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# Surface Geophysical Exploration of TX and TY Tank Farms at the Hanford Site: Results of Background Characterization with Magnetics and Electromagnetics

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Key Words: Waste Management Area TX-TY, 216-T trenches, 216-T-19 crib, 216-T cribs, electromagnetic induction, magnetic gradiometry

Abstract: This report presents the results of the background characterization of the cribs, trenches, and tile fields surrounding the TX and TY tank farms.



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# EXECUTIVE SUMMARY

This report documents the results of preliminary surface geophysical exploration activities performed between September and October 2007 at the waste management areas surrounding the TX and TY tank farms. The TX-TY tank farms are located in the 200 West Area of the U.S. Department of Energy's Hanford Site in Washington State. The objective of the preliminary investigation was to acquire background characterization information using magnetic gradiometry (Mag) and electromagnetic induction (EM) methods to understand the spatial distribution of buried metallic objects that could potentially interfere with the results of a subsequently completed high resolution resistivity survey.

Data coverage included a total of approximately 82 acres over five main focus areas: the eastern cribs (216-T-26 through 216-T-28), northern cribs (216-T-36-13 and T216-T-13), south tile field (216-T-19), western trenches (216-T-21 through 216-T-25), and the area directly west of the TX farm.

Results of the background characterization indicate that there are several areas located around the tank farms that have large metallic subsurface debris or metallic infrastructure that will likely influence the resistivity results.

Figure ES-1 shows the results of the magnetic vertical gradient response patterns, in nanoTeslas (nT). The vertical magnetic gradient reveals some shallow ferrous materials most noticeably between the eastern TX farm fence and the eastern survey boundary. Several other linear features appear within the survey area and are exhibited by the red and blue color contours. Areas that have no buried metallic objects are represented by yellow hues. Interpreted responses were correlated to available infrastructure maps and then grouped into three classes based on how they might influence resistivity data: below ground (pipes and utilities), above ground (overhead electric lines, surface transfer lines, structures), and roads (with different material properties and increased moisture).

Figure ES-2 shows the electrical conductivity survey results using the 10 kHz frequency. The color scale was developed so that background conditions are represented by orange and yellow colors and high conductivity features are shown in red tones. The figure shows several high conductivity regions that could be indicative of subsurface metals, including stainless-steel pipes. The features correlate with the results of the magnetic survey, which provides the ability to segregate ferrous metals that will appear on the Mag and EM data, and non-ferrous metals that will only be visible only on the EM results. Unlike the Mag survey, overhead electric lines are visible in the electromagnetic survey, most noticeably west of the TX-TY farms.

**Figure ES-1. Results of the Magnetic Vertical Gradient.**

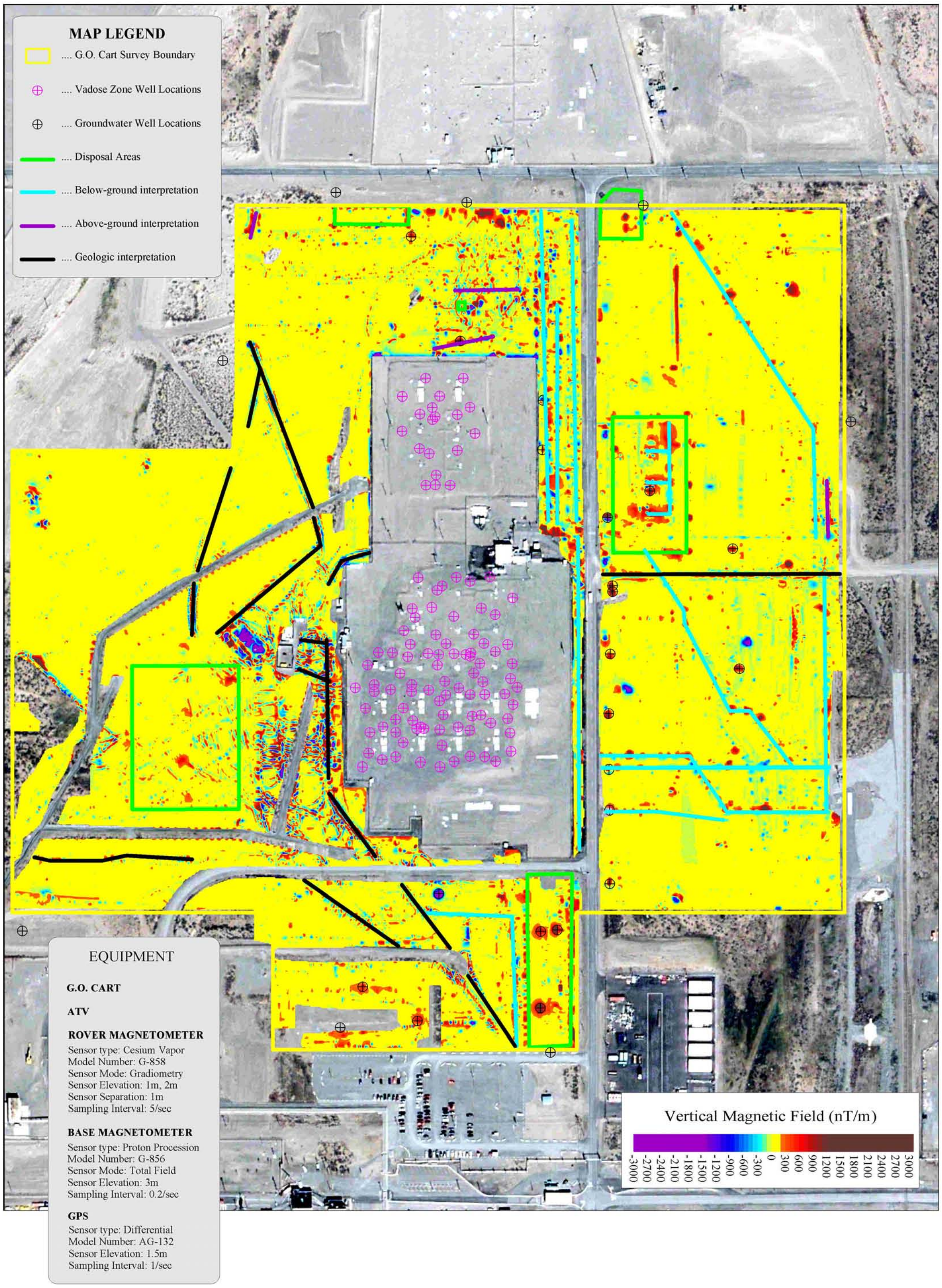


**Figure ES-2. Electrical Conductivity from the Electromagnetic Induction at 10 kHz.**

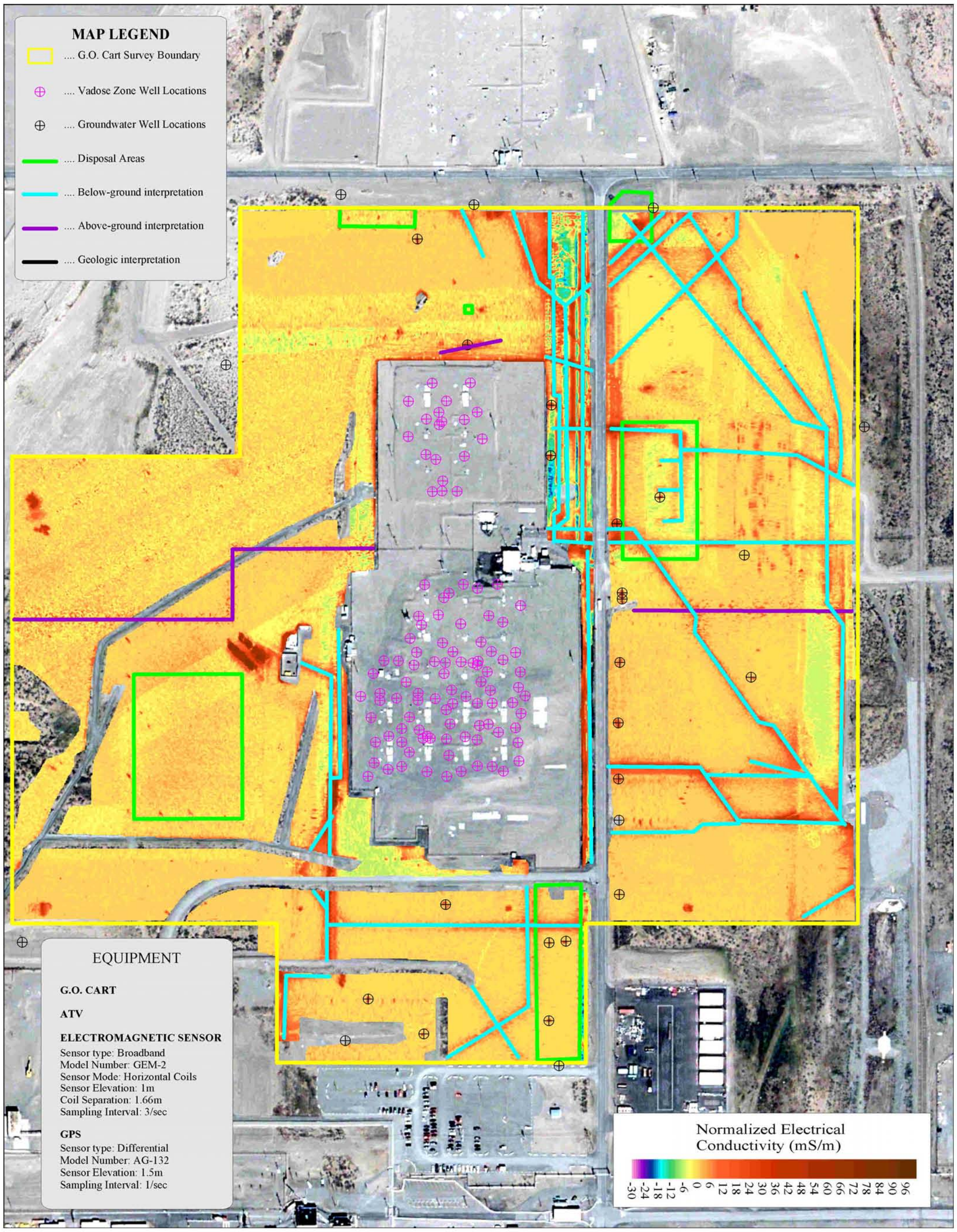
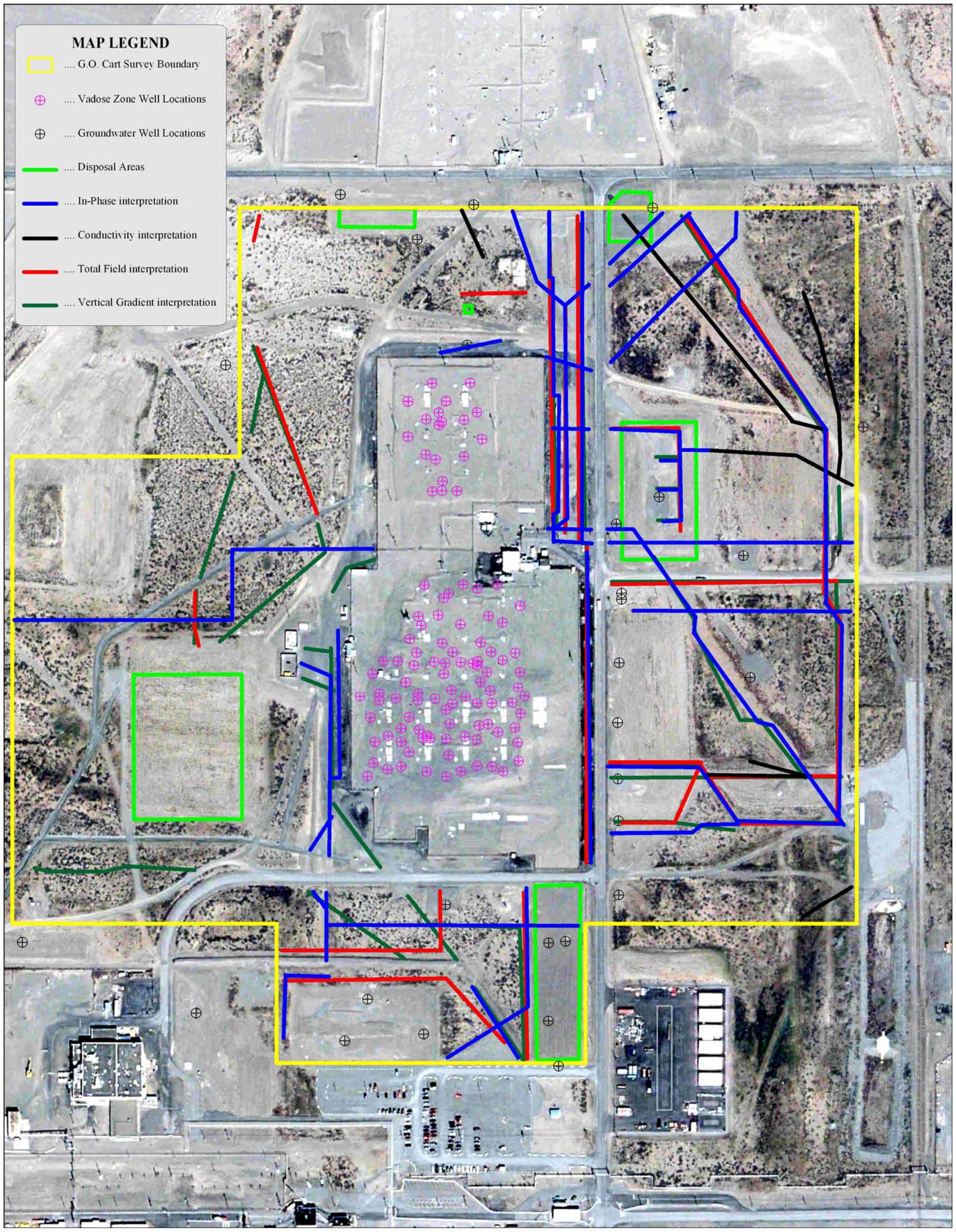



Figure ES-3 shows a summary of features identified from the Mag and EM interpretation after correlation with available Hanford Site utility maps. The map indicates agreement between the methods for the majority of features. Features that do not correlate between the EM and Mag surveys provide additional segregation of material properties that will be used to support resistivity data interpretation.

**Figure ES-3. Summary of Interpreted Features from G.O.Cart™ Survey**



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## Terms

Conductivity. The ability of a material to transmit or conduct an electric impulse; reciprocal of resistivity.

Inversion. Inversion, or inverse modeling, attempts to reconstruct subsurface features from a given set of geophysical measurements, and to do so in a manner that the model response fits the observations according to some measure of error.

Resistance. The opposition of a material to current passing through it; received voltage normalized by transmitted current.

## Abbreviations and Acronyms

| | |
|---|---|
| ATV | all-terrain vehicle |
| CH2M HILL | CH2M HILL Hanford Group, Inc. |
| Columbia Energy | Columbia Energy & Environmental Services, Inc. |
| EM | electromagnetic |
| G.O. Cart™ | Geophysical Operations Cart |
| GPR | ground penetrating radar |
| GPS | Global-Positioning System |
| HGI | hydroGEOPHYSICS, Inc. |
| MAG | magnetic gradiometry |
| mS/m | milli-Siemen per unit meter |
| nT | nanoTesla |
| Ppm | parts per million |
| Rx | receiving coil |
| SGE | Surface Geophysical Exploration |
| Tx | transmitting coil |
| WMA | waste management area |

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# 1.0 INTRODUCTION

Beginning in November 2007 and ending in December 2007, a preliminary geophysical study was completed for the waste management areas (WMAs) surrounding the 241-TX and 241-TY tank farms at the U.S. Department of Energy's Hanford Site in eastern Washington State. Columbia Energy & Environmental Services, Inc. (Columbia Energy) of Richland, Washington, and hydroGEOPHYSICS, Inc. (HGI) of Tucson, Arizona, with support from CH2M HILL Hanford Group, Inc., conducted background geophysical surveys of the WMAs surrounding the TX-TY tank farms located in the 200 West Area of the Hanford Site. The geophysical surveys consisted of electromagnetic (EM) induction and magnetic gradiometry (Mag) around the periphery of the tank farms.

