MHz antenna is often used in archaeological applications because of its intermediate depth abilities. All frequencies of antenna emit a cone of energy that is roughly 90 degrees from front to back and 60 degrees from side to side (GSSI 1999:45).

Limitations in GPR are related to the mechanics of sending electromagnetic energy through materials with high dielectric values (Reynolds 1997:688). Such soils cause the electromagnetic energy to attenuate at shallow depths from dispersion of energy (Conyers and Goodman 1997:55). Attenuation blurs the view of resultant data; returns from even strong reflectors can be obscured. Wet soils, including clays, and high salinity materials are not ideal conditions for GPR survey. Dry sand, however, can often produce dramatic results.

GPR has demonstrated effectiveness at detecting a number of archaeological features, including pits, trenches, hearths, stone foundations, kilns, buried living surfaces, metal objects, voids, burials, tombs, tunnels, and caches (Conyers and Goodman 1997:23, 197-200). In some cases, construction stages in prehistoric mounds can be detected (Figure 2.2-2). Archaeological features that are unlikely to be detected using GPR include thin stratigraphic layers, features within a rock-lined burial, small clay or stone artifacts, and any feature below a wet clay layer (Conyers and Goodman 1997:197-200).

The processing necessary for archaeological GPR data to be used to maximum potential is more involved than for any other geophysical method. Analysis begins by locating targets in radar profiles, estimating average RDP, and estimating depth of targets. In radar profiles, the amplitude of a reflection is positive if a high dielectric medium is encountered below a low dielectric medium, and negative when the reverse occurs. A strong narrow reflector will often produce an anomaly alternating between signs in a hyperbolic shape. Further processing is somewhat complex and includes creating planimetric amplitude slice maps and three-dimensional data cubes. Usually, amplitudes are squared so strong positive or negative anomalies appear the same.

The University of Mississippi operates a Geophysical Survey Systems Incorporated (GSSI) SIR2000 system with 400 MHz and 300 MHz antennas (Figure 2.2-3). GSSI radar systems are used regularly for archaeological research in North America. The SIR2000 system includes a control unit, built from a laptop computer with 1.3 GB of storage, and a battery pack that are worn together on a harness (GSSI 1999:5). Vertical profiles are displayed in real time on the screen. An integrated survey wheel, used to determine distance along a transect line, attaches to the antenna sled. Data are often collected along transects of 0.5 m or 1.0 m, at 32 samples per meter and at 512 scans vertically. As a result, very large data sets are produced that are often desampled during processing. Detailed specifications of the SIR2000 can be found in Appendix B.

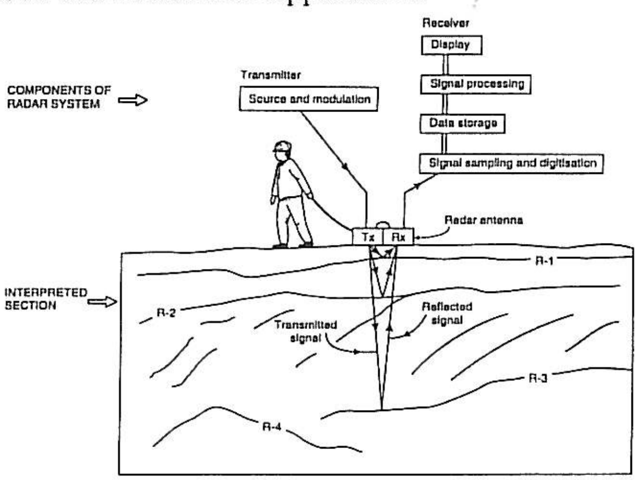


Figure 2.2-1. Operation of a GPR system (from Reynolds 1997).

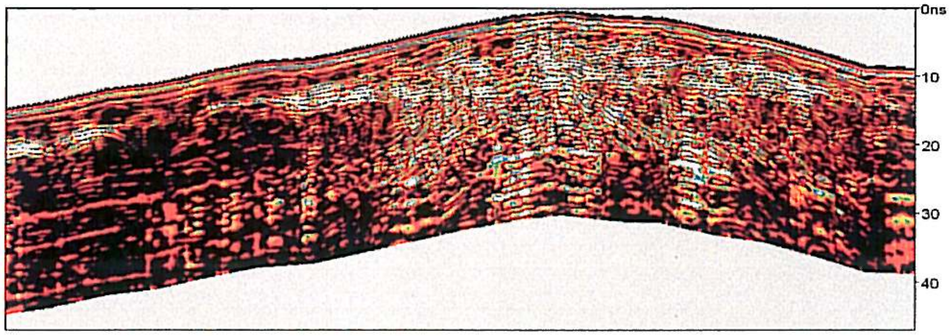


Figure 2.2-2. Vertical, topography corrected, GPR profile of Sapelo Island Shell Ring (from Thompson et al. 2002). High amplitude responses from the shell deposits are displayed in white.

Figure 2.2-3. GPR survey with the SIR2000 and 400 MHz antenna.

# 3. FIELD PROCEDURES

Geophysical survey was conducted on a metric grid already established by the University of South Alabama. The survey area encompassed a 2 hectare strip of land, from the 1902 commemorative monument on the north and extending approximately 225 meters to the southeast along the west bank of the Mobile River. Figure 3-1 shows the University of South Alabama's topographic map, with 20-meter geophysical survey grid superimposed. Although we surveyed all of the grid units that were clear, some were skipped that had not been cleared of dense undergrowth or because of extensive modern disturbance. Of course, areas of open excavations were not surveyed.

