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Geophysical Survey for the Second Street Trash Site Harvey Point Defense Testing Activity Hertford, North Carolina

prepared for

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Executive Summary

ATS International, Inc. (ATS) was retained by Independent Environmental Consultants, LLC (IEC) to conduct a geophysical investigation at the Harvey Point Defense Testing Activity near Hertford, North Carolina. The objective of this study was to characterize the subsurface for the lateral distribution and thickness of buried materials at a study area identified as the Second Street Trash Site, hereafter referred to as the "Second Street Site". This geophysical investigation has arisen as the result of the recent discovery of buried man-made materials at the site.

To evaluate the lateral distribution of buried materials at the site, electromagnetic induction (EM) was used. EM is a geophysical method that measures the conductivity of the materials beneath the instrument. In general, fill materials exhibit a higher conductivity than natural earth materials because the fill often contains objects and/or chemicals that are of higher conductivity than natural soils. In addition to the EM investigation, two-dimensional surface resistivity imaging methods were employed to provide vertical imaging of the subsurface across the study area. Resistivity imaging provides cross-sectional images of the resistance of subsurface materials to electric current, from which geologic conditions can be inferred. In general, fill materials tend to exhibit lower resistivity than natural materials.

Both the EM and resistivity imaging surveys reveal geophysical anomalies which may represent buried materials. There is no evidence in the EM or resistivity data that any buried materials exists south of Fifth Street except for the isolated anomaly that is coincident with the grassy mound west of the tree line. North of Fifth Street, there are elevated EM anomalies at the periphery of the data to the north and east of data set. Therefore, the existing EM data coverage does not necessarily represent the lateral extent of fill at the site. The resistivity data suggest that the depth of the buried materials is probably not more than 16 feet, and the limited vertical extent of the low-resistivity zones suggests little or no migration of dissolved constituents beneath the study area.

1. Introduction

ATS International, Inc. (ATS) was retained by Independent Environmental Consultants, LLC (IEC) to conduct a geophysical investigation at the Harvey Point Defense Testing Activity near Hertford, North Carolina (Figure 1). The objective of this study was to characterize the subsurface for the lateral distribution and thickness of buried materials at a study area identified as the Second Street Trash Site, hereafter referred to as the "Second Street Site" (Figure 2). This geophysical investigation has arisen as the result of the recent discovery of buried man-made materials at the site.

The tasks involved in this study included:

1) Collection, processing, and interpretation of electromagnetic induction (EM) data.

2) Collection, processing, and interpretation of electrical resistivity data.

3) Preparation of this document detailing our methods and findings.

2. Site Description

The geology of the site consists of coastal plain sediments of sand, silt and clay. Observations at the site indicate that the surface soils are primarily sand with minor amounts of finer sediments and organics. Topographic relief at the site is negligible. Groundwater is reported to be approximately 3 to 4 feet below grade.

3. EM Investigation

To evaluate the lateral distribution of buried materials at the site, electromagnetic induction (EM) was used. EM is a geophysical method that measures the conductivity of the materials beneath the instrument. In general, fill materials exhibit a higher conductivity than natural earth materials because the fill often contains objects and/or chemicals that are of higher conductivity than natural soils.

3.1. Electromagnetic Induction Principles

EM investigation utilizes a low frequency transmitter to induce electrical current into the subsurface. The induced current creates secondary electromagnetic fields which are measured by the EM device. The amplitude and phase of these secondary fields are related to the electrical properties of the subsurface material, and therefore a measurement of the secondary fields is a measure of how well the subsurface materials conduct electric current.

The EM device measures the quadrature (terrain conductivity) and in-phase components of the electromagnetic fields generated by the instrument's transmitter. The quadrature component of the EM data reveals apparent terrain conductivity in units of milliSiemens per meter (mS/m), which is a weighted average of the conductivity through the depth of measurement beneath the instrument. High magnitude responses, either positive or negative, indicate high bulk conductivity in the materials under the instrument.

The in-phase component of the EM data is the ratio of the secondary to primary magnetic field, and is presented in parts per million (ppm). The in-phase component is sensitive to the presence of highly conductive material, especially shallow metal objects. It is important to note that the size, depth of burial, and degree of corrosion of a metal object are all factors which affect the in-phase response (Jordan and Constantini, 1995).

The instrument used for this investigation was the EMP-400 manufactured by Geophysical Survey Systems, Inc. The unit consists of a portable control module attached to a boom with a transmitter coil at one end and a receiver coil at the other end, and operated at a frequency of 10000 kHz. The effective depth of exploration of the EMP-400 is approximately 20 to 25 feet.