This report will support a follow-on report documenting the results of a resistivity survey of the TX-TY farms and surrounding areas. The purpose of this report is to document the findings of the EM and magnetic gradiometry survey of the areas surrounding the TX-TY tank farms in an effort to identify the presence of buried infrastructure. This information in turn is to be used as an aid in the interpretation of the resistivity results. A high concentration of buried infrastructure will influence the resistivity results and should be taken into consideration when making interpretations.

## 1.1 SCOPE

The scope of the geophysical surveying included data acquisition, processing, and visualization of EM induction and magnetic gradiometry for areas outside the tank farm fence lines surrounding the TX-TY tank farms to map buried subsurface infrastructure. Potential targets for the survey include buried pipelines, electrical conduits, and other metallic objects that may interfere with direct-current electrical resistivity imaging. The survey was performed in accordance with RPP-PLAN-35244, *Work Plan for Surface Geophysical Exploration of the TX and TY Tank Farm and Surrounding Area*. The scope of this survey does not include the mapping of electrolytic targets that are a result of increased salt or moisture content from the direct disposal of liquid waste to the vadose zone.

The data acquisition was conducted by attaching the EM induction and magnetic gradiometry instruments to a Geophysical Operations Cart™ (G.O. Cart), which included an all-terrain vehicle and a fiberglass-towed trailer. The G.O. Cart was outfitted with a Global-Positioning System (GPS) for geo-referencing of data and to allow tracking of its location while traversing the area. Data coverage included a total of approximately 82 acres over five main focus areas: the eastern cribs (216-T-26 through 216-T-28), northern cribs (216-T-36-13 and T216-T-13), south tile field (216-T-19), western trenches (216-T-21 through 216-T-25), and the area west of the TX farm. Figure 1 shows a plan view location map of the five focus areas. Nearly two million data points per method were acquired.

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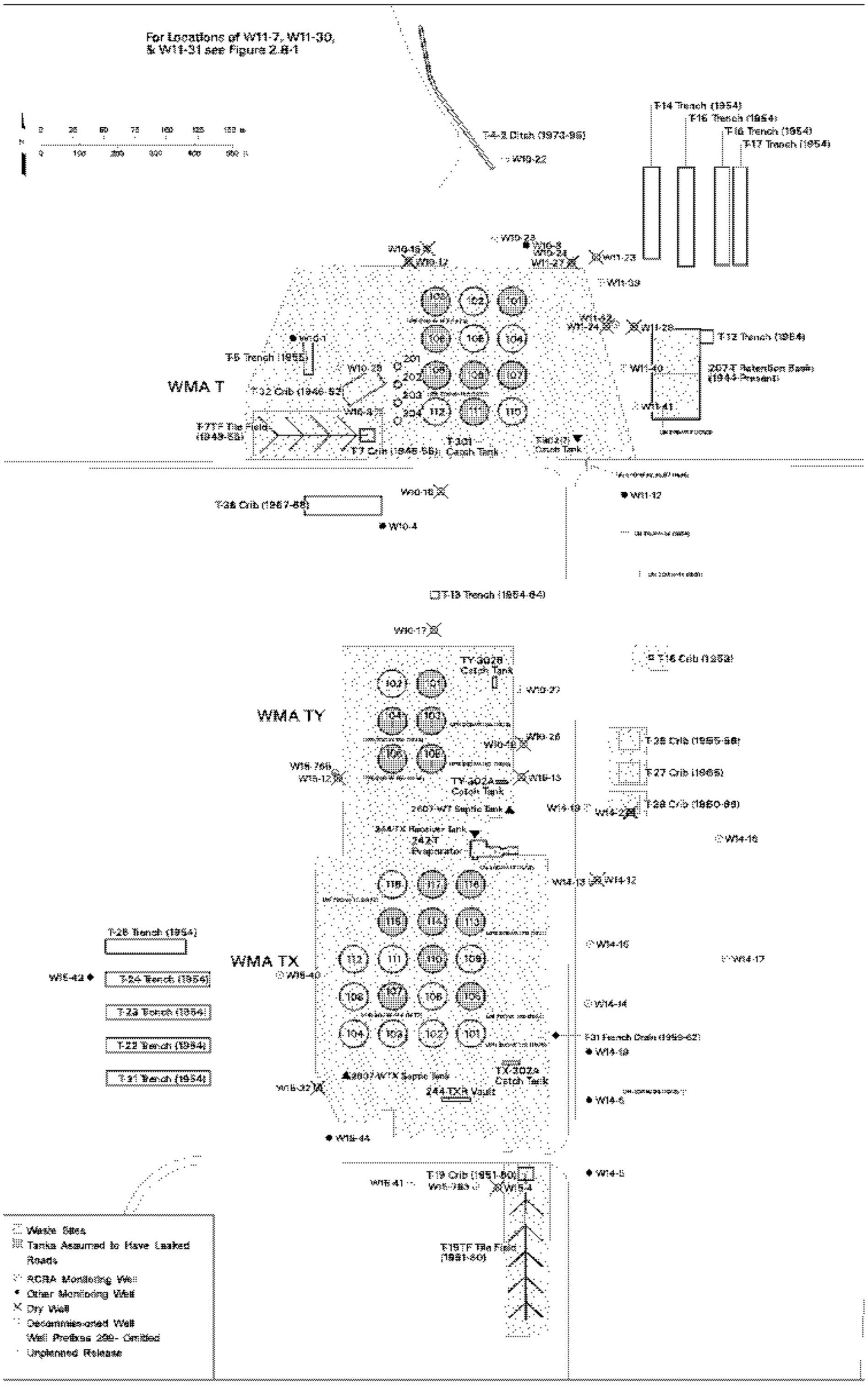
**Figure 1. Waste Management Area TY-TY and Surrounding Areas.**



## 1.2 OBJECTIVES

The main objective for this geophysical investigation was to map the subsurface outside the tank farms with regards to the extent of buried metallic infrastructure and debris. The subsurface metal may interfere with electrical resistivity measurements, which are being completed as the second phase of the surface geophysical exploration scope for the TX-TY tank farms and surrounding areas geophysical characterization. The results of the electrical resistivity survey will be presented in separate reports.

## 1.3 REPORT LAYOUT

This report is divided into seven main sections.

- Section 1.0, Introduction – describes the scope and objectives of the investigation.
- Section 2.0, Background – describes the setting of the TX-TY tank farms and information regarding the metallic infrastructure in and around the tank farm.
- Section 3.0, Theory – briefly provides the theory behind EM induction and magnetic gradiometry.
- Section 4.0, Methodology – discusses the methodology and logistics of conducting the geophysical survey at the TX-TY tank farms.
- Section 5.0, Quality Assurance – description of quality assurance practices.
- Section 6.0, Analysis, Results and Interpretation – presents the results from the surveying effort.
- Section 7.0, Conclusions – provides conclusions drawn from the results, interpretations, and subsequent assessment of results.
- Section 8.0, References – lists reference documents cited in the report.
- Appendix A, Supplemental Plots – large format plots and additional magnetic and electromagnetic plots
- Appendix B, Quality Assurance – field observation forms, and calibration statements.

# 2.0 BACKGROUND

The TX-TY tank farms are two of 12 single-shell tank (SST) farms on the Hanford Site that form WMA TX-TY. The surface geophysical exploration (SGE) investigation extended beyond the WMA TX-TY boundary; therefore, the TX-TY tank farms and surrounding areas are herein referred to as the TX-TY Complex. The TX-TY Complex is located in the northern portion of the 200 West Area as shown in Figure 2, and includes a number of past-practice liquid discharge facilities (i.e., cribs and trenches) located mainly to the west, southeast, and northeast of the TX and TY tank farms (Figure 1). The TX-TY Complex facilities received a variety of waste streams generated primarily during bismuth phosphate plutonium separations operations at T Plant and uranium recovery operations a U Plant (*Historical Vadose Zone Contamination from T, TX, and TY Tank Farm Operations* [RPP-5957]).

CH2M HILL has responsibility for vadose zone characterization at the tank farms under the direction of the U.S. Department of Energy (DOE), Office of River Protection. Fluor Hanford, Inc. has responsibility for characterization of the cribs and trenches outside the tank farm, as well as groundwater monitoring program.

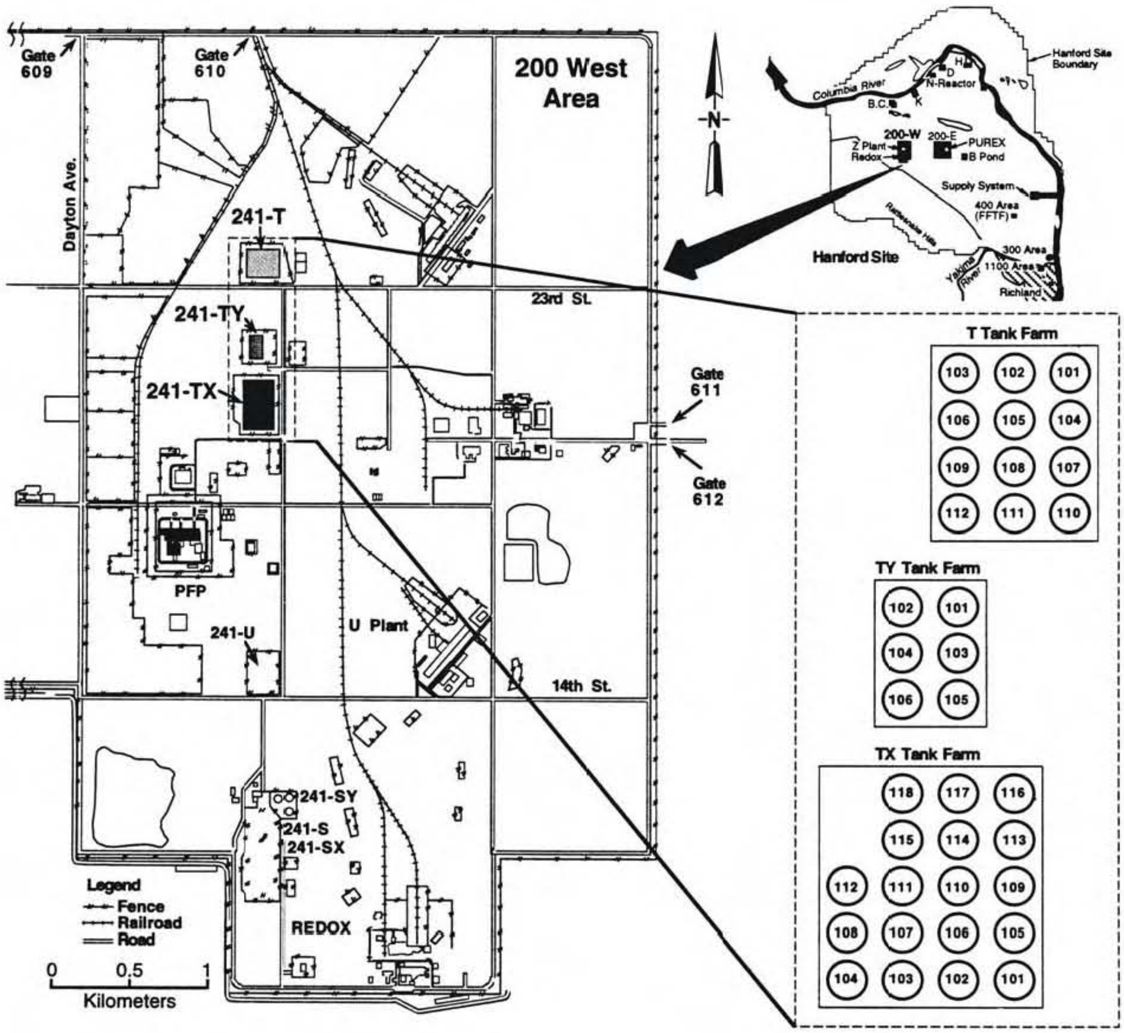
The TX-TY Complex contains the following tank farm facilities:

- TX tank farm—Eighteen 100-series SSTs with 758,000-gallon capacity
- TY tank farm—Six 100-series SSTs with 758,000-gallon capacity
- Leak detection systems
- Tank ancillary equipment.

Facilities of interest for magnetic and electromagnetic investigation within the TX-TY Complex include the surrounding cribs, tile fields, and trenches that were accessible from the surface. The location of the facilities are shown on Figure 1.

The TX tank farm was constructed between 1947 and 1949 and began receiving waste in 1949. It was originally built to provide tank space for bismuth phosphate waste from T Plant and later was used as part of the uranium recovery process (RPP-7123, *Surface Conditions Description of the T-TX-TY Waste Management Area*). The TY tank farm was constructed between 1951 and 1952 and began receiving waste in 1953. It was built to provide tank space for the uranium recovery process (RPP-7123). Due to limited tank space, the 242-T Evaporator was built in 1951 to reduce waste volumes and the 216-T-19 crib and tile field was constructed to receive condensate from the evaporator. Through the 1950s and into the 1960s, generated waste volumes continued to exceed the available tank space, forcing the intentional discharge of relatively high waste volumes into the vadose zone. Additional cribs and trenches were constructed to receive the liquid discharges. Planned waste management activities continued up until the early 1980s.

**Figure 2. Location of TY and TY Tank Farms.**




Source: RPP-23752, 2005, *Field Investigation Report for Waste Management Areas T and TX-TY*, CH2M HILL Hanford Group, Inc., Richland, Washington.

## 3.0 THEORY

This section provides summary level descriptions for the theory behind different geophysical tools and methods used in the assessment.

## 3.1 MAGNETOMETRY

Magnetic gradiometry (Mag) studies the Earth's magnetic field (*Applied Geophysics* [Telford et al. 1990). The Earth's field is composed of three main parts:

- Main Field – internal to the Earth (i.e., from a source from within the Earth and varies slowly in time and space)
- Secondary Field – external to the Earth and varies rapidly in time
- Small Internal Fields – constant in time and space and are caused by local magnetic anomalies in the near-surface crust.

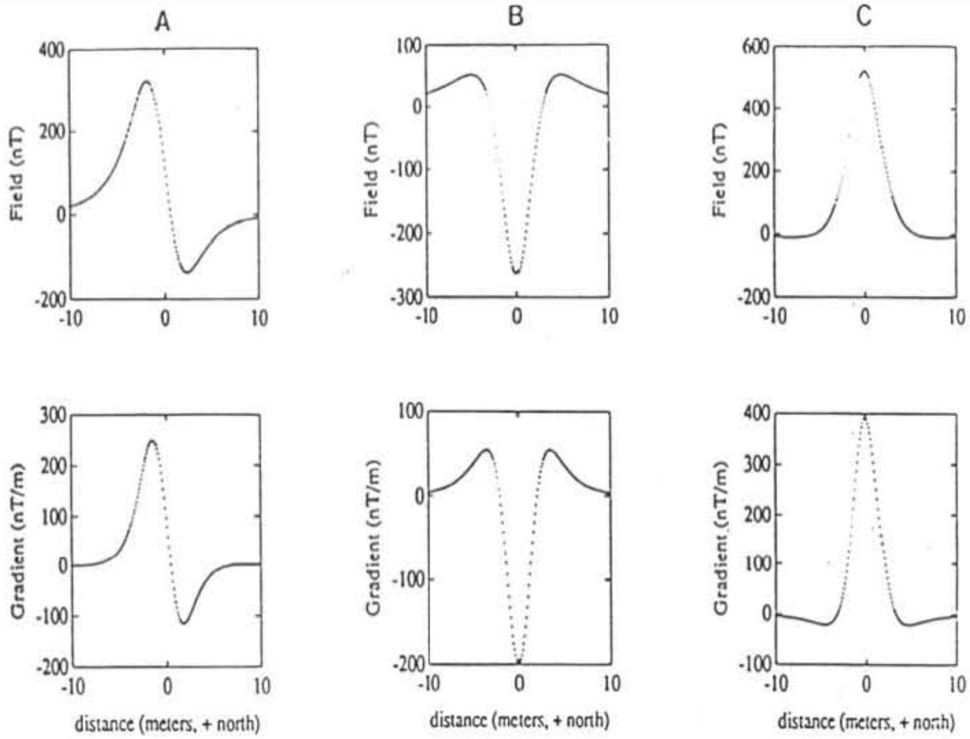
Localized magnetic anomalies are caused by magnetic minerals (mainly magnetite or pyrrhotite) or buried steel and contrast in the magnetic susceptibility (k) with the background sediments. The average values for k are typically less than 1 for sedimentary formations and up to 20,000 for magnetite minerals.