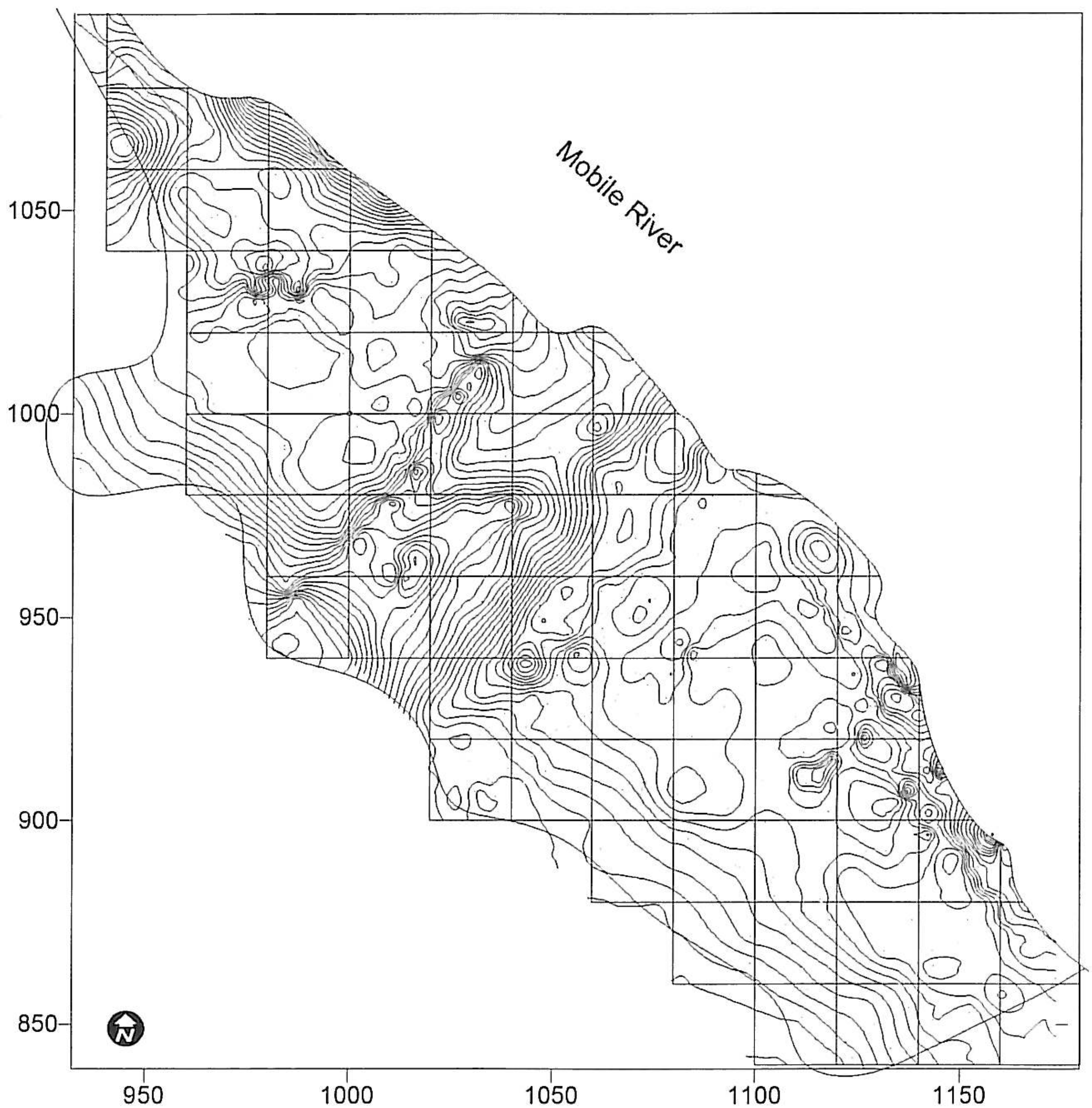


Figure 3-1. University of South Alabama's topographic map with 20-meter geophysical grid superimposed.

## 3.1. Electrical Resistance in the Field

A electrical resistance survey was accomplished using 20 x 20-meter grid cells as the basic recording unit. Baseline ropes were placed in an east-west orientation and north-south transect ropes were used to guide the spacing of measurements. Data density was 50 centimeters along the Y (north-south) axis and 50 centimeters along the X (east-west) axis. In areas of extremely high resistance, such as in the gravel road in the center of the survey tract, the resistance instrument could not log a stable reading. Therefore some grid units within the survey tract were skipped.

## 3.2. Ground Penetrating Radar in the Field

Ground penetrating radar data were collected using transect lines ranging from 20 to 80 meters long, depending upon the maximum line length possible at any one location. Transects were spaced 1.0 meter apart in the X (east-west) direction. Data were collected at 30 scans per meter and 512 samples per scan. Unlike the resistance instrument, the GPR was not adversely affected by the highly resistant areas, such as the gravel road. Therefore a larger area was surveyed using this instrument.

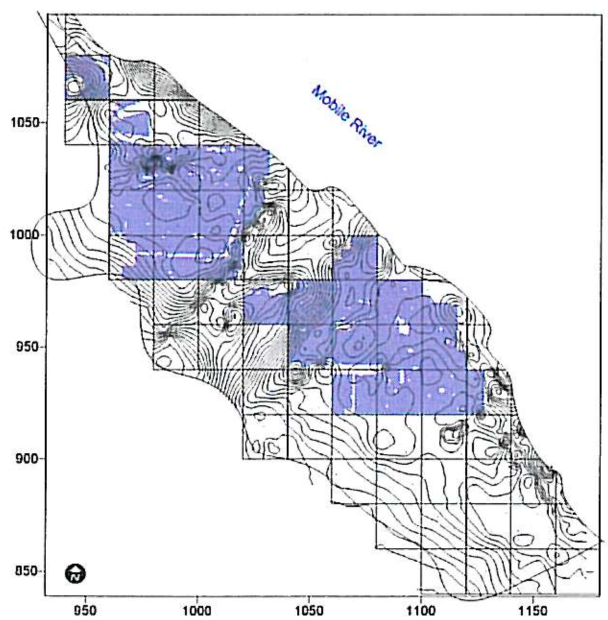


Figure 3.2-1. Electrical resistance survey area.

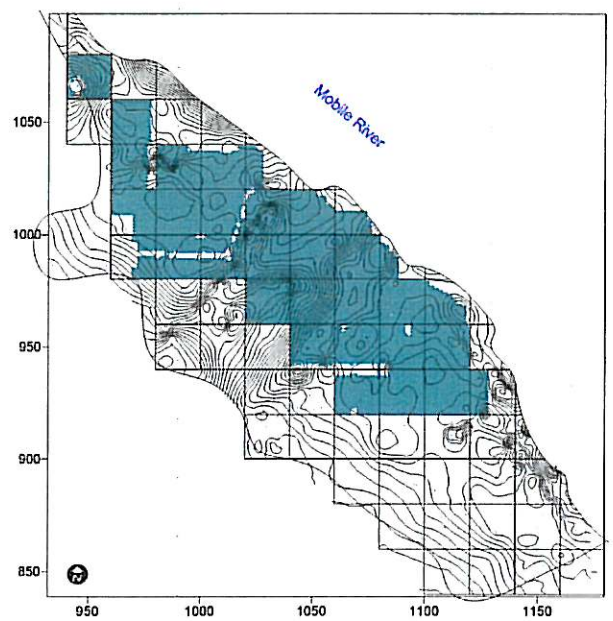


Figure 3.2-2. GPR survey area.

# 4. LABRATORY PROCEDURES

## 4.1 Electrical Resistance

Resistance data were downloaded and processed using Geoscan's Geoplot software. Data defects were removed using operations such as despike and grid matching. Data were then exported to Surfer grid files. Surfer was used for final interpolation and display of the data. Also, overlays were created to allow better interpretation of the data sets.

## 4.2. Ground Penetrating Radar

Ground penetrating radar data were downloaded using the GSSI download utility. Data files were positioned, reversed, given distance markers, resampled, gridded, and displayed using GPR Slice, a software developed by the Geophysical Archaeometry Labratory. Raw profile data were transformed into 12 time slices, each 4 nanoseconds thick with about 1.6 nanoseconds overlap. Due to the expected shallow depth of features, the maximum depth processed is 22 nanoseconds, or only about half of the total collection window of 40 nanoseconds. Final data were exported to Surfer gird files for final display. Overlays were created to allow better interpretation of the data sets.