EM surveys are usually conducted along traverses through the area of interest with measurements taken at fixed distances or at a fixed time interval along the traverse. By conducting sub-parallel traverses, substantial lateral coverage can be obtained. The data can then be contoured to evaluate the spatial distribution of the measured conductivity values.

3.2. EM Field Methods

For this study, data were collected in the open areas of the site in near-parallel traverses spaced approximately 5 to 10 feet apart. In the wooded areas of the site, EM data collection was dictated by the occurrence of thickets and underbrush. Therefore, the EM data in those areas are more randomly distributed, with significant data gaps existing in those areas which were not accessible to traversing with the instrument. The EM data were collected with a continuous time-stamp log with measurements taken at 1-second intervals, while a concurrent time-stamped global positioning system (GPS) track log of coordinates was also collected. Location data from the GPS track log were integrated with the EM data to produce X and Y coordinates for each EM measurement. These data were subsequently contoured to evaluate the spatial distribution of the EM response.

The GPS tracks of traverses with the EM instrument are illustrated in Figure 3. In evaluating the GPS tracks, it is evident that some small degree of drift in the GPS must have occurred at times, likely as a result of the approximately 2- to 3-meter accuracy of the GPS unit. The possible drift is evidenced by some adjacent traverses slightly overlapping one another in Figure 3, whereas in the field they did not overlap. This is a limitation of the accuracy of the GPS signal and/or unit, and the total amount of drift is appears to be minimal when viewed overlain onto the aerial photo.

Contour maps of the quadrature and in-phase components of the EM response are illustrated in Figures 4 and 5, respectively. Several metallic objects observed on site are accentuated in the EM contours in Figures 4 and 5, and include an office trailer, staged heavy equipment, manholes and other utilities.

3.2.1. Quadrature component of the EM response

The contour map of the quadrature component of the EM response in Figure 4 reveals background conductivity values of the natural soils of approximately 1,000 mS/m to -1,000 mS/m, illustrated generally by the green contours. Also observed are several areas of elevated EM response, both positive and negative, which reveal strong changes in the subsurface conductivity. A broad zone of elevated EM response is observed in the northeast corner of the study area. This broader area also contains several slightly isolated "hot-spots". This broad area is likely to be underlain by disturbed soils and/or buried materials.

Another area of elevated EM response is observed in the southwest-central portion of the study area, near the tree line in the field on the south side of Fifth Street. This area is coincident with a slightly elevated mound and is likely the result of an isolated zone of buried materials.

3.2.2. In-phase component of the EM response

The contour map of the in-phase component of the EM response in Figure 5 reveals similar results as the quadrature contours. Since the in-phase component is more sensitive to metallic objects, it is likely that these areas of elevated EM response result in whole or in part from buried metallic material. This is consistent with field observations where metallic objects were seen protruding from the ground in the woods near the tree line.

4. Resistivity Imaging

In addition to the EM investigation, two-dimensional surface resistivity imaging methods were employed to provide continuous imaging of the subsurface across the study area. Resistivity imaging provides cross-sectional images of the resistance of subsurface materials to electric current, from which geologic conditions can be inferred. Electrical resistivity is a fundamental parameter describing how easily a material can transmit electrical current. High values of resistivity imply that the material is very resistant to the flow of electricity; low values of resistivity imply that the material transmits electrical current very easily.

4.1. Principles of Resistivity

Experiments by George Ohm in the early 19th century revealed the empirical relationship between the current flowing through a material and the potential required to drive that current. This relationship is described by

$$V = IR$$

where V is voltage in volts, I is the current in amperes, and R is the proportionality constant. Rearranging the equation to

$$\frac{V}{I} = R$$

gives resistance with the units of volts divided by amperes, or ohms.

The resistance of a material is dependent not only on the property of the material but also the geometry of the material. Specifically, a longer travel path for the current or smaller cross-sectional area would cause the resistance to increase. The geometry-independent property used to quantify the flow of electric current through a material is resistivity, given by

$$\rho = \frac{RA}{L}$$

where ρ is the resistivity, R is the resistance, A is the cross-sectional area through which the current flows, and L is the length of the current flow path. With all length units expressed as meters, the units associated with resistivity are ohm-meters.

Resistivity surveys are conducted by inducing an electric current into the ground between two electrodes, and measuring the potential at other electrodes. Numerous configurations of electrode placement are commonly employed, each with unique data characteristics. The configuration utilized for this study was the dipole-dipole array. For the dipole-dipole array, a current is applied to two adjacent electrodes positioned a predetermined distance apart (distance a). The voltage across two other electrodes is measured simultaneously with the applied current. The two sets of electrodes are always spaced distance a apart and the distance between the current and voltage electrodes is always a multiple of a (n• a). To obtain apparent resistivity values, the voltage and current measurements are input into the following formula for dipole-dipole surveys

$$\rho = 2\pi(n+1)\cdot(n+2)\cdot a\cdot\frac{V}{I}$$

4.2. Field Methods

Data for two resistivity lines were collected at the site on November 1st, 2011. Field data were collected using a SuperSting R8 IP® multi-electrode resistivity system manufactured by

Advanced Geosciences Inc. Data were collected using the dipole-dipole array with a current of up to 200 milliamps. For each electrode configuration in the array, measurements were repeated a minimum of two times or until the error between measurements was less than or equal to five percent.