From basic magnetic field theory (Grant and West, 1965) the magnetic field due either to a point (dipole) source, or a three-dimensional finite volume of magnetized material, decays in proportion to $r^3$ as the distance from the source increases, where r is the separation between the source and the magnetometer. The gradient of the field, on the other hand, decays in proportion to $r^4$. By means of Fourier transform, it is possible to show that a signal proportional to $r^4$ has more power at higher spatial frequencies relative to a signal proportional to $r^3$ (the field itself). Consequently, the magnetic gradient signal due to a given three-dimensional source is more limited in spatial extent, making discrete near-surface bodies appearing more pronounced compared to background readings.

Schlinger (1990) showed the effects of a dipole source (i.e., a uniformly magnetized buried sphere on the geomagnetic field at several latitudes). Figure 3 shows where the anomaly is positioned at 0 meters at a depth of 2 meters below ground surface with the measurement at 2 meters above the ground surface. The figure shows the response of both total magnetic field and vertical magnetic gradient. Both plotting methods are sufficient at discriminating bodies in the near surface, but the total field is only useful for determining deeply buried bodies.

The presentation of magnetic data is accomplished with a contour map, where the magnitude of the magnetic field or vertical magnetic gradient data is represented by isopleths. In general, the buried objects will appear as either a mono-polar or a dipolar anomalous response. For near-surface infrastructure mapping of steel objects, the values of the magnetic field can be several hundred to several thousand times higher than the background field. Linearly continuous anomalies observed along adjacently acquired data are interpreted as buried pipelines and singular anomalies that are not continuous are interpreted as discrete buried objects (tanks, drums, wells, or other metal that comprise the construction of tank farms).

**Figure 3. Magnetic Anomalies for a Sphere at (A) mid latitude, (B) Equator, and (C) near the north pole.**



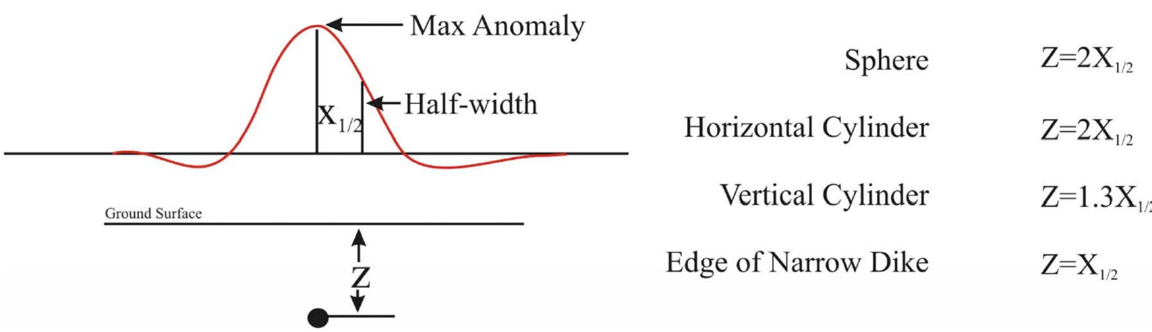

Source: Schlinger, C.M., 1990. Magnetometer and Gradiometer Surveys for Detection of Underground Storage Tanks. Bulletin of the Association of Engineering Geologists Vol. XXVII:37-50.

The magnetic field is measured with a magnetometer. Magnetometers permit rapid, non-contact surveys and were used outside the farm to locate buried ferrous objects and features. Portable (one person) field units can be used virtually anywhere that is accessible. Field portable magnetometers may be single- or dual-sensor. Dual-sensor magnetometers are called gradiometers and measure gradient of the magnetic field; single-sensor magnetometers measure total field.

Magnetic surveys are typically completed with two separate magnetometers. The first magnetometer is used as a base station to record the Earth's primary field and the diurnally changing secondary field. The second magnetometer is used as a rover to measure the spatial variation of the Earth's field. A residual magnetic field from local spatial variations is calculated by removing the temporal variation and, perhaps, the static value of the base station, from that of the rover.

The shortcoming with most magnetometers is that they only record the total magnetic field, F, and not the separate components of the vector field. This shortcoming can make the interpretation of magnetic anomalies difficult. Furthermore, the magnetic intensity or anomalies are highly variable in shape and amplitude. They are almost always asymmetrical, sometimes appear complex even from simple sources, and usually portray the combined magnetic effects of several sources (Breiner 1973). There are simplified depth estimation techniques based on graphical evaluation of data using the half-width rule. In magnetic fields, it can be shown for simple forms that the depth to the center of a buried object is related to the half-width of the measured anomaly. The half-width is the horizontal distance between the principal maximum (or minimum) of the anomaly (assumed to be over the center of the source) and the point where the value is exactly one-half the maximum value (see Figure 4, adapted from Breiner 1973). This rule is only valid for simple shaped forms such as a sphere, horizontal cylinder, vertical cylinder, and the edge of a narrow, nearly vertical dike.

**Figure 4. Depth Estimates for Magnetic Anomalies.**




Source: Breiner, S., 1973. Applications Manual for Portable Magnetometers. Geometrics, Inc. San Jose, California.

## 3.2 ELECTROMAGNETIC INDUCTION

Earth materials have the capacity to transmit electrical currents over a wide range depending on the material property of electrical conductivity. Electrical conductivity is a function of soil type, porosity, saturation, and dissolved salts. Electromagnetic induction identifies various earth materials by measuring their electrical characteristics and is used to identify buried infrastructure within the area where resistivity data are collected.

Electromagnetic induction methods use a transmitting coil and a receiving coil. The transmitting coil induces eddy currents in the Earth, which themselves generate magnetic fields that are affected by the earth materials within the excited zone. The receiving coil intercepts the field resulting in an output voltage that is proportional to the conductivity within the area. Moving these coils results in variations in conductivity that can be interpreted to find buried features or objects.

The transmitting coil frequency and electrical conductivity of the host material primarily determine the depth of investigation for EM techniques. Referred to as skin depth in the literature (Telford et al., 1990), it generally describes the decay of the EM field through a conductive medium. Formally, the skin depth (δ) is defined as the distance through which the field decays to e-1 (~37%) of its original amplitude:

Skin Depth: $\delta = \sqrt{\frac{2}{(\pi f)\mu\sigma}}$

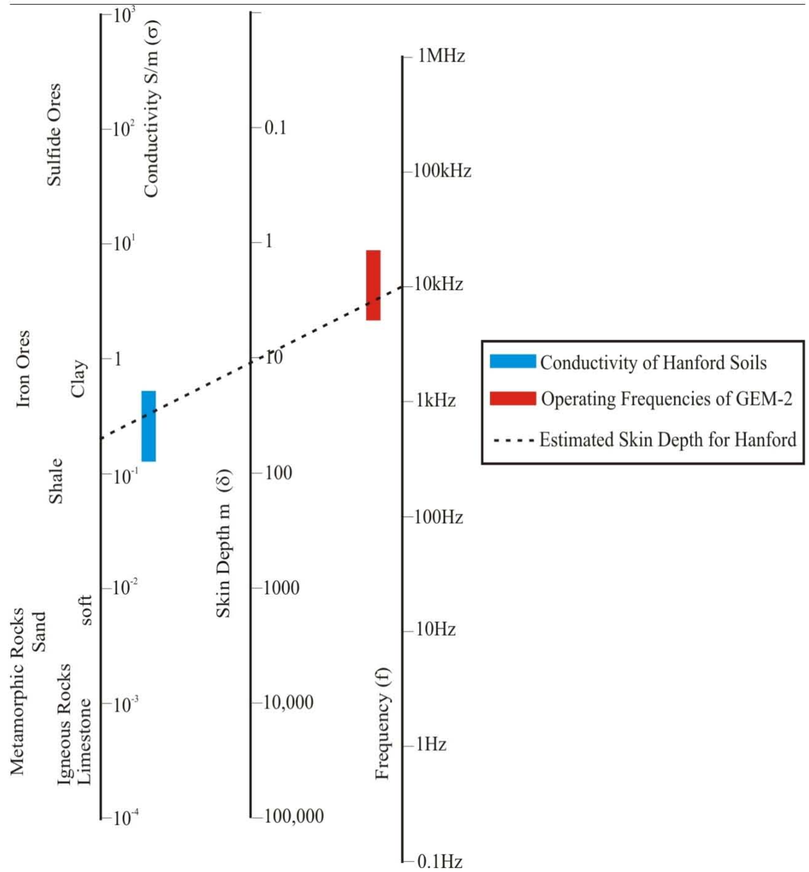
Where:

σ = electrical conductivity of the host material
μ = magnetic permeability
f = operating frequency of the instrument

Graphically, Won (1980) developed a nomogram, from which the skin depth may be determined from a given frequency. Figure 5 shows the nomogram and an example of skin depth for Hanford specific soils. For the 10 kHz frequency, it is expected that the skin depth is approximately 10 meters.

There are several advantages of using a broadband, multi-frequency EM sensor. Since conductivity and permeability of the host material cannot be manipulated, the skin depth can be changed by changing frequencies. In theory, scanning through a frequency window is equivalent to depth soundings, where the results from multiple frequencies can be presented to understand the layering of earth materials. However, in practice HGI has observed that a fixed object of high conductivity (such as a metal pipe) will appear in all frequencies, eliminating the possibility of depth-specific estimations for individual targets.

**Figure 5. Skin Depth Estimates for the GEM-2 at Hanford.**




Adapted from: Won, I.J., 1980. A wideband electromagnetic exploration method – Some theoretical and experimental results. Geophysics 45 (3):928-940.

# 4.0 METHODOLOGY

## 4.1 SURVEY AREA AND LOGISTICS

This section describes the equipment and methodology used to collect, manage, and process geophysical data around the TX-TY WMA. The basis for the survey coverage, equipment selection, methodology, data collection practices, functions and requirements and quality assurance guidelines are discussed in detail within RPP-PLAN-35244, *Work Plan for Surface Geophysical Exploration of the TX and TY Tank Farm and Surrounding Areas*.

A summary of the survey coverage area can be viewed in Figure 6. For this figure, G.O. Cart coverage is shown in yellow, investigation focus areas are shown as colored rectangles, and surrounding trenches, cribs, and tile field areas are shown as green polygons.

Data acquisition commenced on September 25, 2007, establishing a magnetic base station. The magnetic base station data were used to remove diurnal variations of the magnetic field from data acquired using the roving magnetometer attached to the G.O. Cart.

A combination of a Geometrics G-858G rover gradiometer and a G-856 base magnetometer provides magnetic data for this SGE project because each instrument satisfied job-specific requirements listed in RPP-PLAN-35244. The two instruments are commercially available and were designed to be used together to provide diurnally corrected total field (rover top sensor data normalized to base station data) information. The selected equipment has been used on all prior SGE style surveys (T farm; B, BX, and BY farms; and BC cribs) within the Hanford Site and is considered industry-standard equipment.

The gradiometer is easily adapted for use on the custom fabricated non-magnetic HGI G.O Cart (Figure 7). The separation between the two sensors and the data acquisition and storage console is increased using standard extension cables to cover the span between the trailer and the ATV. The gradiometer console contains a serial input and necessary firmware that is used to interface with and store GPS data. Interchangeable 12V DC gel cell batteries supply power to the gradiometer console located on the ATV just behind the operator. The gradiometer and base magnetometer operate independently, but the internal clocks for each instrument are synchronized before surveying. Both instruments record a time stamp for each data point so that post processing of diurnal corrections can be completed.

**Figure 6. G.O. Cart Coverage.**

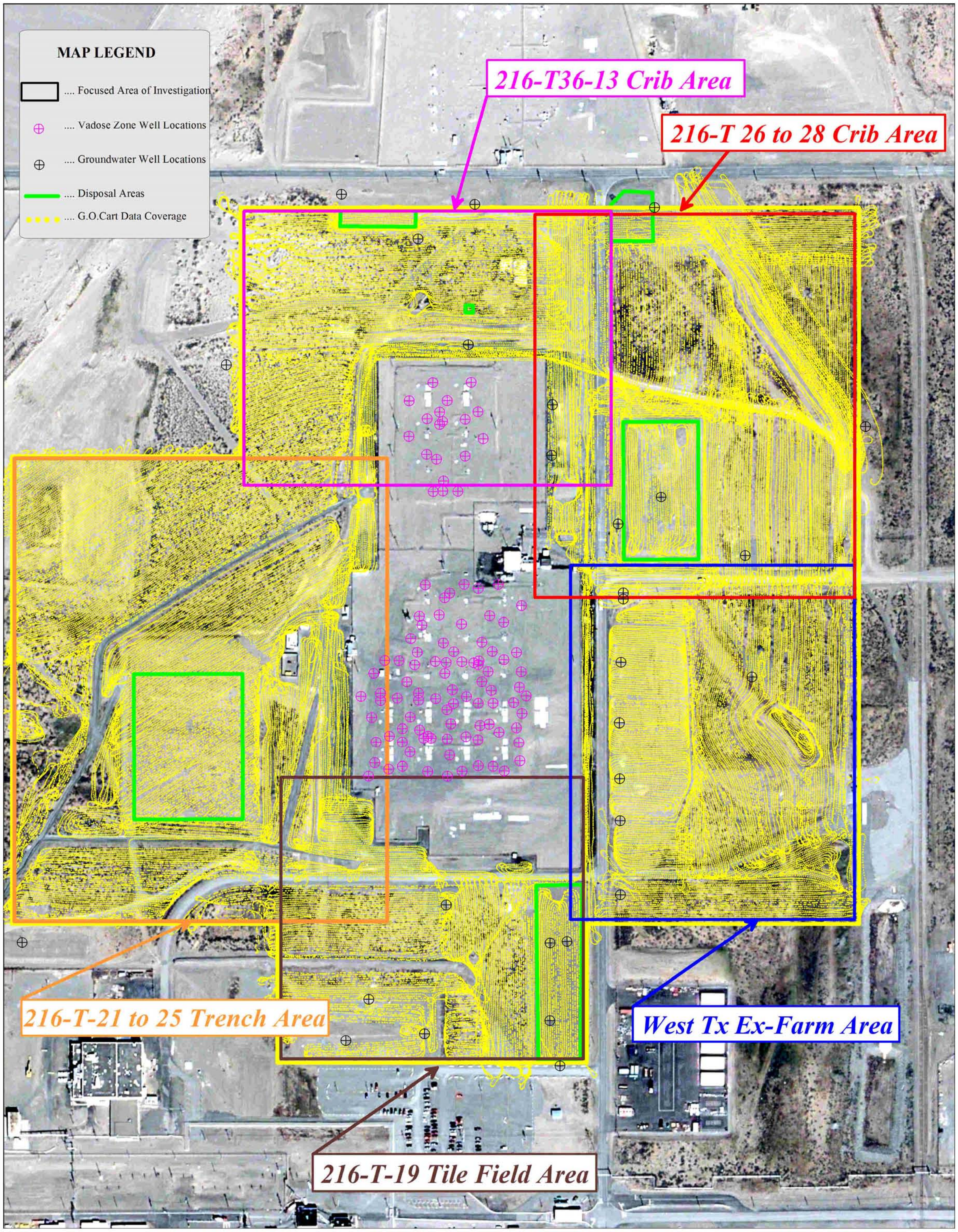
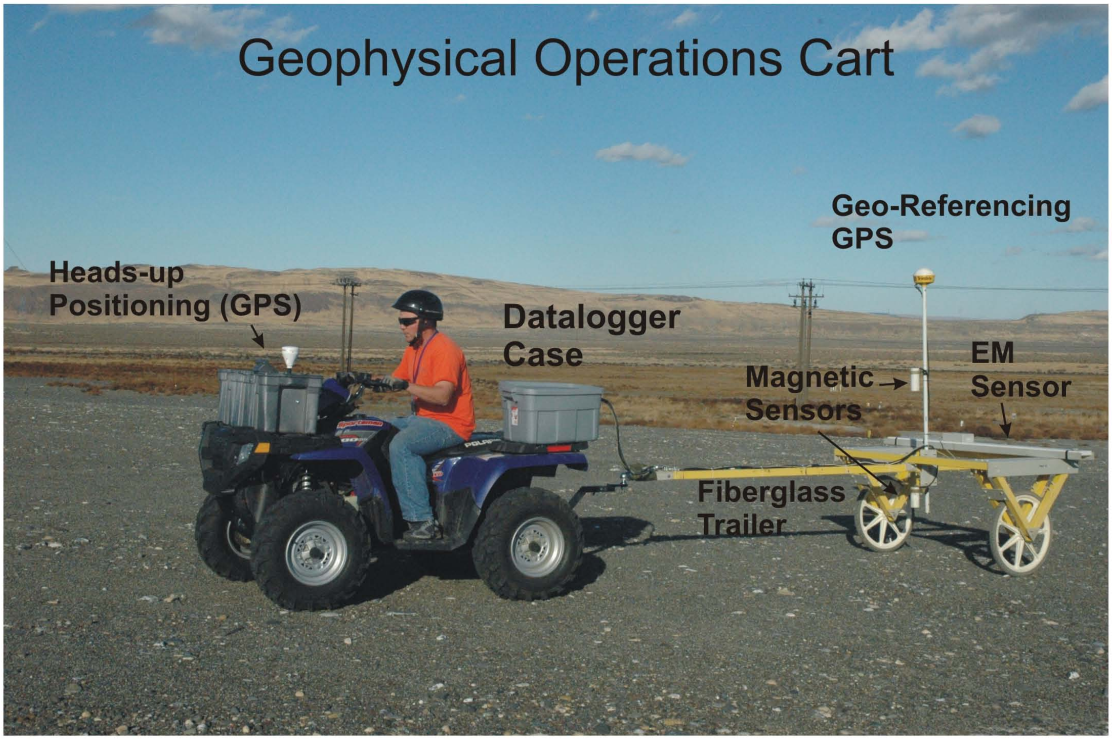


**Figure 7. Geophysical Operations Cart Photo.**




## 4.2 GEOPHYSICAL EQUIPMENT

Five different geophysical or surveying equipment types were deployed at the TX-TY WMA. The different geophysical instruments are described in the following sections.