## 5. Results

Three modern surface features, all related to earlier or existing roads (Fig. 5-1) were found to interfere with the data collection. These features created such high contrast that it is impossible to discern the more subtle archaeological features in these areas. In some cases, special processing could be performed to lessen these effects. Because of these problems, these areas are not emphasized in the following discussion.

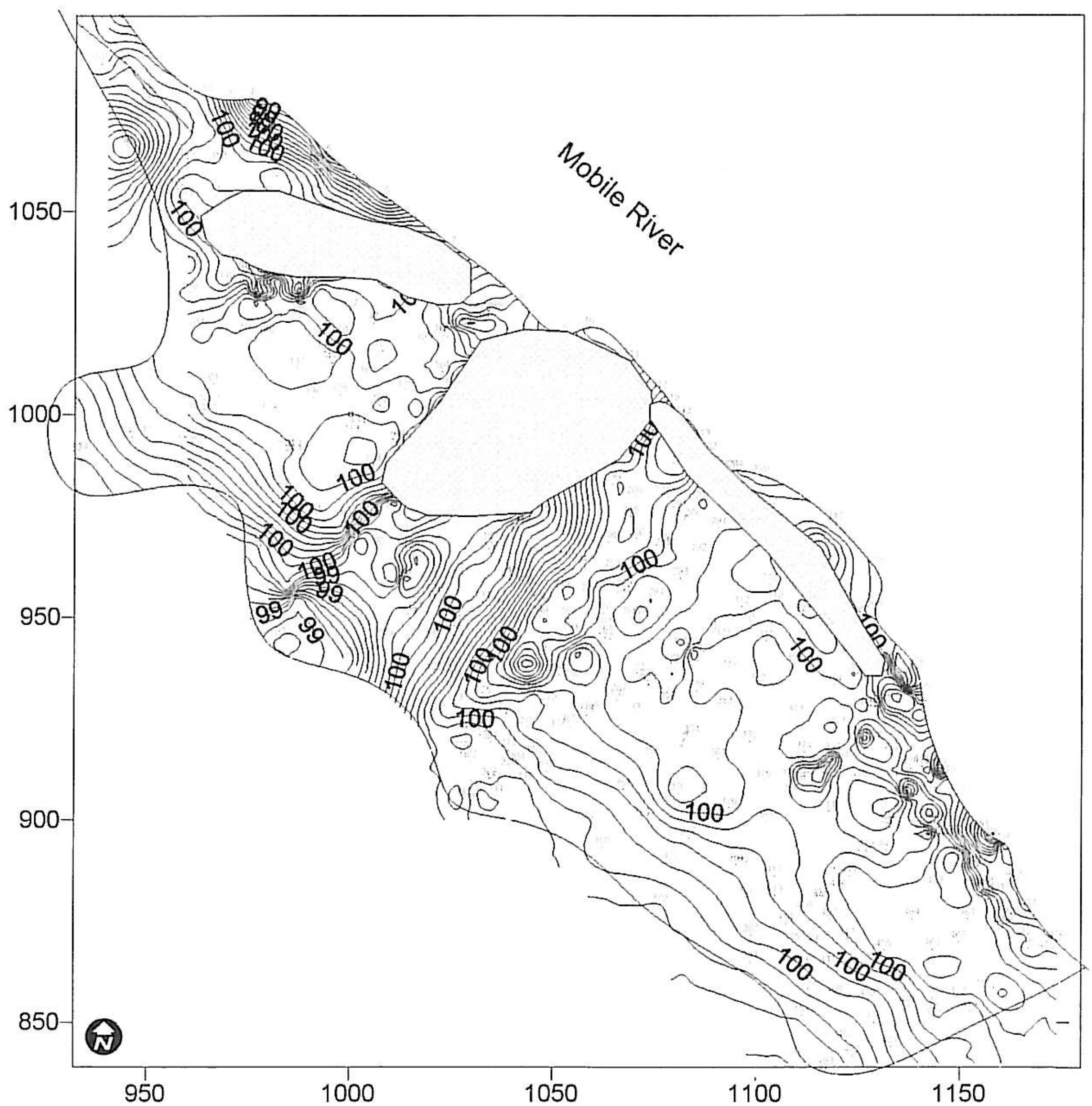


Figure 5-1. Areas of high contrast surface features (gray) on the University of South Alabama's survey map.

## 5.1 Electrical Resistance Results

The electrical resistance results are characterized by highly variable background readings (Figure 5.1-1). If viewed together, it is difficult to detect variation in many areas. A high pass filter reduces this problem by enhancing local variation (Figure 5.1-2).

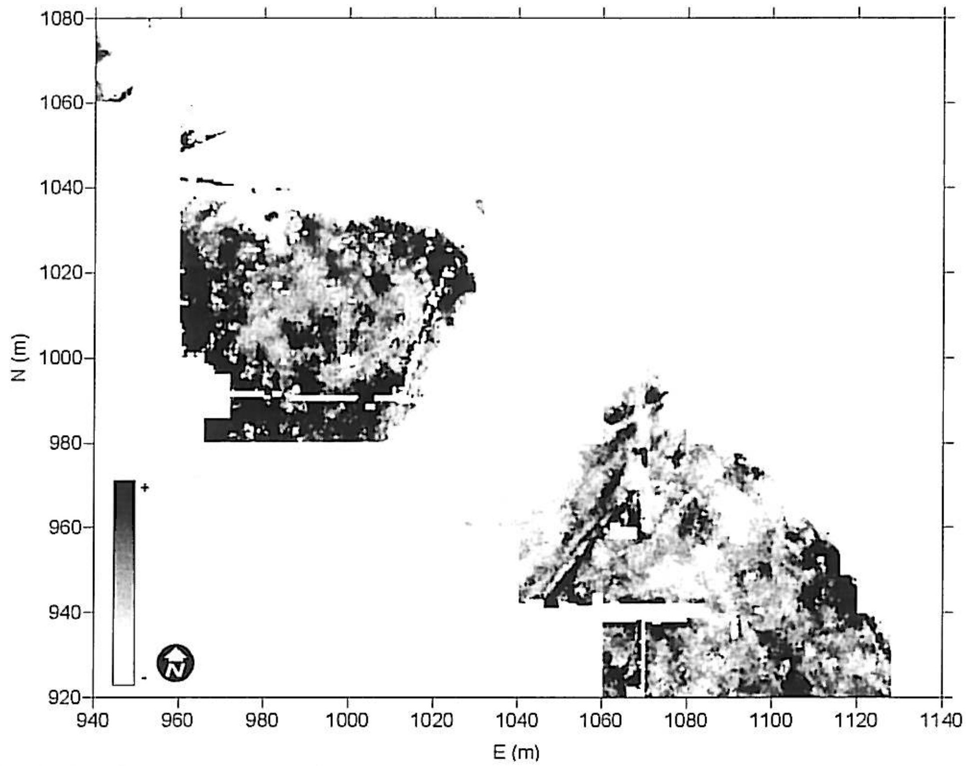


Figure 5.1-1. Electrical resistance survey results.