The electrodes were assigned a unique identifier consisting of the line number followed by a dash and the electrode number. For example, the first electrode on Line 1 is 1-1, the first electrode on Line 2 is 2-1, etc. The locations of the resistivity lines were recorded with a handheld GPS so that they could be plotted onto aerial photography of the site (Figure 6). Line 1 was oriented northwest to southeast, originating on the west side of Second Street and extending across the open area and into the woods to the southeast. Line 2 was oriented southwest to northeast, originating near a storm sewer manhole and extending across Fifth Street through the study area. Both lines consisted of 28 electrodes with a 4 meter (13 feet) spacing between electrodes.

4.3. Inversion Modeling

The resistivity measurements on a section are called apparent resistivities. They may differ from the actual resistivities because of passage through inhomogeneous materials and the distance of travel through the media. Therefore, linear inversion techniques were applied to the data. Linear inversion modeling fits the measured data in the resistivity section to an earth model that may represent the actual resistivities in the section. The inversion modeling is completed by calculating apparent resistivity from the earth model for comparison to the measured data. If the comparison is within reasonable limits, the earth model can be accepted as an approximation of subsurface conditions. Details of the inversion process may be found in Lines and Treitel (1984), Loke and Barker (1995), and Loke and Barker (1996).

4.4. Resistivity Results

The locations of both the broad and isolated areas of elevated EM response, as illustrated in Figures 4 and 5, are shaded red in the resistivity electrode map in Figure 6 so that any correlations can be made between the two geophysical methods. Both Lines 1 and 2 extended through the broad EM anomaly in the northwest portion of the Second Street study area. Additionally, Line 2 passed through the isolated EM anomaly in the southwest portion of the study area.

The measured resistivity values in Lines 1 and 2 range from 11 ohm-meters to 2,780 ohm-meters. In the sections for both Lines 1 and 2, distinct zones of the lowest measured resistivity values are observed coincident with those portions of the lines which extend across the broad EM anomaly (Figure 7). These zones are illustrated in the resistivity sections from electrodes 1-16 through 1-28 and from electrodes 2-19 through 2-28. The characteristics of these zones, exhibited by the very low resistivity values at the near-surface, are consistent with buried materials or fill. These low-resistivity zones extend to a depth of approximately 16 feet. However, it should be noted that if dissolved constituents from the buried materials has migrated vertically downward, then the interface between the fill materials and the natural soils could be masked by the low-resistivity dissolved constituents.

Of additional interest is a low-resistivity zone in the section for Line 2 beneath electrodes 2-2 to 2-8. This zone is coincident with the location of the isolated EM anomaly illustrated in plan-view Figures 4 through 6. As such, this area may also represent buried materials.

5. Conclusions

Both the EM and resistivity imaging surveys reveal geophysical anomalies which may represent fill materials. There is no evidence in the EM or resistivity data that any buried materials exists south of Fifth Street except for the isolated anomaly that is coincident with the grassy mound west of the tree line. North of Fifth Street, there are elevated EM anomalies at the periphery of the data to the north and east of data set. Therefore, the existing EM data coverage does not necessarily represent the lateral extent of fill at the site. The resistivity data suggest that the depth of the buried materials is probably not more than 16 feet, and the limited vertical extent of the low-resistivity zones suggests little or no migration of dissolved constituents.