### 4.2.1 Geophysical Operations Cart

The complexity of site characterization required information about multiple physical properties that could be combined to enhance characterization efforts. Recent technological advances in mobile computing and geophysical instrumentation have greatly improved surveying. The G.O. Cart™ provides the ability to simultaneously deploy multiple survey instruments.

### 4.2.2 Global Positioning Systems

A Trimble Ag-132 GPS was used to establish the physical location of magnetic and EM data. The accuracy of the system is based partly on the G.O. Cart™ speed and was within 6.6 feet (2 meters) for this survey.

### 4.2.3 Magnetometry

Two Geometrics, Inc. magnetometers were used to monitor variations within the Earth's magnetic field. A model G-856 proton procession magnetometer was used as a base station and a model G 858G cesium vapor magnetometer was used as a roving magnetic gradiometer. The G-858G was set up with two sensors oriented vertically, spaced one meter apart with the lowest sensor approximately 0.5 meters from the ground surface.

### 4.2.4 Electromagnetic Induction

EM data were collected using a Geophex, Ltd. GEM-2® unit. The GEM-2 is a broadband multi-frequency meter (from 300 Hz to 96 kHz) with bistatic transmitter and receiver coils. The coils have a separation of 1.6 meters. Based on survey design, three frequencies were selected for the survey: 5050Hz, 9990Hz and 20010Hz. HGI collected both in-phase and quadrature data for the electromagnetic signal. Typically, the in-phase data relates to magnetic susceptibility, and quadrature data relates to electrical conductivity. Each are a function of signal frequency, vertical distance of the coils to the ground, coil orientation (horizontal or vertical), and coil separation. The in-phase and quadrature data were subjected to an inversion algorithm provided by Geophex, Ltd. As part of the instrument download software. The inversion algorithm converted the measured quadrature data to electrical conductivity.

## 4.3 PROCESSING

### 4.3.1 Downloading, Parsing, Quality Control – Onsite

The rover and base magnetic data were downloaded to a field laptop computer using MagMap2000 software. The data were saved in binary format, with the instrument type, date stamp, and location as part of the naming structure. Table 1 lists the data files for the magnetic data and Table 2 lists the files for the EM data. The G.O. Cart™ survey was completed using a series of small grids that were designed to accommodate site logistics. A preliminary assessment of each survey grid was conducted onsite each day. Where unacceptable data was found, repeat data were collected. As a result, the EM and Mag grids vary slightly. Figure 7 shows the individual Mag grids, each grid number corresponds to the file record in Table 1. Figure 9 shows the individual EM grids, each grid number corresponds to the file record in Table 2.

**Table 1. Magnetic Data File Names, Acquisition Dates, and Data Count. (3 Sheets)**

| File Record | File Name | Date | Point Count |
|---|---|---|---|
| 1 | MAG_100107_B1_DAT | 01-Oct-07 | 18,070 |
| 2 | MAG_100307_A1_DAT | 03-Oct-07 | 64,995 |
| 3 | MAG_100307_B1_DAT | 03-Oct-07 | 32,062 |

**Table 1. Magnetic Data File Names, Acquisition Dates, and Data Count. (3 Sheets)**

| File Record | File Name | Date | Point Count |
|---|---|---|---|
| 4 | MAG_100407_A1_DAT | 04-Oct-07 | 41,558 |
| 5 | MAG_100407_B1_DAT | 04-Oct-07 | 11,640 |
| 6 | MAG_100407_C1_DAT | 04-Oct-07 | 25,364 |
| 7 | MAG_100907_A1_DAT | 09-Oct-07 | 26,860 |
| 8 | MAG_100907_B1_DAT | 09-Oct-07 | 24,245 |
| 9 | MAG_100907_C1_DAT | 09-Oct-07 | 16,038 |
| 10 | MAG_100907_D1_DAT | 09-Oct-07 | 15,899 |
| 11 | MAG_100907_E1_DAT | 09-Oct-07 | 11,120 |
| 12 | MAG_101007_A1_DAT | 10-Oct-07 | 41,703 |
| 13 | MAG_101007_B1_DAT | 10-Oct-07 | 24,999 |
| 14 | MAG_101007_C1_DAT | 10-Oct-07 | 47,409 |
| 15 | MAG_101107_A1_DAT | 11-Oct-07 | 13,919 |
| 16 | MAG_101107_B1_DAT | 11-Oct-07 | 11,462 |
| 17 | MAG_101107_C1_DAT | 11-Oct-07 | 34,329 |
| 18 | MAG_101107_D1_DAT | 11-Oct-07 | 48,367 |
| 19 | MAG_101107_E1_DAT | 11-Oct-07 | 31,698 |
| 20 | MAG_101107_F1_DAT | 11-Oct-07 | 14,679 |
| 21 | MAG_101207_A1_DAT | 12-Oct-07 | 35,351 |
| 22 | MAG_101207_B1_DAT | 12-Oct-07 | 31,509 |
| 23 | MAG_101207_B2_DAT | 12-Oct-07 | 38,756 |
| 24 | MAG_101207_C1_DAT | 12-Oct-07 | 42,698 |
| 25 | MAG_101207_D1_DAT | 12-Oct-07 | 38,728 |
| 26 | MAG_101307_A1_DAT | 13-Oct-07 | 42,723 |
| 27 | MAG_101307_A2_DAT | 13-Oct-07 | 42,144 |
| 28 | MAG_101307_B1_DAT | 13-Oct-07 | 33,718 |
| 29 | MAG_101307_C1_DAT | 13-Oct-07 | 14,809 |
| 30 | MAG_101307_D1_DAT | 13-Oct-07 | 18,378 |
| 31 | MAG_101307_E1_DAT | 13-Oct-07 | 3,620 |
| 32 | MAG_101507_A1_DAT | 15-Oct-07 | 37,839 |
| 33 | MAG_101507_B1_DAT | 15-Oct-07 | 62,466 |
| 34 | MAG_101507_C1_DAT | 15-Oct-07 | 9,930 |
| 35 | MAG_101607_A1_DAT | 16-Oct-07 | 55,868 |
| 36 | MAG_101607_B1_DAT | 16-Oct-07 | 39,169 |
| 37 | MAG_101607_C1_DAT | 16-Oct-07 | 63,817 |
| 38 | MAG_101607_D1_DAT | 16-Oct-07 | 43,398 |

**Table 1. Magnetic Data File Names, Acquisition Dates, and Data Count. (3 Sheets)**

| File Record | File Name | Date | Point Count |
|---|---|---|---|
| 39 | MAG_101707_A1_DAT | 17-Oct-07 | 27,667 |
| 40 | MAG_101707_A2_DAT | 17-Oct-07 | 38,042 |
| 41 | MAG_101707_B1_DAT | 17-Oct-07 | 38,716 |
| 42 | MAG_101707_C1_DAT | 17-Oct-07 | 59,427 |
| 43 | MAG_101707_D1_DAT | 17-Oct-07 | 27,868 |
| 44 | MAG_101807_A1_DAT | 18-Oct-07 | 62,009 |
| 45 | MAG_101807_B1_DAT | 18-Oct-07 | 39,389 |
| 46 | MAG_101807_C1_DAT | 18-Oct-07 | 37,108 |
| 47 | MAG_101807_D1_DAT | 18-Oct-07 | 35,296 |
| 48 | MAG_102207_A1_DAT | 22-Oct-07 | 62,709 |
| 49 | MAG_102207_B1_DAT | 22-Oct-07 | 48,497 |
| 50 | MAG_102207_C1_DAT | 22-Oct-07 | 56,840 |
| 51 | MAG_102207_D1_DAT | 22-Oct-07 | 16,385 |
| 52 | MAG_102207_E1_DAT | 22-Oct-07 | 4,948 |
| 53 | MAG_102307_A1_DAT | 23-Oct-07 | 39,669 |
| 54 | MAG_102307_B1_DAT | 23-Oct-07 | 46,668 |
| 55 | MAG_102307_C1_DAT | 23-Oct-07 | 11,566 |
| 56 | MAG_102307_D1_DAT | 23-Oct-07 | 16,978 |
| 57 | MAG_102407_A1_DAT | 24-Oct-07 | 10,356 |
| 58 | MAG_102407_B1_DAT | 24-Oct-07 | 38,549 |
| 59 | MAG_102407_C1_DAT | 24-Oct-07 | 32,819 |
| 60 | MAG_102407_D1_DAT | 24-Oct-07 | 8,760 |
| 61 | MAG_102507_A1_DAT | 25-Oct-07 | 9,568 |
| TOTAL | N/A | N/A | 1,981,171 |

**Figure 8. Individual Magnetics Survey Grids – Grid Numbers Correspond to Table 1 File Record.**

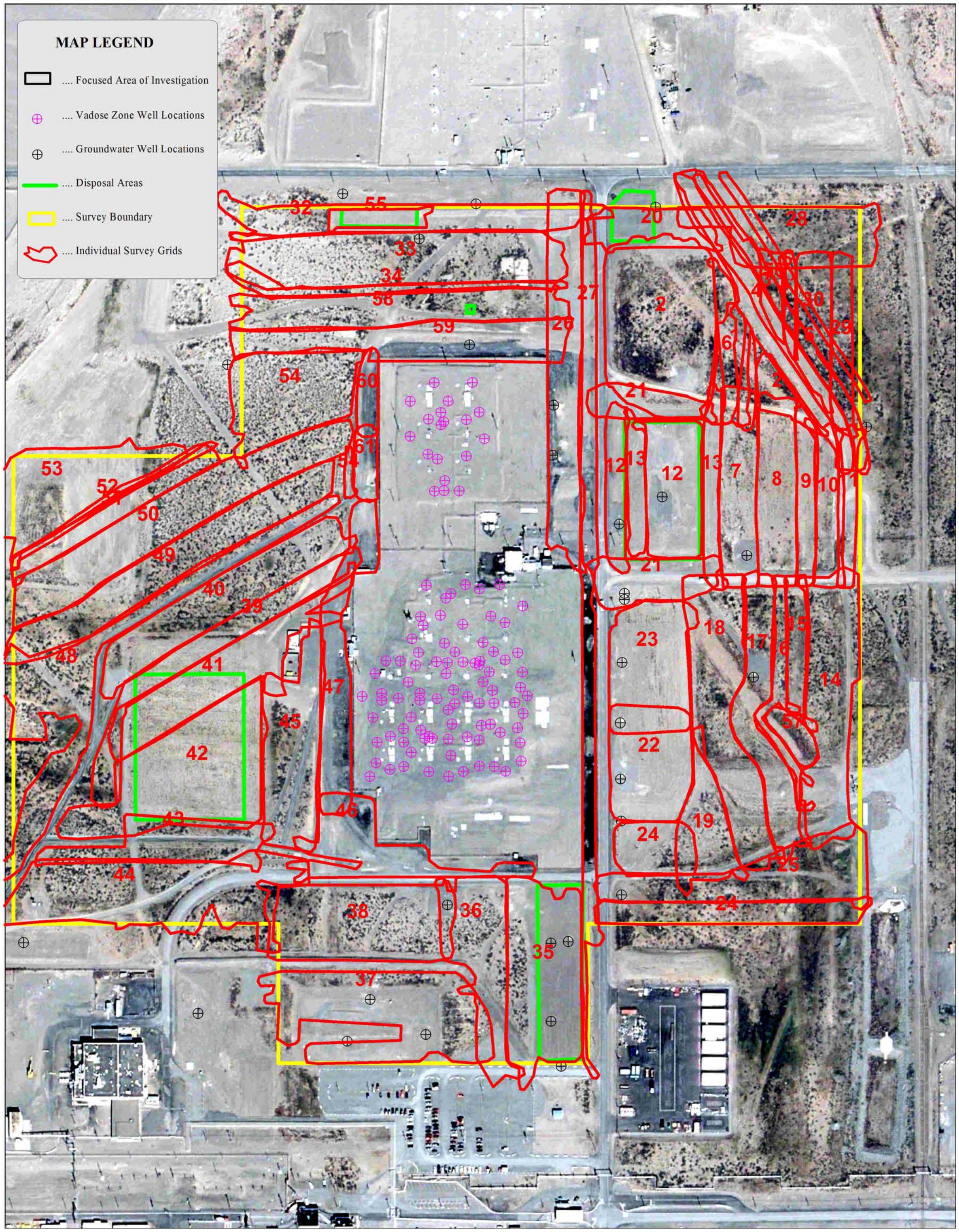


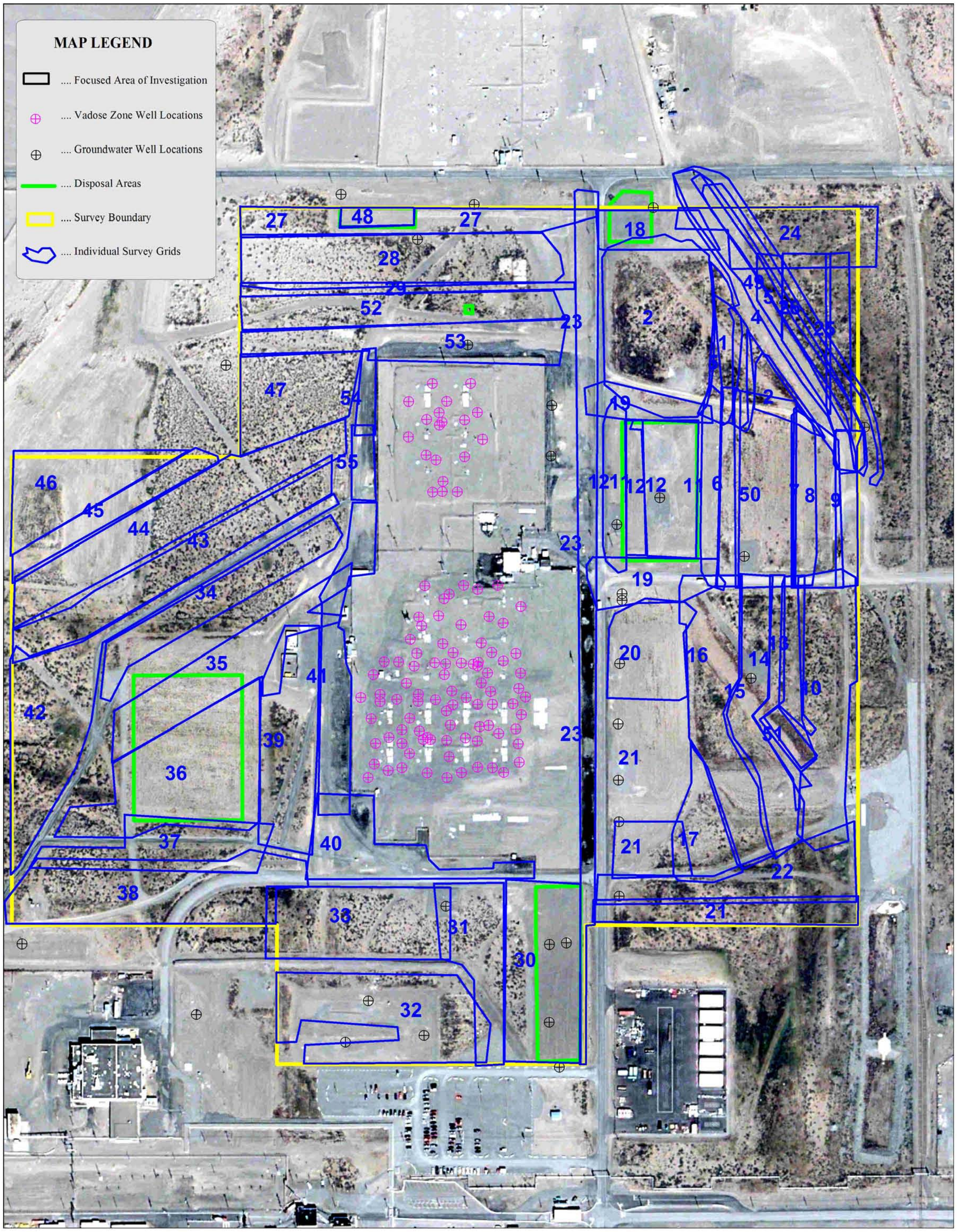
**Table 2. Electromagnetic Data File Names, Acquisition Dates, and Data Count. (2 Sheets)**