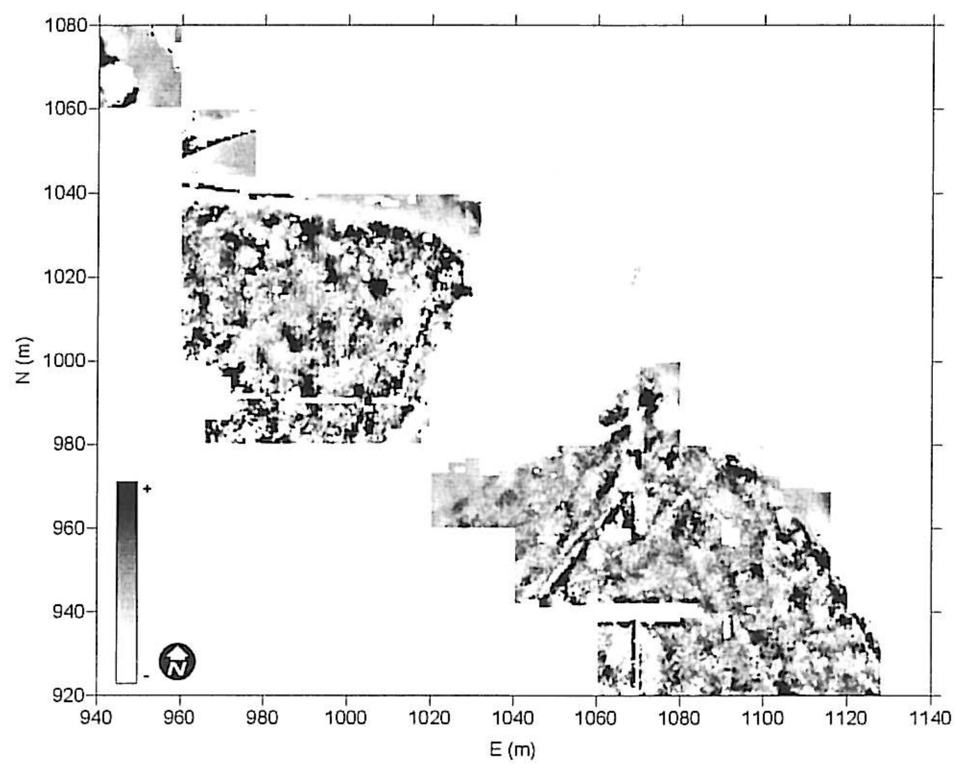


Figure 5.1-2. High pass filtered electrical resistance survey results.

Significant resistance anomalies are shown in Figure 5.1-3. These are primarily identified by shape since the long linear features produced by boundary fence ditches, structures, and palisades are rarely duplicated in nature. Although there are a few partial lineaments of low resistance in the area northwest of the gravel road, none are clear enough to suggest the location of historic activity. There are also some areas of high resistance which might be compacted clay house floors but, once again, the patterns are not clear.

Some very clear, low-resistance linear features appear in the area southeast of the gravel road. That they are linear and show up as areas of low resistance is consistent with the appearance of filled ditches in resistance data. Perhaps the most interesting of these is a long diagonal line starting at about 922N 1103E and running north-northeast, terminating in an obtuse angle. Historic sketches of the fort plan show several features that join at obtuse angles. Moreover, the orientation of this anomaly does not match surface features in the area. This is not the case with two parallel lines beginning at about 945N 1045E and running to about 965N 1063E. There is a clear ridge that follows this same path, suggesting that these might be twentieth-century features. Another lines runs from about 960N 1070E toward the suspected location of an early twentieth-century farm house. A line running from approximately 963N 1076E to 976N 1088E must be a cultural feature, given its clarity in the imagery, although its period of construction is uncertain.

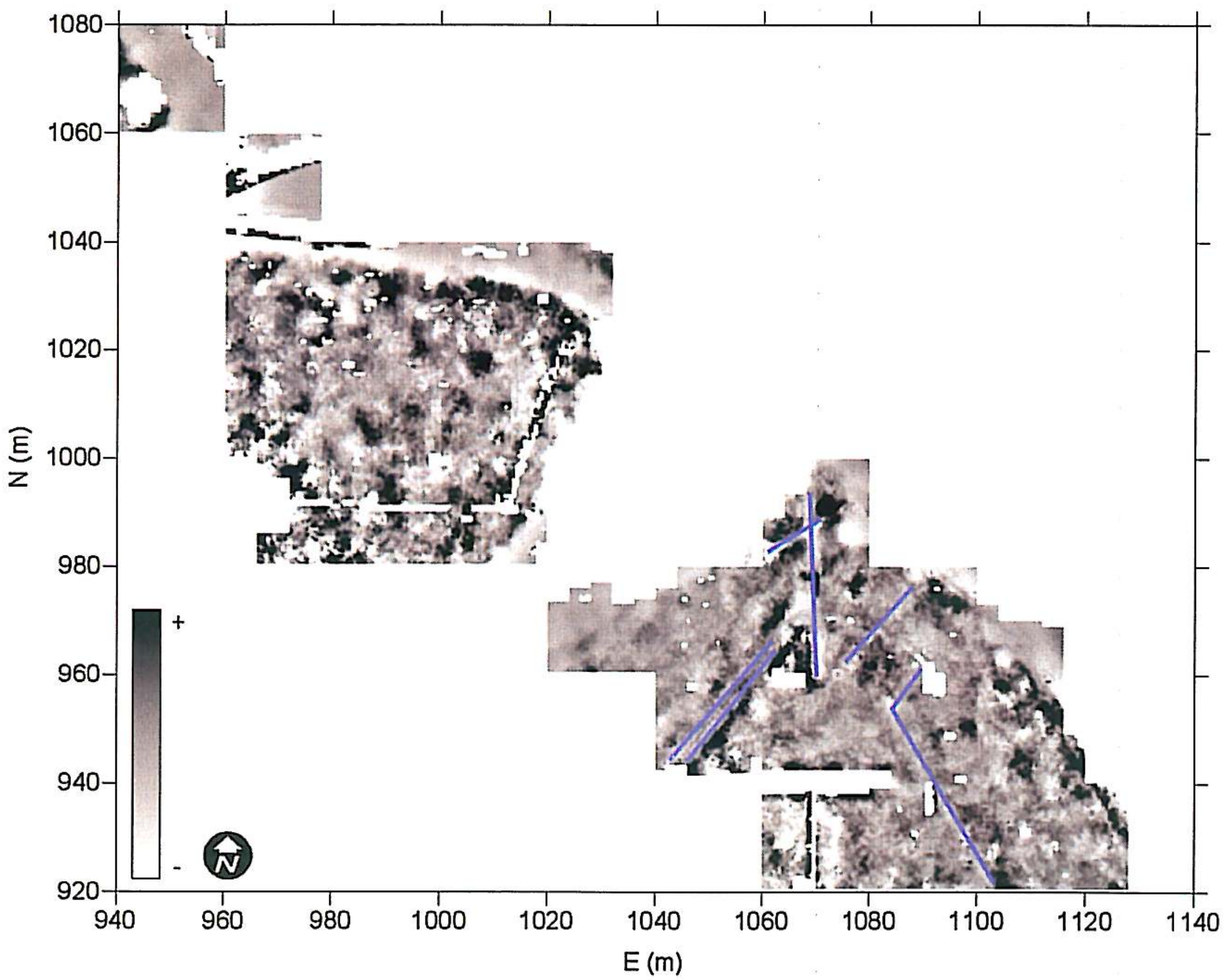


Figure 5.1-3. Resistance anomalies (blue) over high pass filtered resistance data.