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7. Figures

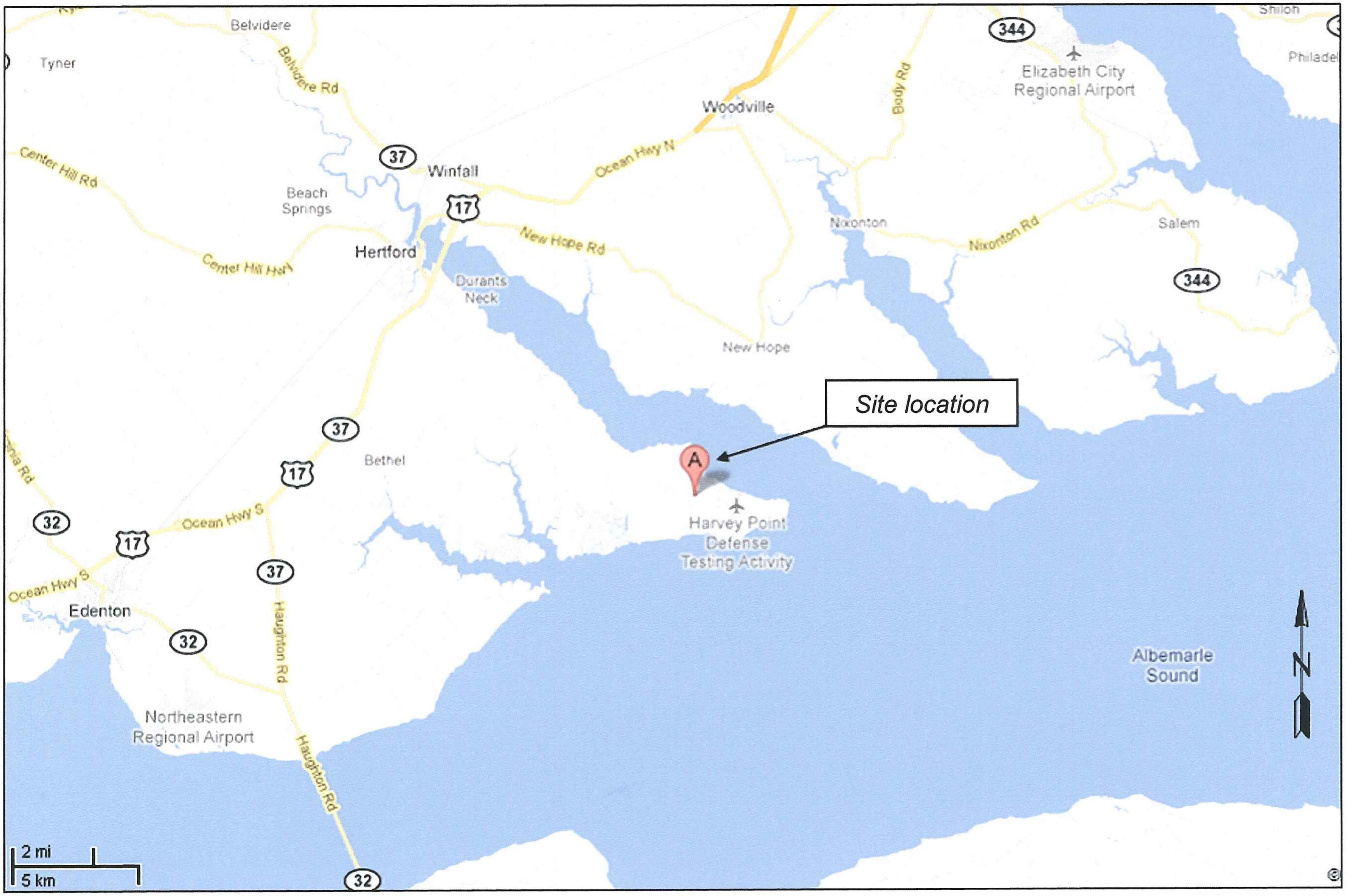

Figure 1. Site location map.

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Scale: 1 inch = 20 meters

0 10 20 30 40

Map axis coordinates: UTM Zone 18 WGS84 meters

Figure 2. Aerial photo of the Second Street Trash Site.