| File Record | File Name | Date | Point Count |
|---|---|---|---|
| 1 | EM_100107_B1_DAT | 1-Oct-2007 | 18,142 |
| 2 | EM_100307_A1_DAT | 3-Oct-2007 | 65,525 |
| 3 | EM_100307_B1_DAT | 3-Oct-2007 | 32,541 |
| 4 | EM_100407_A1_DAT | 4-Oct-2007 | 60,005 |
| 5 | EM_100407_B1_DAT | 4-Oct-2007 | 31,439 |
| 6 | EM_100907_A1_DAT | 9-Oct-2007 | 16,183 |
| 7 | EM_100907_B1_DAT | 9-Oct-2007 | 16,099 |
| 8 | EM_100907_C1_DAT | 9-Oct-2007 | 33,694 |
| 9 | EM_100907_D1_DAT | 9-Oct-2007 | 11,581 |
| 10 | EM_101007_A1_DAT | 10-Oct-2007 | 57,383 |
| 11 | EM_101007_B1_DAT | 10-Oct-2007 | 25,190 |
| 12 | EM_101007_C1_DAT | 10-Oct-2007 | 41,880 |
| 13 | EM_101107_A1_DAT | 11-Oct-2007 | 18,179 |
| 14 | EM_101107_B1_DAT | 11-Oct-2007 | 11,859 |
| 15 | EM_101107_C1_DAT | 11-Oct-2007 | 34,420 |
| 16 | EM_101107_D1_DAT | 11-Oct-2007 | 48,560 |
| 17 | EM_101107_E1_DAT | 11-Oct-2007 | 31,780 |
| 18 | EM_101107_F1_DAT | 11-Oct-2007 | 14,670 |
| 19 | EM_101207_A1_DAT | 12-Oct-2007 | 36,751 |
| 20 | EM_101207_B1_DAT | 12-Oct-2007 | 35,675 |
| 21 | EM_101207_B2_DAT | 12-Oct-2007 | 34,875 |
| 22 | EM_101207_C1_DAT | 12-Oct-2007 | 45,098 |
| 23 | EM_101207_D1_DAT | 12-Oct-2007 | 38,528 |
| 24 | EM_101307_A1_DAT | 13-Oct-2007 | 46,131 |
| 25 | EM_101307_A2_DAT | 13-Oct-2007 | 40,410 |
| 26 | EM_101307_B1_DAT | 13-Oct-2007 | 34,520 |
| 27 | EM_101307_C1_DAT | 13-Oct-2007 | 15,310 |
| 28 | EM_101307_D1_DAT | 13-Oct-2007 | 24,601 |
| 29 | EM_101507_A1_DAT | 15-Oct-2007 | 39,379 |
| 30 | EM_101507_B1_DAT | 15-Oct-2007 | 62,551 |
| 31 | EM_101507_C1_DAT | 15-Oct-2007 | 9,940 |
| 32 | EM_101607_A1_DAT | 16-Oct-2007 | 57,510 |
| 33 | EM_101607_B1_DAT | 16-Oct-2007 | 39,940 |
| 34 | EM_101607_C1_DAT | 16-Oct-2007 | 64,620 |
| 35 | EM_101607_D1_DAT | 16-Oct-2007 | 44,681 |

**Table 2. Electromagnetic Data File Names, Acquisition Dates, and Data Count. (2 Sheets)**

| File Record | File Name | Date | Point Count |
|---|---|---|---|
| 36 | EM_101707_A1_DAT | 17-Oct-2007 | 30,612 |
| 37 | EM_101707_A2_DAT | 17-Oct-2007 | 36,957 |
| 38 | EM_101707_B1_DAT | 17-Oct-2007 | 40,980 |
| 39 | EM_101707_C1_DAT | 17-Oct-2007 | 60,651 |
| 40 | EM_101707_D1_DAT | 17-Oct-2007 | 28,341 |
| 41 | EM_101807_A1_DAT | 18-Oct-2007 | 63,460 |
| 42 | EM_101807_B1_DAT | 18-Oct-2007 | 40,360 |
| 43 | EM_101807_C1_DAT | 18-Oct-2007 | 39,170 |
| 44 | EM_101807_D1_DAT | 18-Oct-2007 | 36,031 |
| 45 | EM_102207_A1_DAT | 22-Oct-2007 | 64,670 |
| 46 | EM_102207_B1_DAT | 22-Oct-2007 | 49,691 |
| 47 | EM_102207_C1_DAT | 22-Oct-2007 | 59,920 |
| 48 | EM_102207_D1_DAT | 22-Oct-2007 | 23,007 |
| 49 | EM_102307_A1_DAT | 23-Oct-2007 | 40,580 |
| 50 | EM_102307_B1_DAT | 23-Oct-2007 | 47,419 |
| 51 | EM_102307_C1_DAT | 23-Oct-2007 | 12,020 |
| 52 | EM_102307_D1_DAT | 23-Oct-2007 | 16,901 |
| 53 | EM_102307_E1_DAT | 23-Oct-2007 | 35,109 |
| 54 | EM_102407_A1_DAT | 24-Oct-2007 | 17,920 |
| 55 | EM_102407_B1_DAT | 24-Oct-2007 | 39,365 |
| 56 | EM_102407_C1_DAT | 24-Oct-2007 | 33,640 |
| 57 | EM_102407_D1_DAT | 24-Oct-2007 | 9,040 |
| 58 | EM_102507_A1_DAT | 25-Oct-2007 | 10,821 |
| TOTAL | N/A | N/A | 2,076,315 |

**Figure 9. Individual Electromagnetics Survey Grids.**



Onsite quality control included plotting the GPS locations of the G.O. Cart™ onto the working TX-TY WMA base map. The plotting ensured that spatial coverage for the day met expectations, and off-normal situations (e.g., full data logger or dead battery) did not result in the loss of data. All binary files were uploaded daily for processing and evaluation of data quality statistics (i.e., low noise, sufficient data density, low drop-out rate). Onsite quality control also included plotting the magnetic field versus time to observe the diurnal changes in the base station data.

### 4.3.2 Magnetics Processing and Plotting

Due to the quantity of data, the majority of magnetics data processing was performed in a Microsoft Access database. The process included the following steps:

1. Removal of diurnal fluctuations was completed using the manufacturer supplied MagMap2000 software (Geometrics, Inc).

2. Coordinate conversion from UTM to WA State Plane (meters) using Corpscon Software (US Army Corps of Engineers).

3. Assembling the master data base table from the individual data files listed in Table 1, using Microsoft Access.

4. Removing data spikes from the individual data files, using Microsoft Access.

5. Removing data points where the G.O. Cart™ was stationary, using Microsoft Access.

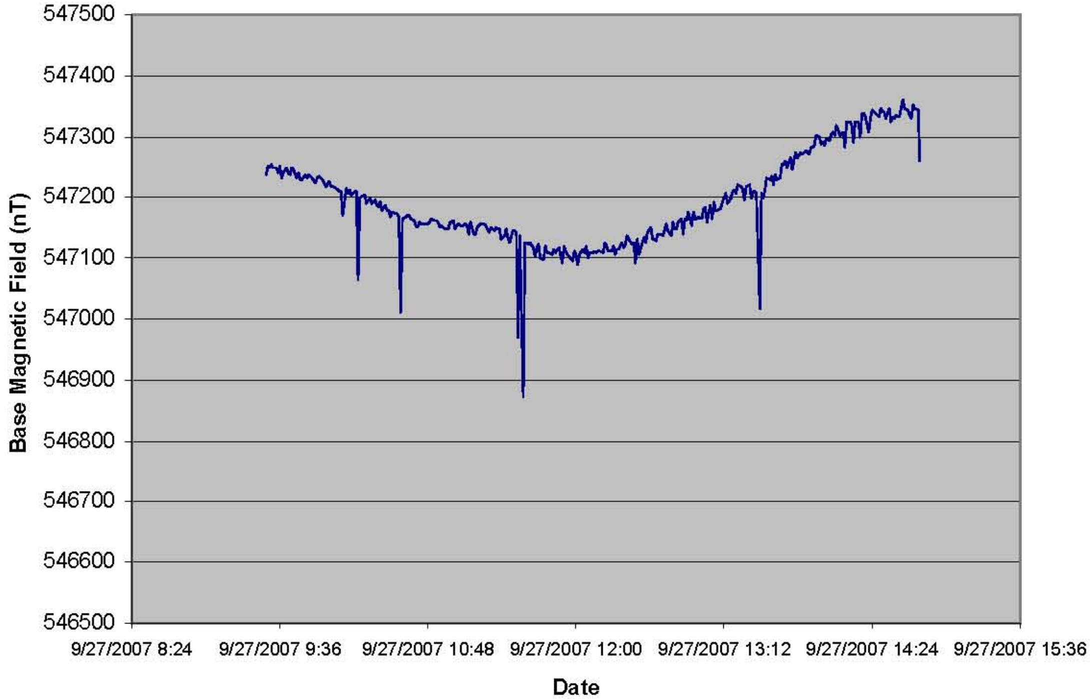
6. Correcting data for variations in heading to reduce the effect preferential alignment of the magnetic sensors with respect to the Earth's magnetic field, using a combination of Microsoft Excel and Access.

7. Applying a 24 point smoothing filter to reduce high frequency chatter or noise, using Microsoft Access.

8. Visualization of results using Surfer software (Golden Software, Inc.)

**4.3.2.1. Diurnal Correction.** After downloading the data, the MagMap2000 software was used to make diurnal corrections. The diurnal correction was applied by subtracting the coincident time readings of the base station from the rover magnetic data. Subtracting the diurnal field from the total field resulted in a relative magnetic field for both the upper and lower magnetic sensors. Figure 7 shows the results of the diurnal magnetic field for September 27, 2008. Data spikes (Figure 7) which are often caused by close proximity vehicles or personnel checking on the instrument, are removed prior to completing diurnal correction.

**Figure 10. Magnetic Base Station Data.**




**4.3.2.2. Coordinate Conversion.** After diurnal corrections to the data, the GPS coordinate data are converted from a Universal Transverse Mercator (UTM) to State Plane coordinate system using Corpscon V.6 Software (Army Corps of Engineers). GPS data were recorded every second and magnetic data were recorded five times per second, therefore the resulting GPS coordinate point for each magnetic reading was linearly interpolated within the magnetometers data acquisition system.

**4.3.2.3. Assembling Master Table.** After coordinate conversion, the data from the individual survey files are combined within a single Microsoft Access data table. Data are copied from an Excel sheet and pasted within a single Access table referred to as the "Master" table. The number of data points for each data file is checked against the Access table to verify the copy process.

**4.3.2.4. Spike Removal.** After assembling the master table, erroneous large magnitude data spikes are removed. The total field magnetic data were typically around 54,000 nanoTeslas before diurnal corrections and ranged between –1,500 and 1,500 after diurnal corrections depending on items buried in the ground. A typical data spike had a value outside the range of –2,000 to 2,000 nanoTeslas.

**4.3.2.5. Stationary Point Removal.** After removal of data spikes, stations where the magnetometer was stationary are located and subsequently removed. A point is considered stationary if the distance between two sequential data records was less than 0.13 feet (0.04 meters).

**4.3.2.6. Heading Correction.** After removing stationary data points, the heading error was removed. Heading error in the magnetic data results from the preferential alignment of the magnetic sensors with the Earth's magnetic field. Breiner (1973) discusses the heading error problem more thoroughly. Heading errors cause anomalous readings unrelated to any response from buried metallic debris. The error associated with heading was calculated from the magnetic data collected in eight distinct directions. Data were collected every 45 degrees from a northerly heading. A curve was fit for the direction of travel versus field strength for each sensor (Figures 11 and 12), which was subtracted from the data.

**Figure 11. Heading Error Associated with Magnetometer Readings for the Bottom Sensor.**

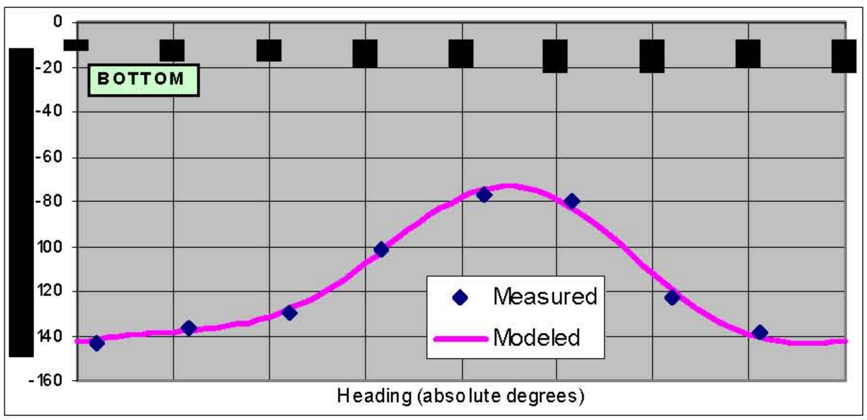
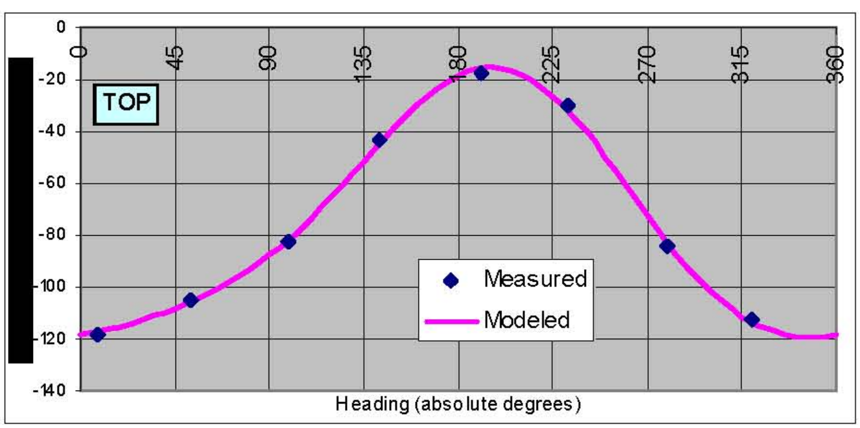



**Figure 12. Heading Error Associated with Magnetometer Readings for the Top Sensor.**



**4.3.2.7. Data filtering.** The last step in the processing regime involves filtering the data to smooth high frequency noise. A 24-point smoothing filter was applied to each day separately to avoid overlap between days. Figure 13 shows graph of the smoothing filter along with the associated coefficients. Figure 14 shows an example of raw data alongside the filtered data for the same time period.