## 5.2. Ground Penetrating Radar Results

Ground penetrating radar data also contain a large number of reflections resulting from surface features such as roads and ditches. They were, however, less affected than the resistance data. After transform matching and vertical filtering, sufficient contrast was present for analysis of archaeological targets. Twelve slices ranging from 0 to 22.2 nanoseconds in two-way travel time are shown in Figure 5.2-1.

Depth estimates for this survey area are very difficult due to the large amount lateral variation. A reasonable dielectric value of 14 was determined using the shape of the reflections from the primary areas of interest. The radar signal travels at 8 centimeters per nanosecond through soils with a dielectric of 14. Therefore, the depth at which a reflection occurs can be computed as approximately half the time multiplied by the velocity [.5 x t x v)]. For example, the first slice has a travel time of 0 to 4 nanoseconds, or about 0 to 16 centimeters.

Linear anomalies occur at two different depths in the GPR imagery. The first are difficult to see but show up best in the third slice (Fig. 5.2-2). This image still shows a good deal of disturbance due to surface conditions, but a few features are suggested by lineaments in the northwestern sector (Fig. 5.2-3). Parallel lines centering on grid coordinates 1025N 1008E are indicated by a pattern of low and high returns. A much clearer line of high returns runs from 994N 984E to 999N 992E.

The second set of images is clearest in slice 7 (Figure 5.2-4). One particularly clear set of reflections starts at 989N 978E, apparently crosses an excavation unit, and ends at 1000N 995E (Fig. 5.2-5). This line coincides with a line evident in the shallower slice and runs at very close to a right angle to the line made by Structures 31 and 32, as revealed by excavations conducted just to the west of this line. Three other lines are evident in the road way and another runs along the eastern edge of the road. Given their orientation, these are presumably modern features.

# 6. Conclusions

As can be seen from the composite map of geophysical features (Fig. 6.1), GPR was more successful in the northwestern portion of the survey tract, while resistance did better in the southeastern quadrant. In no instance did one instrument confirm the results of the other. Although several features appear likely to be related to the French settlement of Old Mobile, none are clearly remains of Fort Louis. Only the long linear feature with the obtuse angle revealed in the resistance imagery in the southeastern quadrant appears to be a possible candidate for that structure.

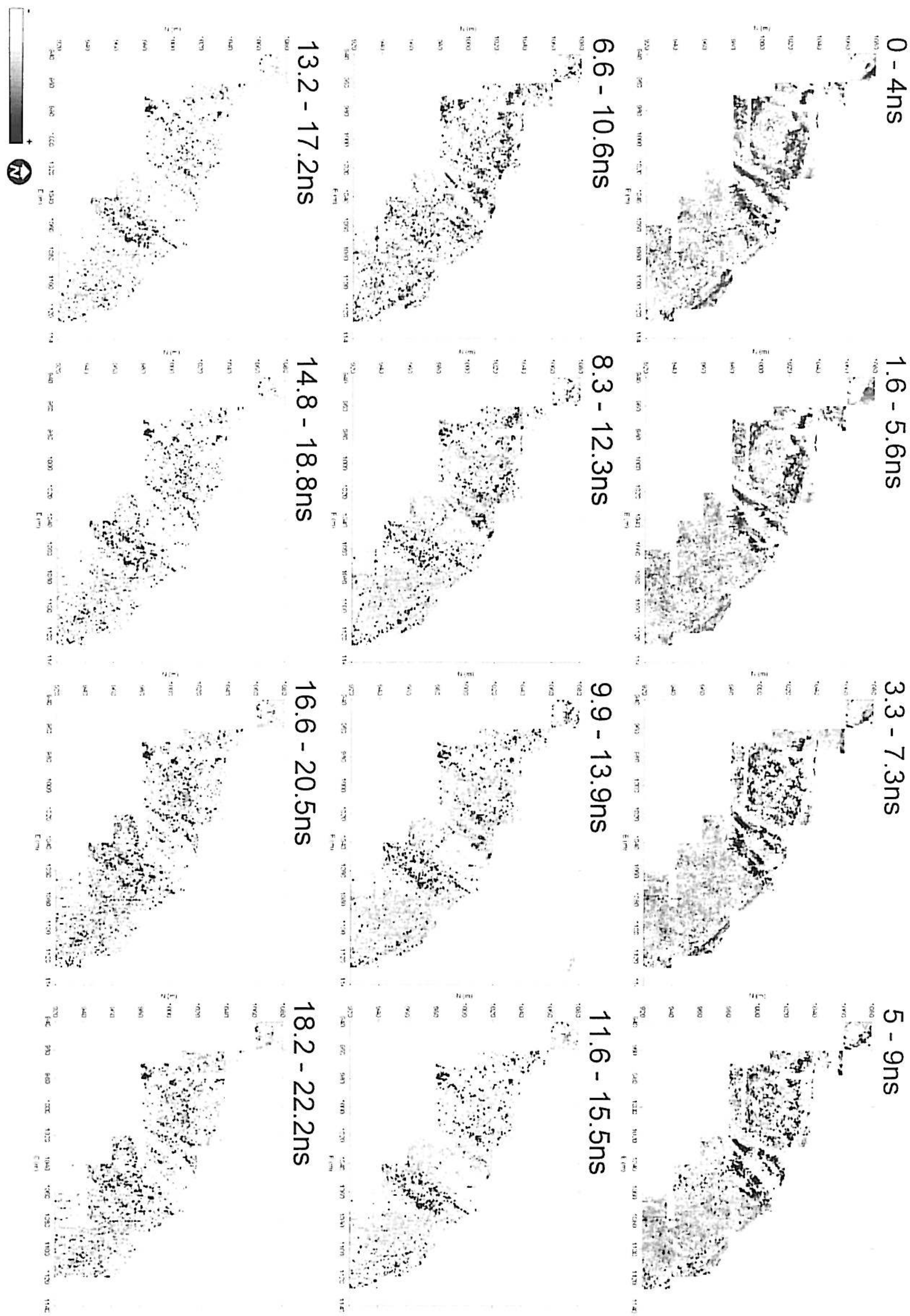


Figure 5.2-1. GPR survey time slice results.