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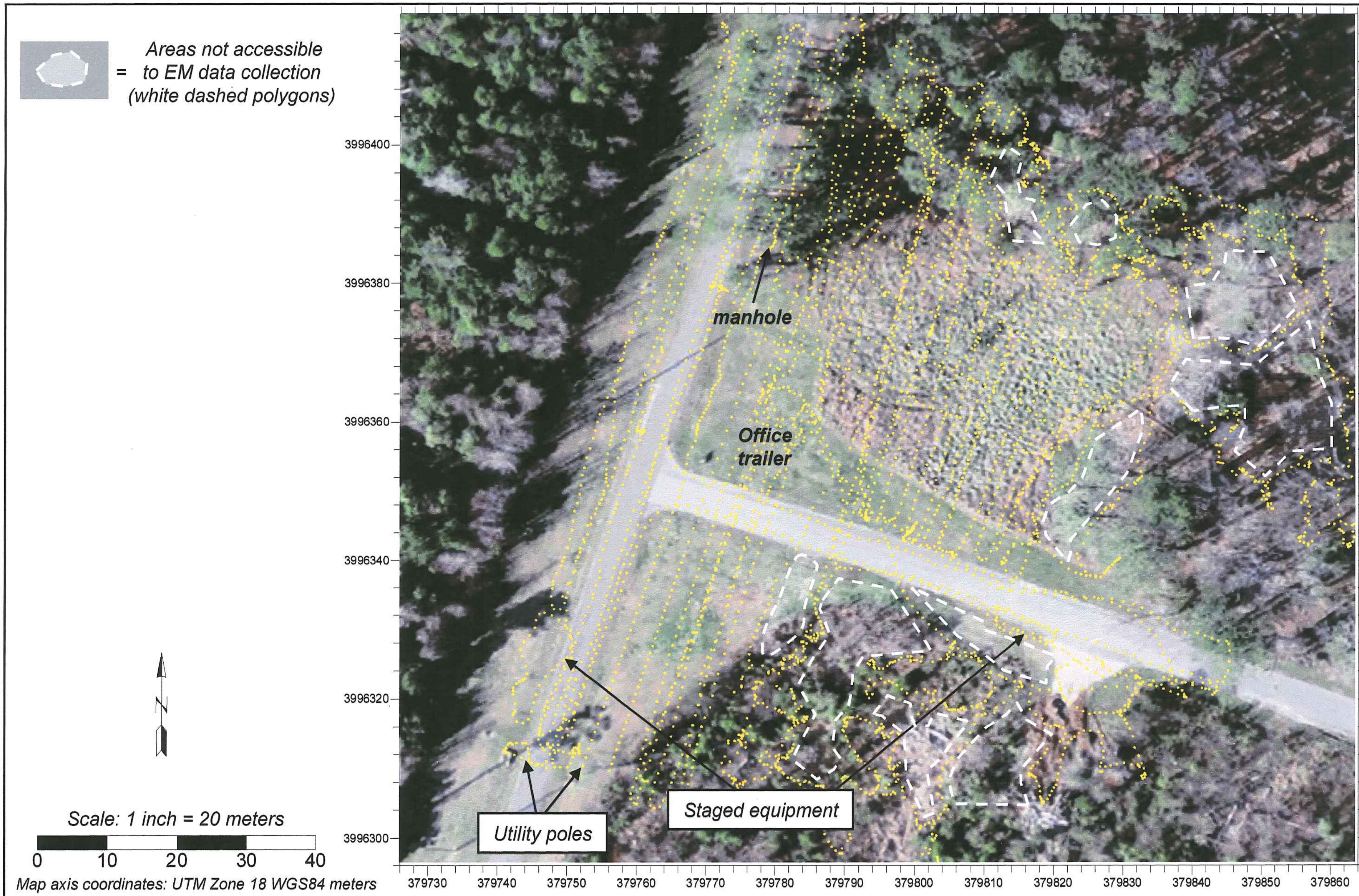

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Figure 3. GPS track of the EM survey illustrating the GPS locations of individual EM datum points (yellow dots).

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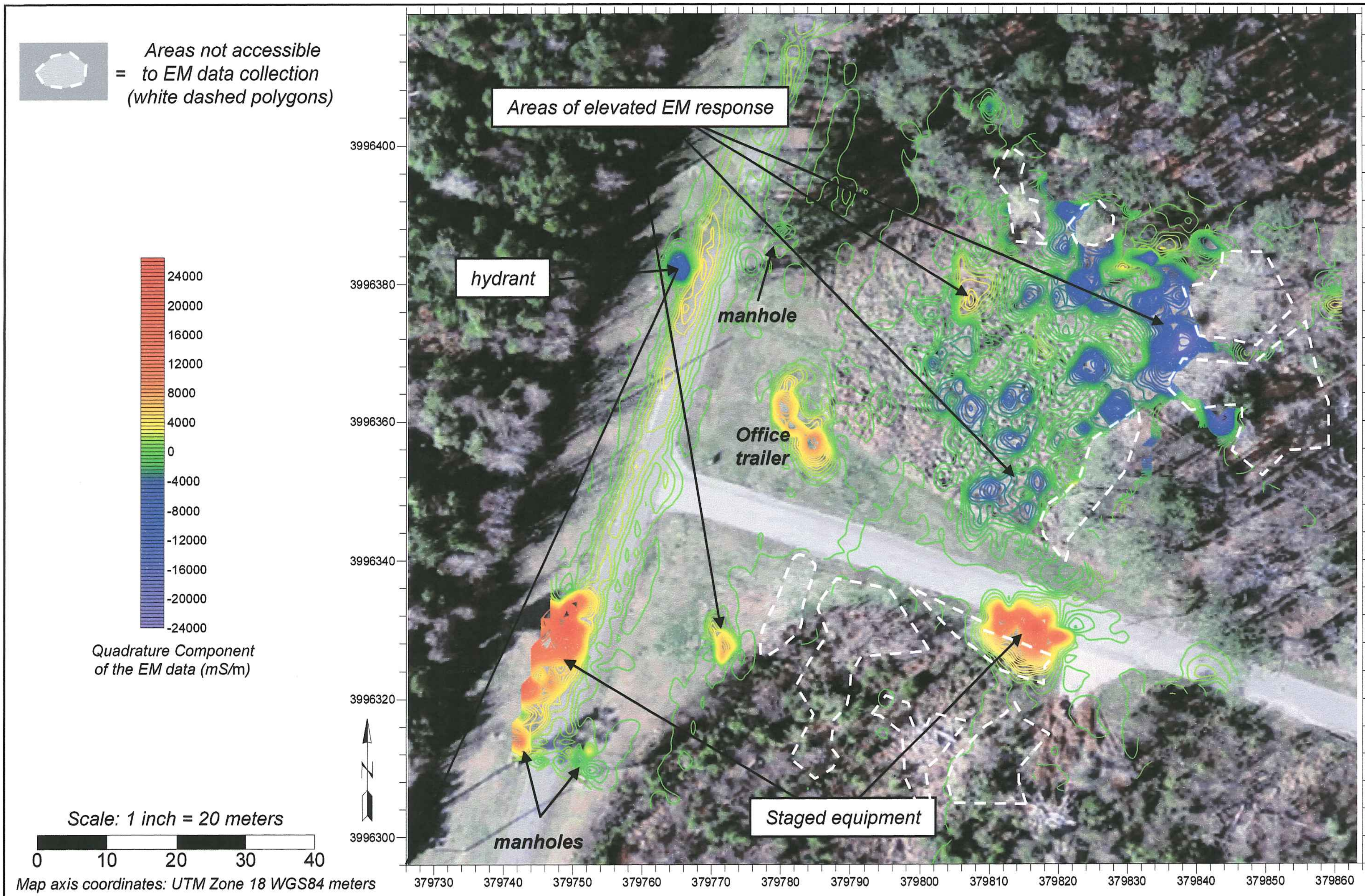