**Figure 13. Smoothing filter Used for Smoothing Magnetic Data.**

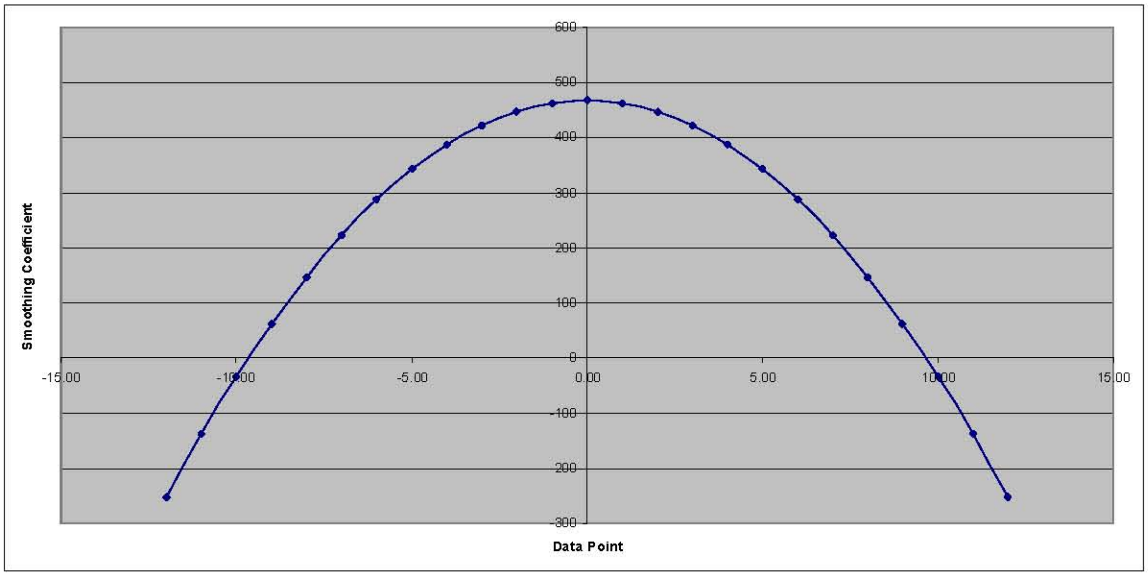
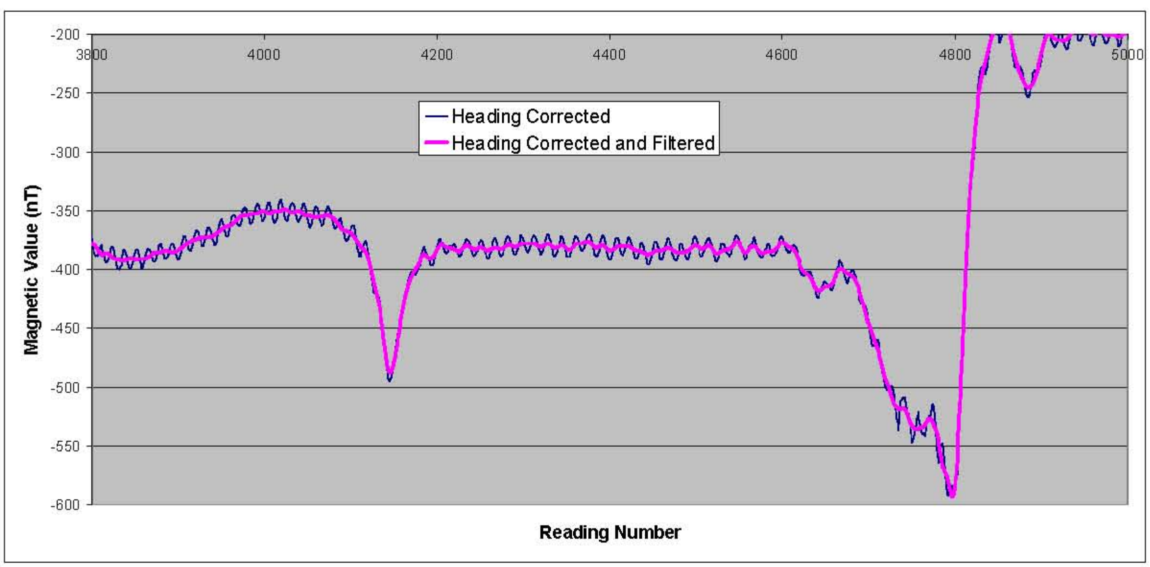



**Figure 14. Example of Raw and Filtered Magnetic Data.**



**4.3.2.8. IGRF Correction.** It should be noted that the International Geomagnetic Reference Field was not subtracted from the magnetic data. The International Geomagnetic Reference Field allows the removal of large scale trends present in magnetic data that covers large areas.

**4.3.2.9. Data Plotting.** The files were gridded in Surfer V.8 Software (Golden Software, Inc) using a spatial interpolation algorithm (krigging or triangulation). The gridding and interpolation allowed a contour plot of data to be placed over the TX-TY farm base map and interpretation of linear or discrete objects. Digital CAD maps for the TX-TY farm area were obtained from CEES and CHG which included subsurface and above ground infrastructure. The digital map files are considered reference purposes only and not considered a direct representation of subsurface conditions. In addition, the location of visible infrastructure that were not reported on the digital CAD maps were recorded using a GPS and added to the digital map file. The infrastructure from the infrastructure drawings and field observations are divided into five groups that are expected to have a different impact on the resistivity data. Infrastructure groups include the following:

1. Subsurface Infrastructure: includes any infrastructure below the ground surface such as buried pipes, electrical lines, conduits, monitoring wells, or continuous subsurface infrastructure.

2. Above ground infrastructure: includes any infrastructure on top of the ground surface such as vapor extraction pipelines, buildings, concrete pads (that contain grounded rebar or remesh), extraction well platforms, etc.

3. Overhead infrastructure: includes any overhead utilities supported by poles or structures such as over head power lines, overhead steam pipelines, etc.

4. Roads: includes both paved and unpaved (dirt or gravel) roads.

5. Waste disposal areas: includes all areas that received liquid, solid or mixed waste whether intentional or unintentional.

The large coverage area makes presentation of results on one plot challenging. Therefore, the G.O. Cart™ survey area was divided into five focus areas that were divided according to investigation area and plotting logistics. The focus areas can be viewed on Figure 6. Gridding and plotting parameters are the same for the focus areas and the complete survey area.

### 4.3.3 Electromagnetic Processing and Plotting

Electromagnetic data processing was similar to magnetic processing. Processing occurred in discrete steps, within a Microsoft Access database, so that all data from a previous step could be recovered or viewed. The process included the following steps:

1. Coordinate conversion from UTM to WA State Plane (meters) using Corpscon Software (US Army Corps of Engineers).

2. Assembling the master data base table from the individual data files listed in Table 2, using Microsoft Access.

3. Removing data spikes from the individual data files, using Microsoft Access.

4. Normalization of data for each individual data collection file to correct for instrument drift that occurs each time the data acquisition system is restarted.

5. Visualization of results using Surfer software (Golden Software, Inc.)

**4.3.3.1. Coordinate Conversion.** The first step in processing was to convert the GPS coordinate data from a Universal Transverse Mercator (UTM) to State Plane coordinate system using Corpscon V.6 Software (Army Corps of Engineers). Since electromagnetic data were recorded at a higher sampling rate than the GPS data, the resulting GPS coordinate point for each electromagnetic data reading was linearly interpolated within the electromagnetic data acquisition system.

**4.3.3.2. Assembling Master Table.** After coordinate conversion, the data from the individual survey files are combined within a single Microsoft Access data table. Data are copied from an Excel sheet and pasted within a single Access table referred to as the "Master" table. The number of data points for each data file is checked against the Access table to verify the copy process.

**4.3.3.3. Spike Removal.** After assembling the master table, erroneous large magnitude data spikes are removed in a similar process that was performed with the magnetic data. The 9990Hz frequency was used as a reference frequency for the spike removal of all three frequencies. The majority of the conductivity data ranged between 0 and 100 mS/m and data spikes beyond 100 mS/m were removed. The bulk of the In-phase data population ranged between -2000 and 5000 ppm and data spikes were typically coincident with data spikes that were rejected for the conductivity data.

**4.3.3.4. Data Normalization.** After inversion, the data were shifted for the day-to-day changes called drift. The day-to-day changes were calculated from a coincident data collection run at the beginning of each collection day that was performed at a calibration site. Slight differences in the daily data records occurred due to environmental or instrument setup changes. Calibration data were acquired for one to five minutes, while stationary, after an instrument warm up period of no less than 15 minutes. The calibration data record was compared to the mean data value for each data file and from that of an offset value from the previous data file was calculated.

**4.3.3.5. Data Plotting.** Data plotting was performed in the same process listed above for Magnetics data.

# 5.0 QUALITY ASSURANCE

Data quality is controlled through implementation of the Quality Assurance Plan for Surface Geophysical Exploration Projects (CEES-0333) along with the Software Management Plan for Surface Geophysical Exploration Projects (CEES-0338). The quality assurance plan describes how Columbia Energy & Environmental Services, Inc. (Columbia Energy) and HGI will perform SGE using a graded approach that conforms to applicable requirements from Columbia Energy quality assurance procedures. The Columbia Energy procedures implement the requirements of Quality Assurance Requirements for Nuclear Facility Applications (ASME NQA-1) and Quality Assurance (DOE O 414.1C).

## 5.1 CALIBRATION AND MAINTENANCE OF EQUIPMENT AND INSTRUMENTS

Calibration and maintenance of equipment used for data collection is addressed in the Surface Geophysical Exploration System Design Description (CEES-0360). Where periodic calibration and/or maintenance of instruments used to collect quality affecting data is recommended those instruments shall be current on calibration at the time the instrument is used for data collection and the calibration certificate shall be maintained in the project files. Requirement of calibration records is discussed in detail within RPP-PLAN-35244-Rev-0 "Work Plan for Surface Geophysical Exploration of the TX and TY Tank Farm and Surrounding Areas"

## 5.2 FIELD LOGS

Field notes will be used to document the specific instruments used. Electronic logs will be utilized to provide traceable documentation for each data set collected. Information to be recorded in the electronic field log shall include date, instrument identification, operator, and applicable settings for each data set collected. All instruments shall have current calibration certificates and documentation shall be maintained in the project files. Instrument calibration frequency and calibration tests performed in the field are documented in the system design description (CEES-0360). A copy of field logs can be viewed in Appendix B.

# 6.0 ANALYSIS, RESULTS AND INTERPRETATION

This section contains figures created from the magnetic and electromagnetic surveying effort. These figures and the results within are discussed in the subsequent sections. Engineering drawings of the results are shown in Appendix A.

## 6.1 MAGNETIC GRADIOMETRY

### 6.1.1 Total Magnetic Field

The magnetic total field reveals some ferrous materials most noticeably over the western trenches, eastern cribs, and between the eastern TX farm fence and Camden Road. The majority of these features correlate with surface concrete & steel trench markers, metallic crib infrastructure, and subsurface transfer lines that connect T Farm to TX farm. Several other linear features appear within the survey area and are exhibited by the red and blue color contours. Background is represented by yellow. The series of color contour result maps are designed to allow direct interpretation. A more detailed view of each focus area shown in Figure 3 is presented in Appendix A.

NOTE: The color scale used for the total field is specifically designed to distinguish subsurface features of interest that may influence resistivity results for the specific survey area. It is therefore not consistent with color scales used on previous magnetic surveys conducted on the Hanford site.

Figure 15 shows the results for the total magnetic field with infrastructure layers from available infrastructure drawings. Localized monopolar features appear as an extreme positive response in the total magnetic field. Ferrous metallic objects that extend deeply into the subsurface account for many of these responses, where one pole is near the surface and the other pole is buried deeply within the subsurface. For infrastructure mapping, these responses usually correlate to well casings.

In order to determine the possible impact of the detected utilities, it is necessary to correlate the features to known infrastructure. Figure 16 shows the results for the total magnetic field with interpretation of magnetic features that match infrastructure drawings within ±2.5 meters (bold black line).