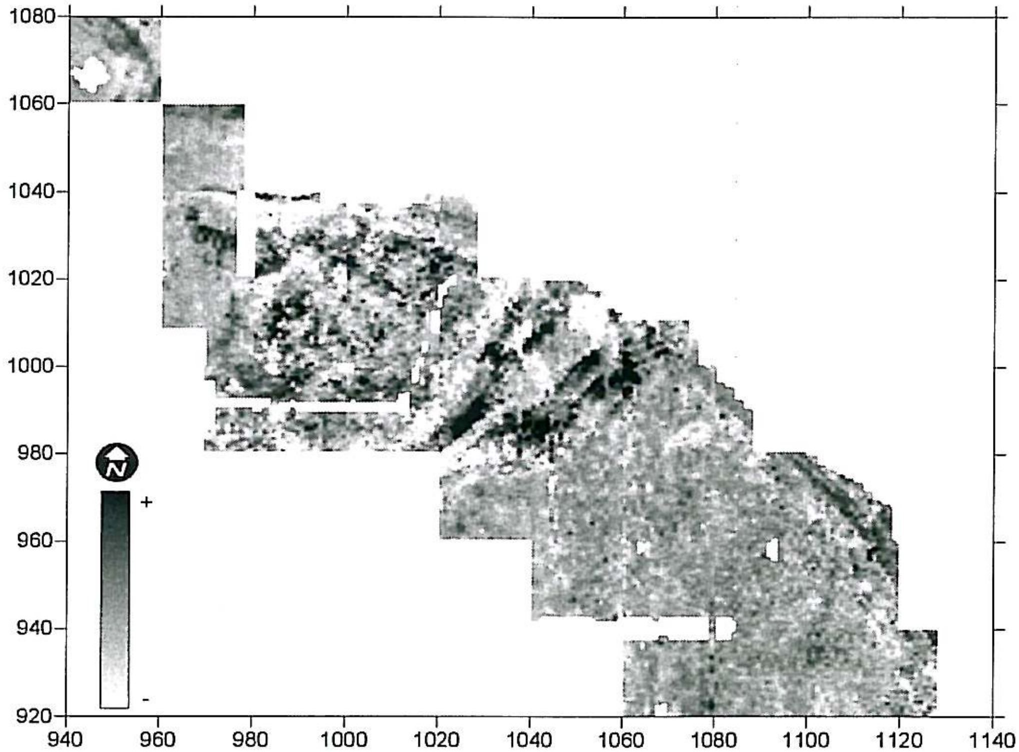


Figure 5.2-2. GPR time slice 3 (3.3-7.3 ns, 13.2-29.2 cm).

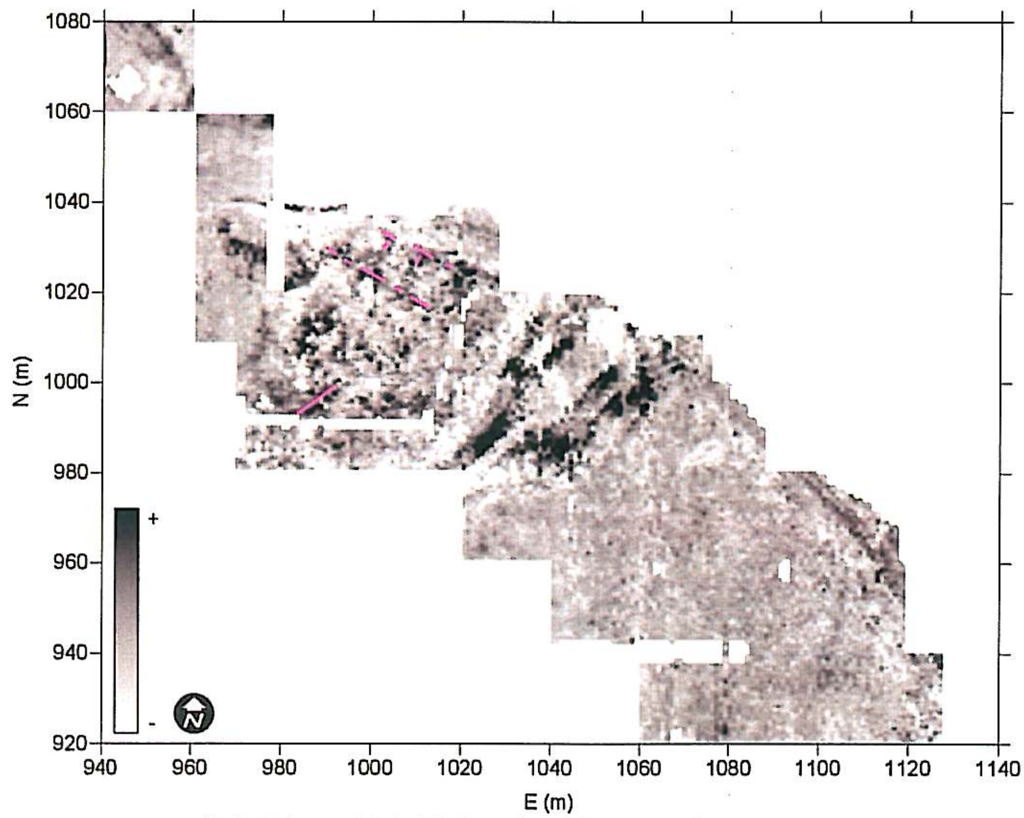


Figure 5.2-3. GPR time slice 3 (3.3-7.3 ns, 13.2-29.2 cm) with annotations.