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Figure 4. EM response for the quadrature component of the EM data, in milliSiemens per meter.

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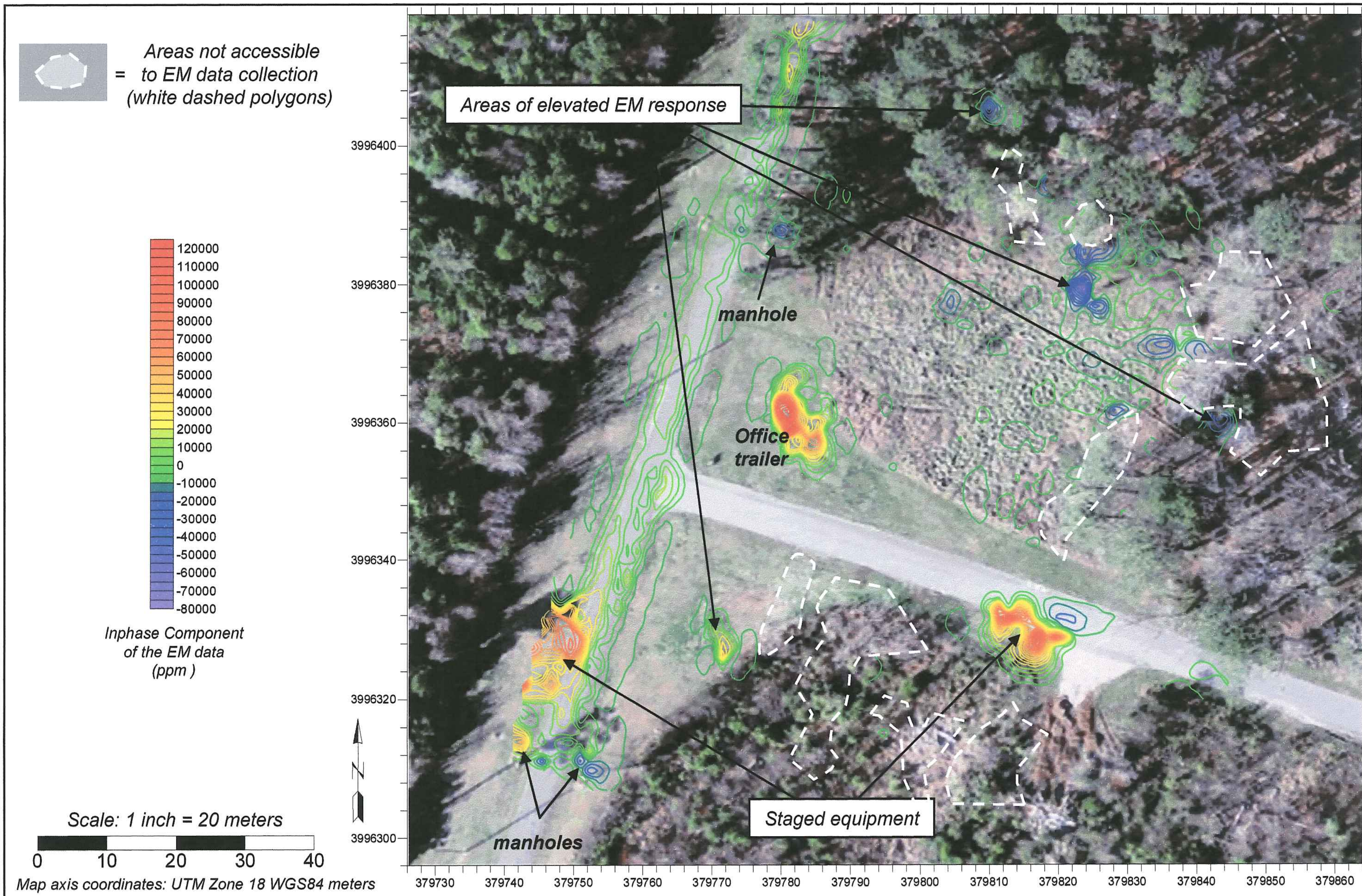