**Figure 15. Total Magnetic Field shown with Infrastructure Drawings.**

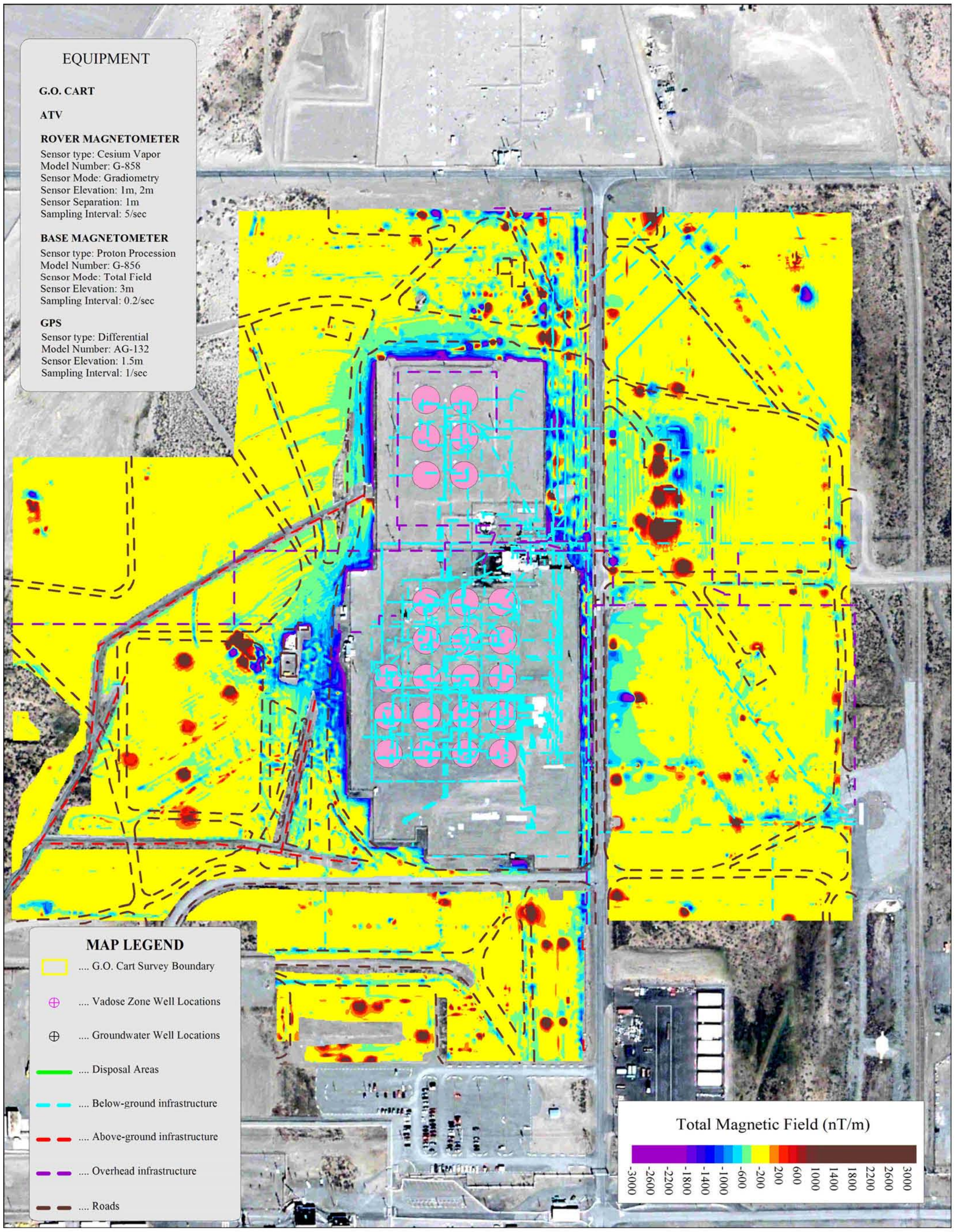


**Figure 16. Total Magnetic Field for Showing Features That Correlate with Infrastructure Drawings.**

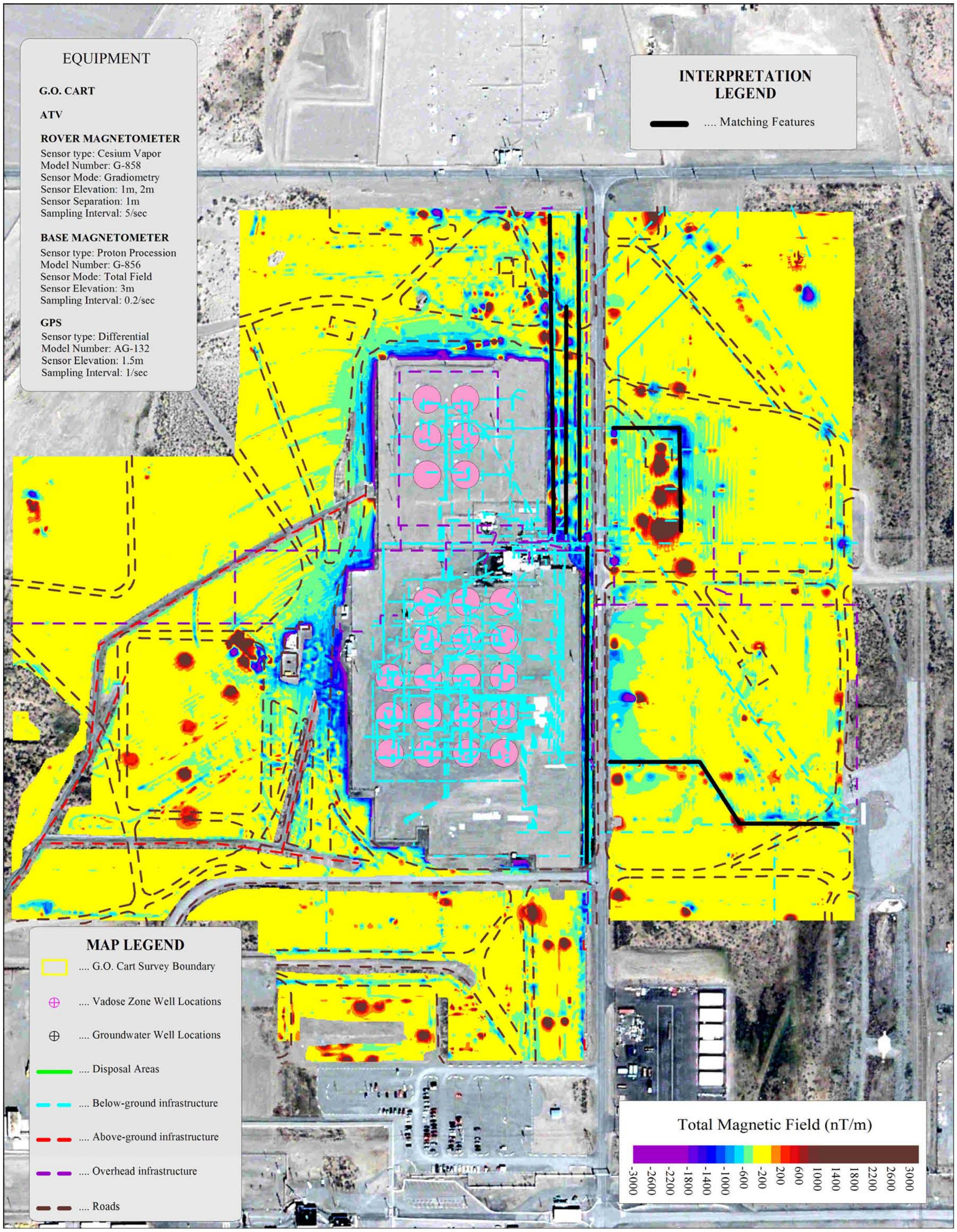


Figure 17 shows the remaining magnetics features that do not correlate with infrastructure drawings within ±2.5 meters (bold black line).

**Figure 17. Total Magnetic Field Showing Interpreted Features that Do Not Correlate with Infrastructure Drawing.**

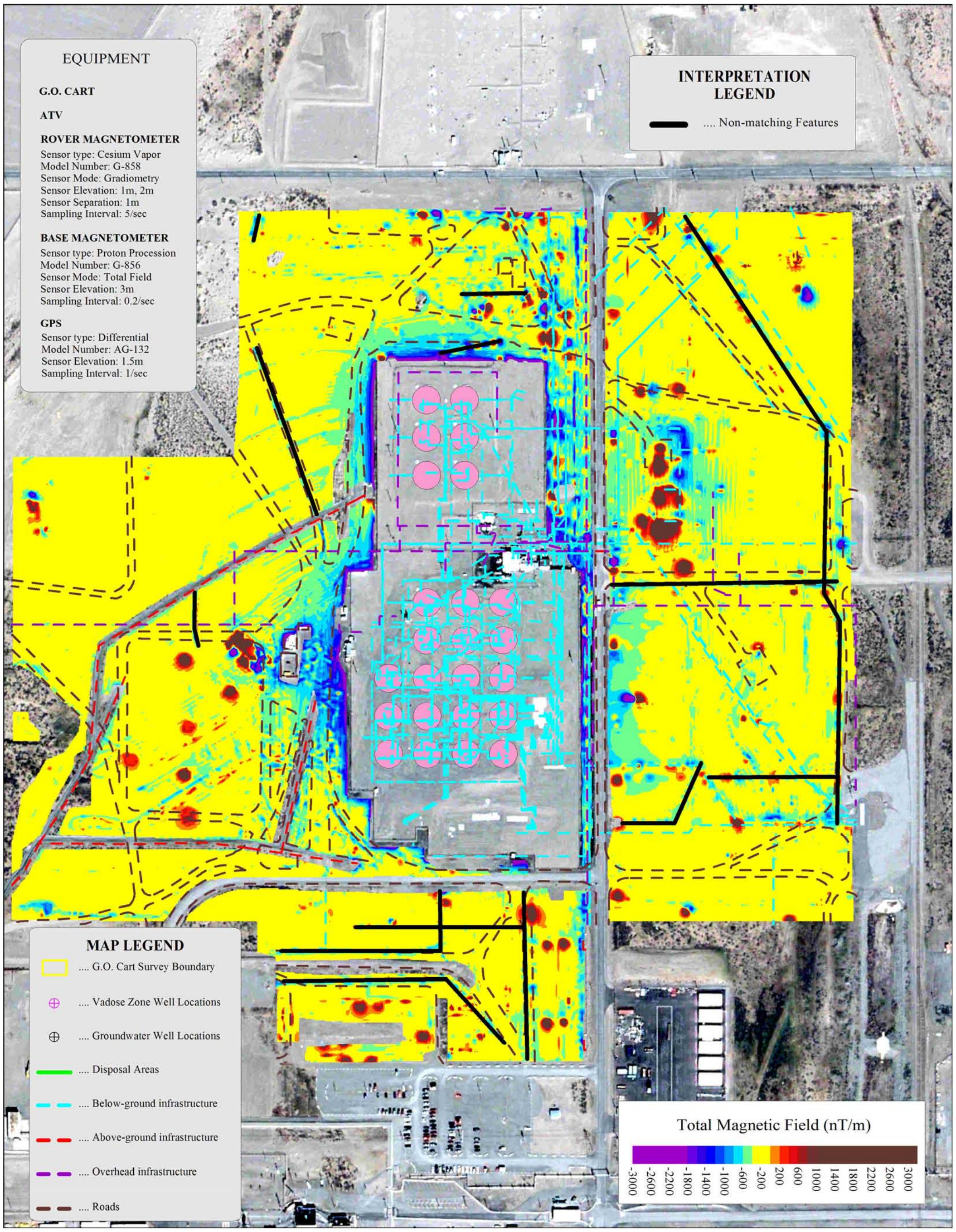
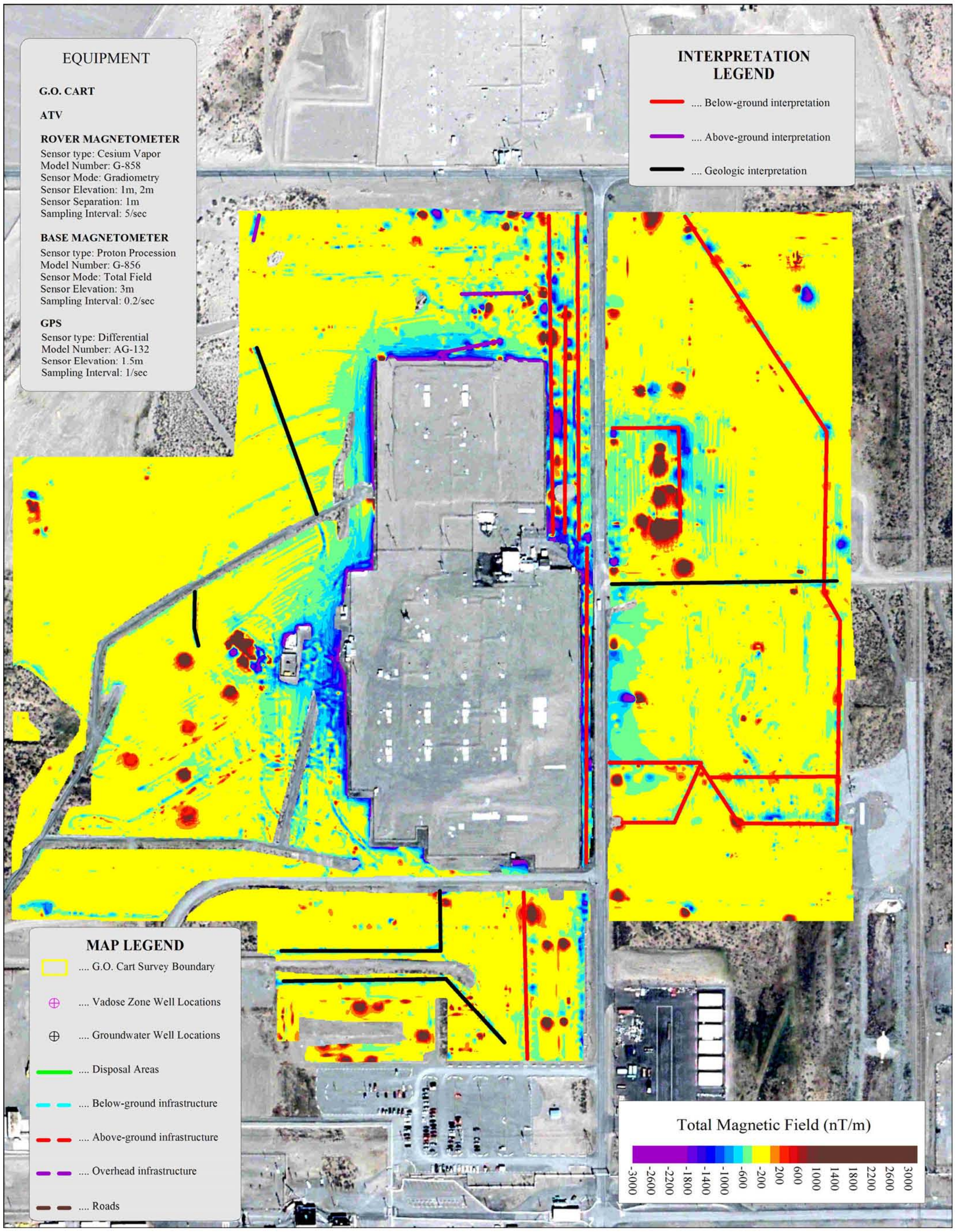


**Figure 18. Total Magnetic Field Showing Interpreted Features Grouped by Classification Type.**



Interpreted Mag features were then classified into three interpretation groups: interpreted above ground features, interpreted below ground features, and interpreted geologic features.

- Above ground features include overhead electric lines, overhead steam lines, transfer or vapor extraction lines that lay on the ground surface, concrete pads or structures, disposal area markers, and fences.
- Below Ground Features include underground utilities, pipes, conduits, an wells.
- Geologic Features include changes in soil chemistry, moisture content or mineral type that may be caused by disposal volumes, dirt roads that consist of a different geologic medium or areas that were disturbed due to excavation.

Figure 18 shows a summary of interpreted Mag features and the associated interpretation grouping as discussed in the paragraph above.

### 6.1.2 Vertical Magnetic Gradient

The vertical magnetic gradient is the difference between the magnetic field of the bottom sensor and the top sensor, divided by the separation distance of 3.3 feet (1 meter). This calculation provides a tool for mapping near-surface objects. Features closer to the surface (e.g., pipes) stand out prominently compared to deep objects (e.g., wells). Several linear anomalies appear in the data that indicate the presence of subsurface infrastructure that will likely influence resistivity surveying results.

The same series of plots that correlate Mag features to infrastructure drawings are shown for the vertical magnetic gradient. The vertical magnetic gradient reveals some shallow ferrous materials most noticeably between the eastern TX farm fence and Camden Road, and west of TY farm. The detected features east of TX farm correlate well with transfer lines between T farm and TX farm. The scattered features west of TY farm correlate with surface debris, gravel along the dirt roads that are likely to have a different geologic composition, and fences. Additional features over the western trenches correlate with concrete/steel trench markers and the features over the eastern cribs correlate metallic crib infrastructure. Several other linear features appear within the survey area and are exhibited by the red and blue color contours. Background is represented by yellow. The series of color contour result maps are designed to allow direct interpretation. A more detailed view of each focus area shown in Figure 6 is presented in Appendix A.

NOTE: The color scale used for the vertical gradient is specifically designed to distinguish subsurface features of interest that may influence resistivity results for the specific survey area. It is therefore not consistent with color scales used on previous Magnetic surveys conducted on the Hanford site.

Figure 19 shows the results for the vertical magnetic gradient with infrastructure layers from available infrastructure drawings. Figure 20 shows the interpreted results for the vertical magnetic gradient survey that correlate with infrastructure drawings within +/- 2.5 meters (bold black line). Figure 21 shows the remaining Mag features that do not correlate with infrastructure drawings within +/- 2.5 meters (bold black line). Interpreted vertical gradient features were then classified into the same interpretation groups as described above for the magnetic total field: interpreted above ground features, interpreted below ground features, and interpreted geologic features. Figure 22 shows a summary of interpreted Vertical Gradient features and the associated interpretation grouping as discussed in the Total Magnetic Field section above.