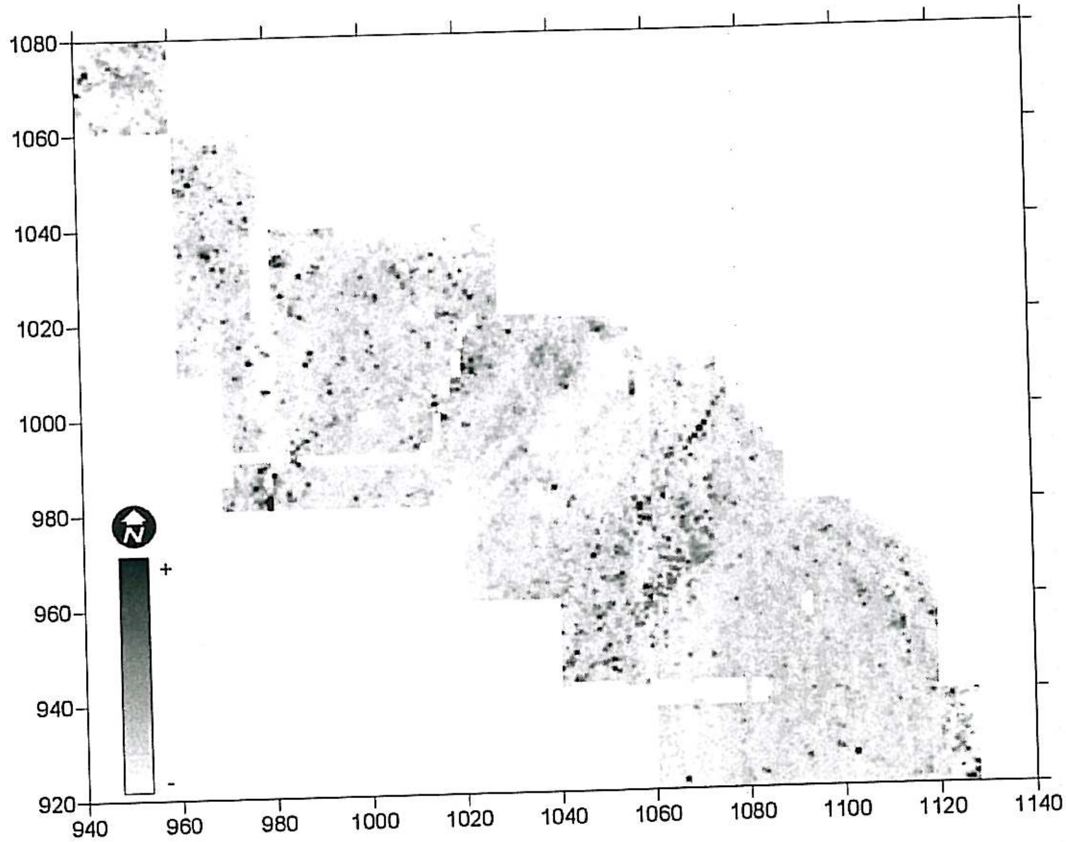


Figure 5.2-4. GPR time slice 7 (9.9-13.9 ns, 39.6-55.6 cm).

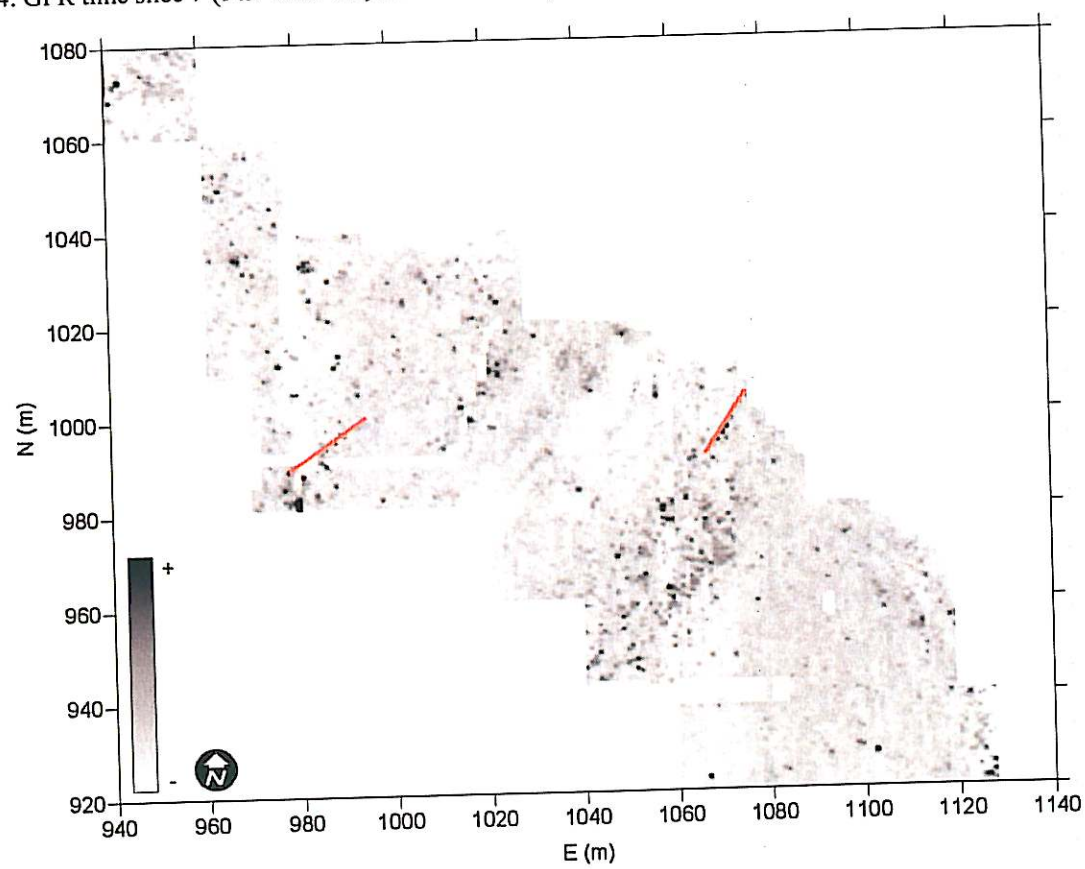


Figure 5.2-5. GPR time slice 7 (9.9-13.9 ns, 39.6-55.6 cm) with annotations.