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Figure 5. EM response for the in-phase component of the EM data, in parts per million.

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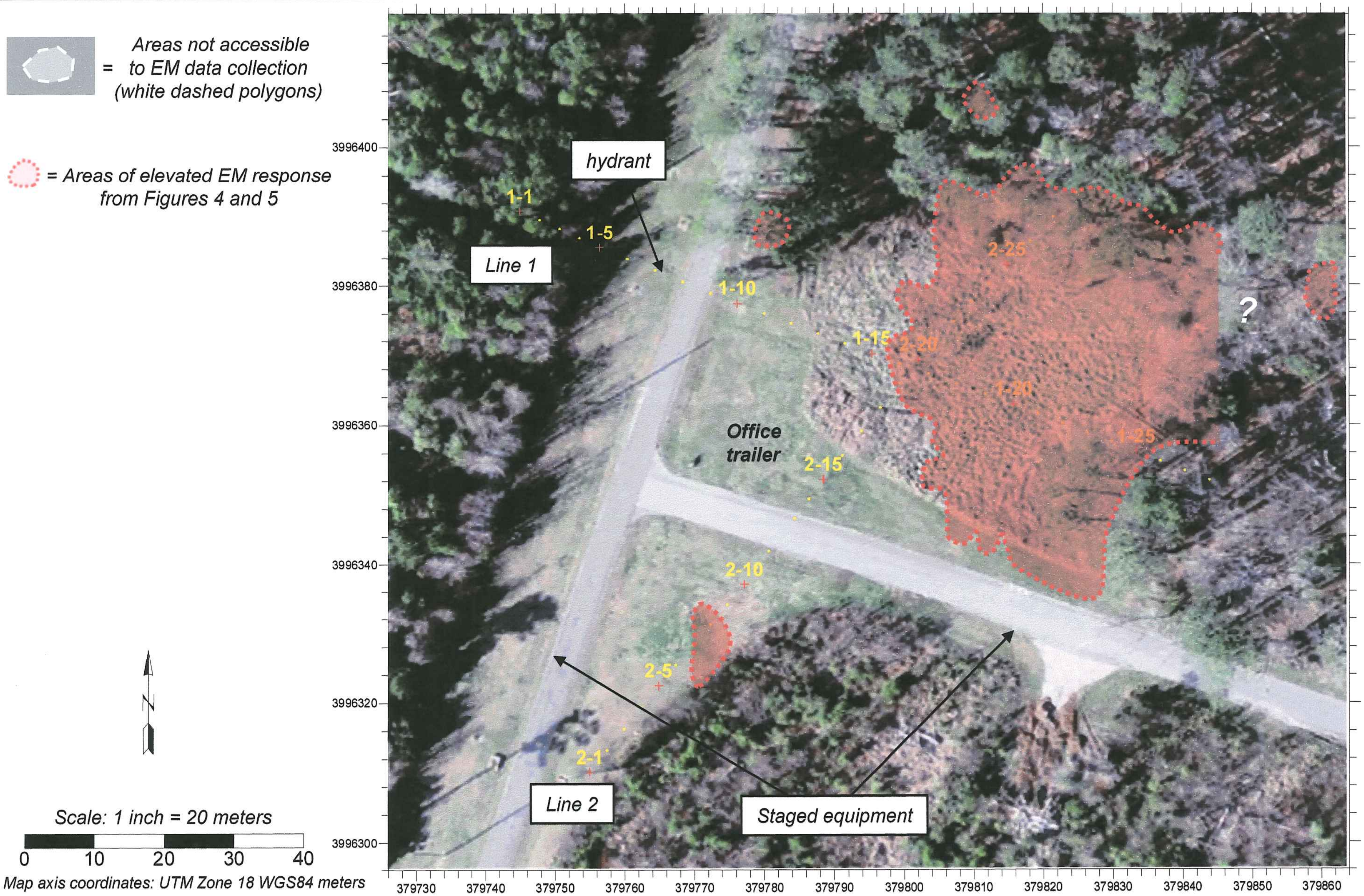

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Figure 6. Locations of electrodes for resistivity Lines 1 and 2 and areas of elevated EM response from Figures 4 and 5.

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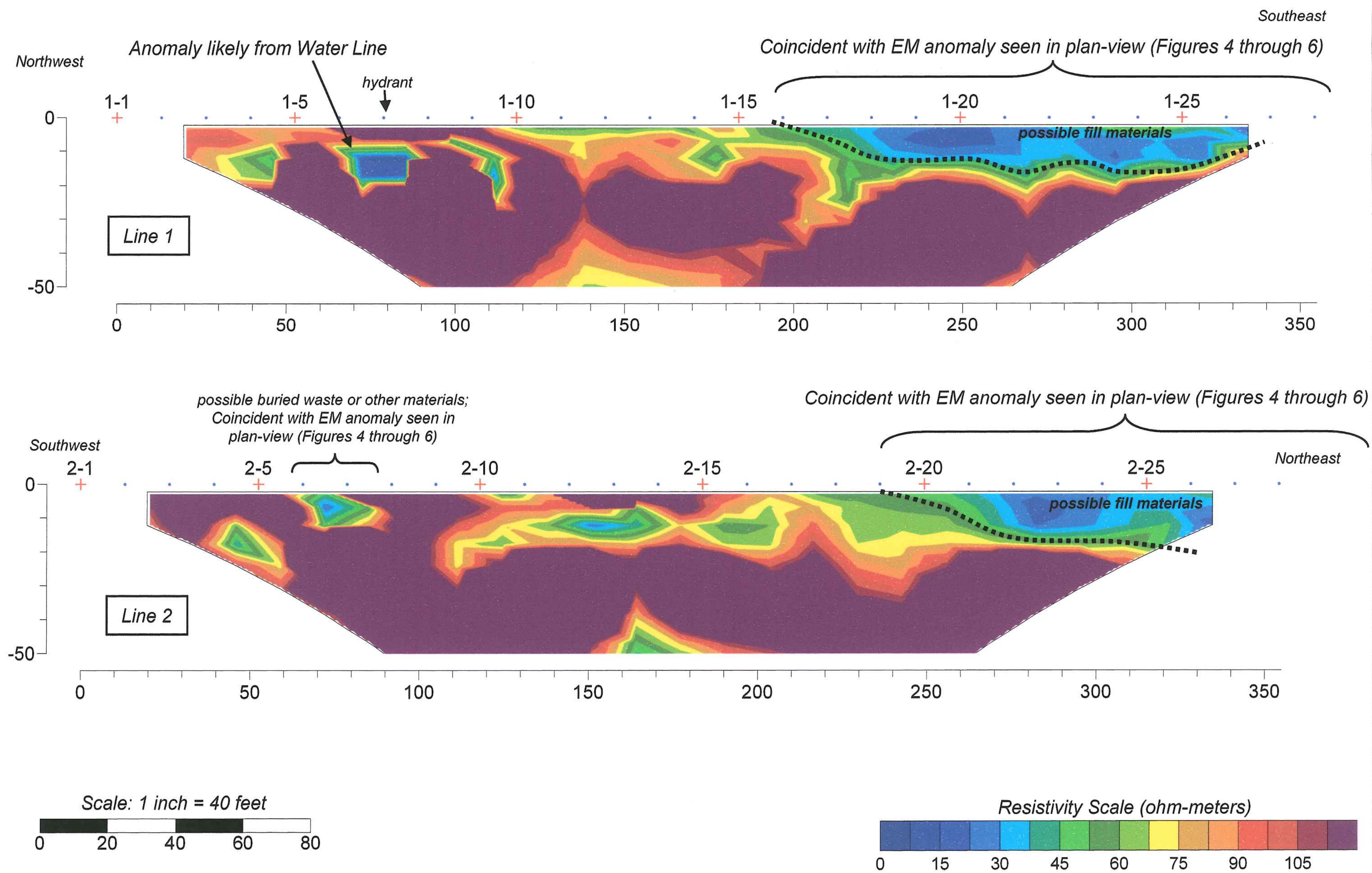

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Figure 7. Resistivity results for Lines 1 and 2.

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