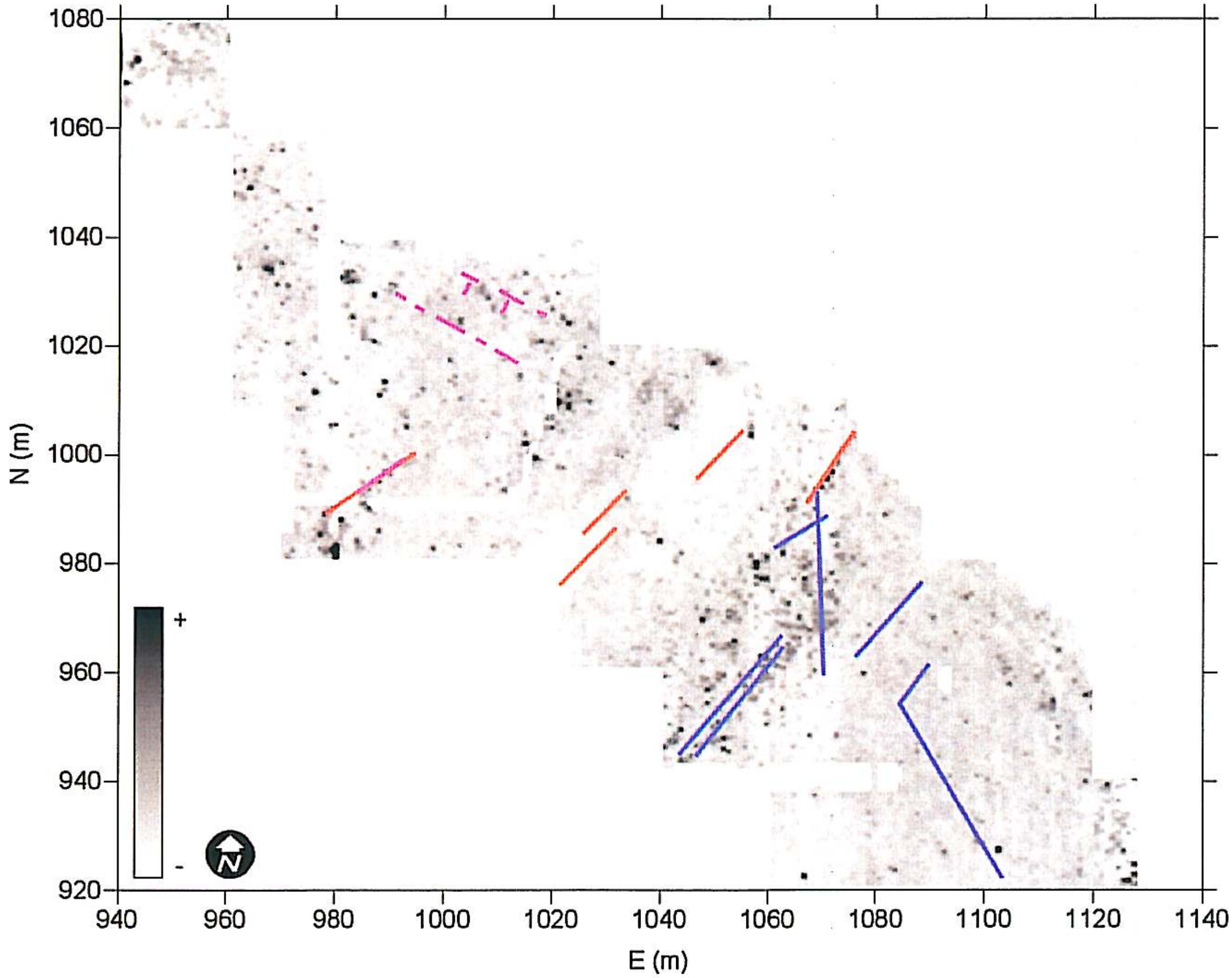


Figure 6-1. Resistance (blue) and GPR (purple-shallow, red-deep) anomalies.

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# Appendix A: Technical Specifications for the Geoscan RM-15 Resistance Meter

## RM15 ADVANCED

| | | | | | |
|---|---|---|---|---|---|
| **TRANSMITTER** Output voltage | 40 / 100 V | | | | |
| Constant current ranges (p-p) | 10 mA | | 1 mA | | 0.1 mA |
| Maximum contact resistance (at 100 V) | 10 Kohm | | 100 Kohm | | 1 Mohm |
| Current variation with contact resistance | < 0.1% | | | | |
| **RECEIVER** Resistance ranges (manual) | 2ohm | 20ohm | 200ohm | 2000ohm | 20,000ohm |
| Logged Resolution (ohm) | 0.0005 | 0.005 | 0.05 | 0.5 | 5 |
| Reading variation with battery voltage (7-12 V) | < 0.01% / V | | | | |
| Operating Frequencies | 35, 85, 137 Hz | | | | |
| Receiver input impedance | 100 Mohm | | | | |
| Measurement time - High Freq. Multicycle Mode | 0.25, 0.5, 1 seconds programmable | | | | |
| High pass filter | 0.01, 0.05, 0.16, 1.6, 8, 13 Hz | | | | |
| SP correction range (automatic) | +/- 2 V | | | | |
| Analogue output | +/- 2V fsd each range | | | | |

## RM15 BASIC AND ADVANCED

| | |
|---|---|
| **LOGGER** Memory capacity | 3600, 15000, 30000 readings |
| Data retention time | > 10 years at 25 degrees C, less at higher temps. |
| RS232 Baud rate | 600, 1200, 2400, 4800, 9600 baud |
| RS232 output | +/-6.5V min, 3 state o/p when shutdown |
| RS232 connections | TXD, RCV, GND, CTS, RTS |
| **GENERAL** Power supply | 8 AA Nickel-Cadmium 600mAH batteries |
| Battery life | 11 hr at 1mA, 9.5 hr at 10 mA (40 V output)<br>7.5 hr at 10 mA (100 V output) |
| Battery voltage range | 8 to 12 V |
| Working temperature | 0 degrees C.....+ 50 degrees C |
| Weight (inc. batteries) | 1.5 Kg |
| Case dimensions | 200 x 120 x 90 mm |
| **BATTERY CHARGER** Output | 300 mA at 17 V constant voltage<br>(Internal constant current circuit<br>and charge indicator in RM15) |
| Charge time for full capacity | 12 hours (Nickel-Cadmium) |
| Input voltage to charger | 120 V, 220 V, 240 V, 50/60 Hz<br>(specify USA/Japan, European, UK) |

## Appendix B: Technical Specifications for the GSSI SIR2000 GPR

### Hardware

| | |
|---|---|
| IDE INTERNAL HARD DRIVE, | minimal capacity 1.4 GB. |
| DISPLAY: | 21cm color active matrix LCD VGA for real-time display, 640 x 480 pixels. |
| INPUTS/OUTPUTS: | 1 Antenna Input (including survey wheel)<br>1 12VDC Power Input<br>1 Keyboard (PC/AT-compatible) connector<br>1 Parallel Connector<br>1 Serial Connector<br>1 Audible Warning Beeper (speaker)<br>3 LED Indicators, 2 Power, 1 hard drive |
| PRINTER: | Optional thermal plotter for real-time hard copy of wiggle-trace or grayscale linescan data. |

### Software

| | |
|---|---|
| DATA COLLECTION: | Continuous profile, survey wheel-controlled or stacking (point collection) modes. DISPLAY MODE: User-selected; color/grayscale linescan, wiggle trace or oscilloscope data formats. Menus and system parameters. |
| RANGE GAIN: | Automatic or user-selected; range gain function **prior** to digitization for maximum system dynamic range. |
| DATA TRANSFER: | Bi-directional parallel port. Optional serial transfer. |

### Electrical

| | |
|---|---|
| TRANSDUCER: | operates with any GSSI model transducer. |
| RANGE: | 6-3000 nanoseconds full scale, user selectable, fixed ranges of 8,15, 25, 35, 50, 70, 100, 150, 200, 250, 300, 400, 500, 750, 1000. |
| PULSE REPETITION RATE: | Automatically selected, 8 to 64 KHz. |
| SAMPLING: | Automatically or manually selected, 128, 256, 512, 1024, or 2048 samples/scan. |
| QUANTIZATION: | 8 or 16-bit |
| INPUT POWER: | 12VDC from vehicle or belt mounted, rechargeable battery with operating range of 10-12.5 volts, 100 watts. |

## Environmental

OPERATING TEMPERATURE: 0° C to 40° C (32 F to 104 F) external.

RELATIVE HUMIDITY: 0-100%

STORAGE TEMPERATURE: -25° C to 50° C (-20° F to 122° F)

WATER: Splash-proof - not intended to be immersed

DUST: All sensitive components are housed in dust-resistant enclosures.

## Mechanical

DIMENSIONS: 13.5" x 11.5" x 6"

WEIGHT: 15 lbs