**Figure 19. Vertical Magnetic Gradient Shown With Infrastructure from Drawings.**

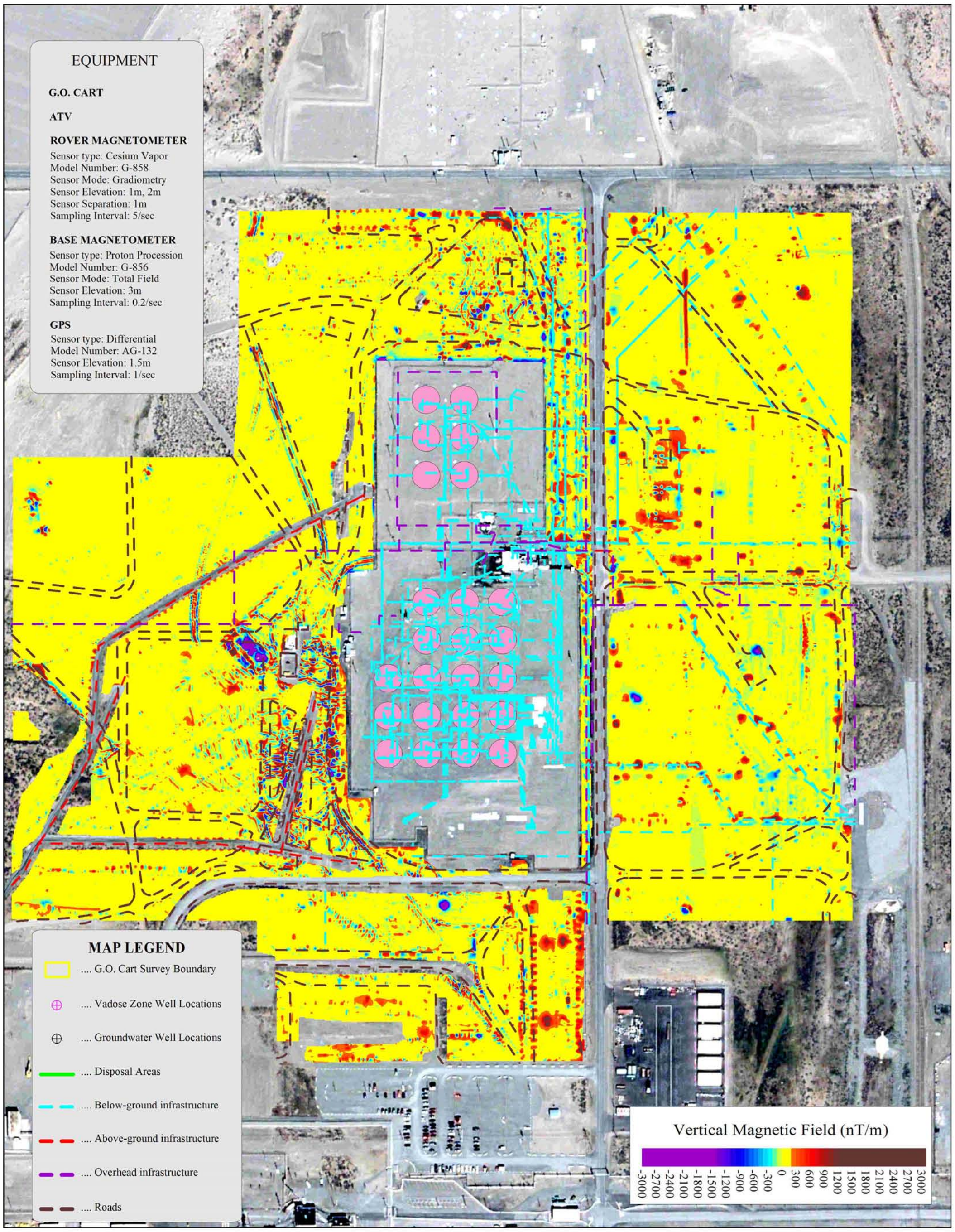


**Figure 20. Vertical Magnetic Gradient Showing Features That Correlate with Drawings.**

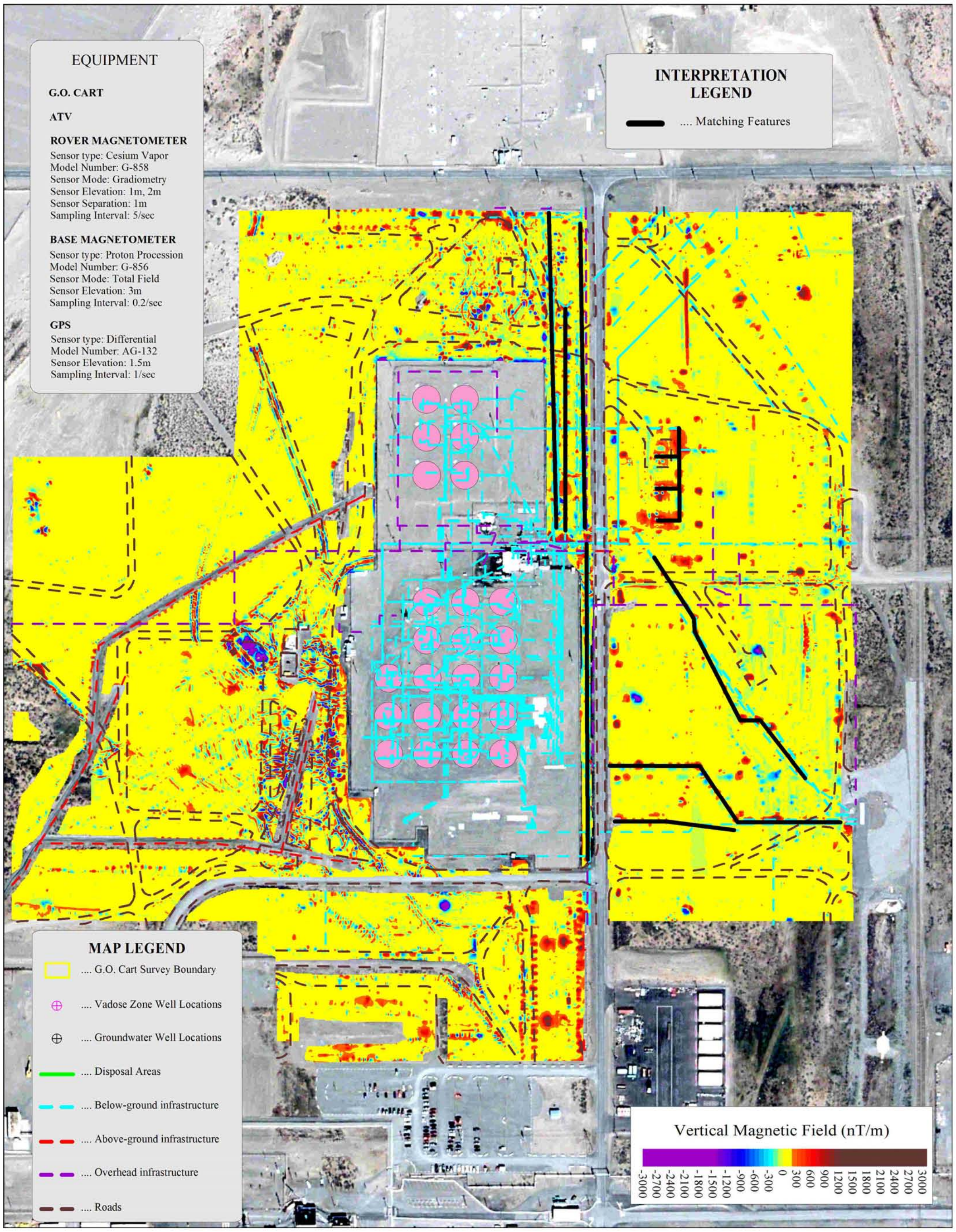


**Figure 21. Vertical Magnetic Gradient Showing Interpreted Features that Do Not Correlate with Drawings.**

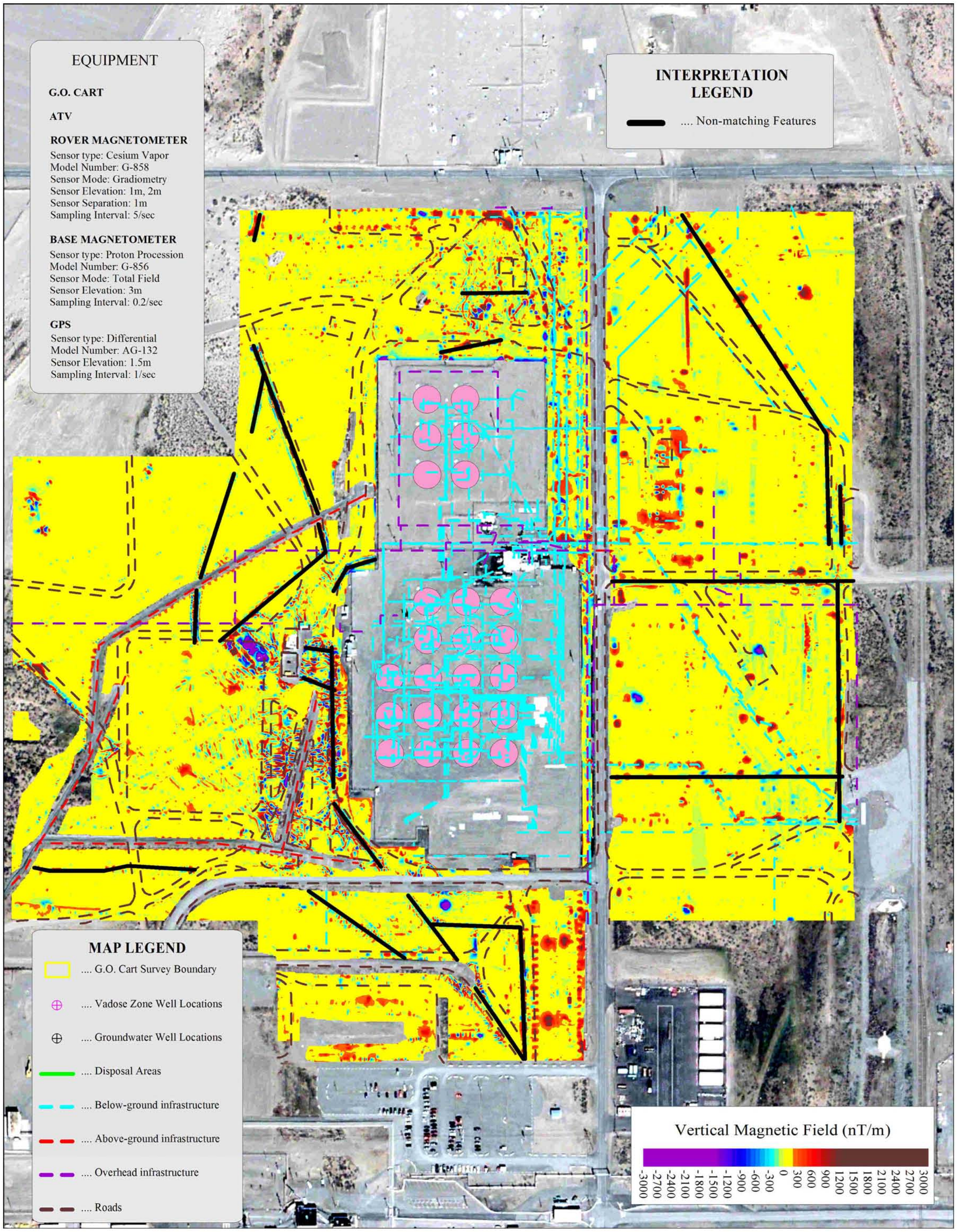
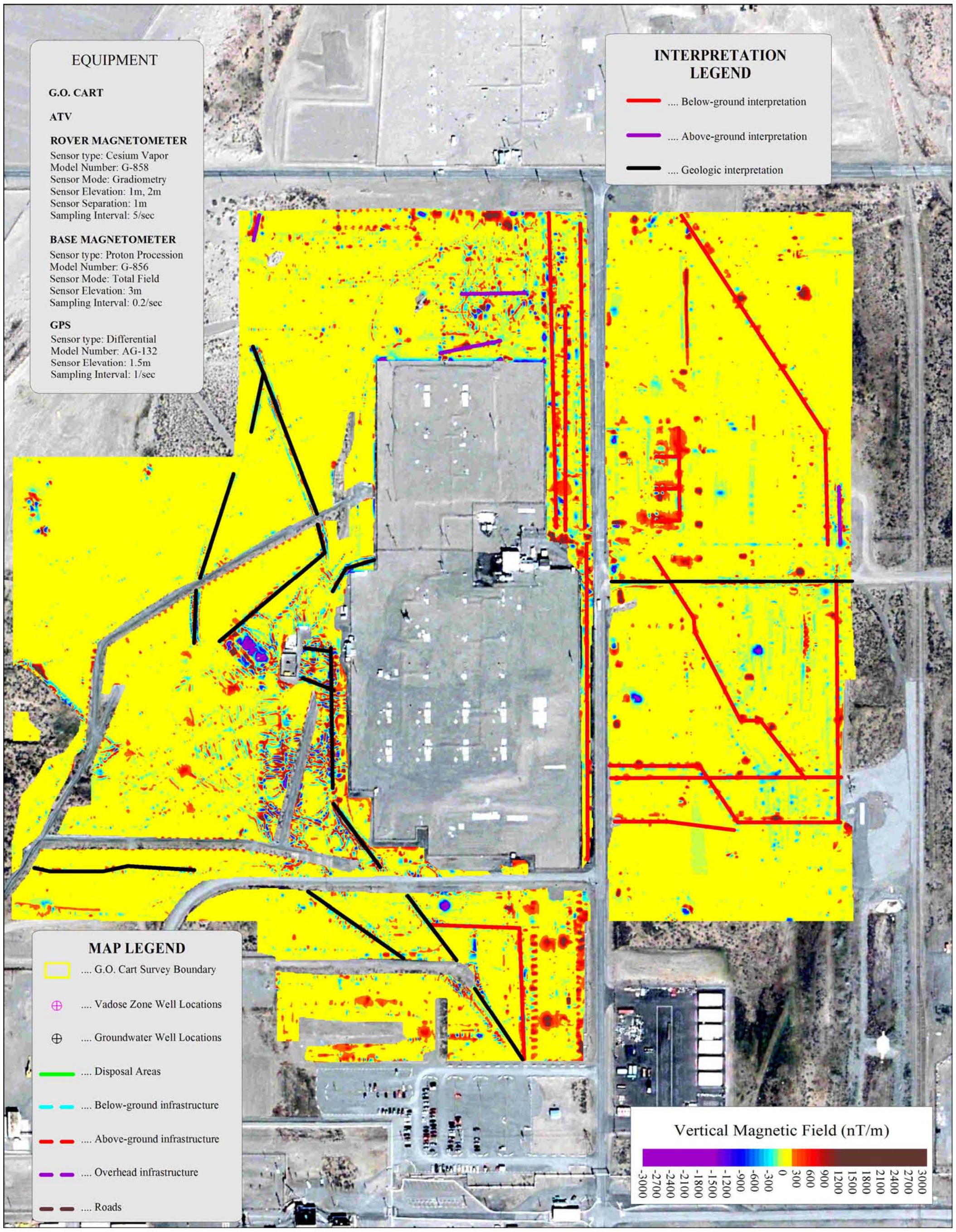


**Figure 22. Vertical Magnetic Gradient Showing Interpreted Features Grouped by Classification Type.**



## 6.2 ELECTROMAGNETIC INDUCTION

### 6.2.1 Electrical In-Phase (9990Hz)

Electrical in-phase measurements from electromagnetic induction was acquired for the frequencies of 5010, 9990, and 20010 Hz. The results for the three frequencies are similar enough that for this report the 9990 Hz frequency was selected for presentation. Plots for the additional frequencies can be viewed in Appendix A. The data were contoured to show the spatial representation of relevant subsurface features.

In general, the figures show linear anomalies that could be indicative of subsurface infrastructure. Many of the linear features correlate well with available Hanford infrastructure maps. This provides confidence that most of the linear features detected by the EM In-phase survey, but are not shown on the available maps, are likely to be subsurface utilities. The monitoring wells produce little response because the EM sensor was not placed directly over top of their locations. A more detailed view of each focus area (Figure 6) is presented in Appendix A.

In contrast to the results for the Mag survey which showed sporadic and loosely connected responses, the EM In-Phase detected features show several continuous linear responses that are indicative of subsurface infrastructure. In addition to the scattered utilities, which are predominantly east of the TX-TY farms, the EM in-phase reveals three distinct features over the eastern cribs that may correlate with metallic crib infrastructure. The figures use a color scheme that represents variations in the data. Hues ranging from yellow to red represent high electrical in-phase responses. Green, light blue, and dark blue hues represent low electrical in-phase responses or background. The series of color contour result maps are designed to allow direct interpretation. Electromagnetic data were collected in several grids that were normalized to each other to reduce drift between each data collection period. Therefore the results presented in this report reflect a normalized value following a data processing regiment discussed in Section 4.3.3.

NOTE: The color scale used for the electrical in-phase survey is specifically designed to distinguish subsurface features of interest that may influence resistivity results for the specific survey area. It is therefore not consistent with color scales used on previous Magnetic surveys conducted on the Hanford site.

A similar series of plots that correlate EM In-phase features to infrastructure drawings are shown in Figures 23 through 26. Figure 23 shows the results for EM In-Phase with infrastructure layers from available infrastructure drawings. Figure 24 shows the interpreted results for the EM In-Phase survey that correlate with infrastructure drawings within +/- 2.5 meters (bold black line). Figure 25 shows the remaining EM In-Phase features that do not correlate with infrastructure drawings within +/- 2.5 meters (bold black line). Interpreted EM features were then classified into the same interpretation groups as mentioned above for the Magnetic Total Field: interpreted above ground features, interpreted below ground features, and interpreted geologic features. Figure 26 shows a summary of interpreted EM In-phase features and the associated interpretation grouping as discussed in the Total Magnetic Field section above.

**Figure 23. Electrical In-Phase Shown With Infrastructure from Drawings.**

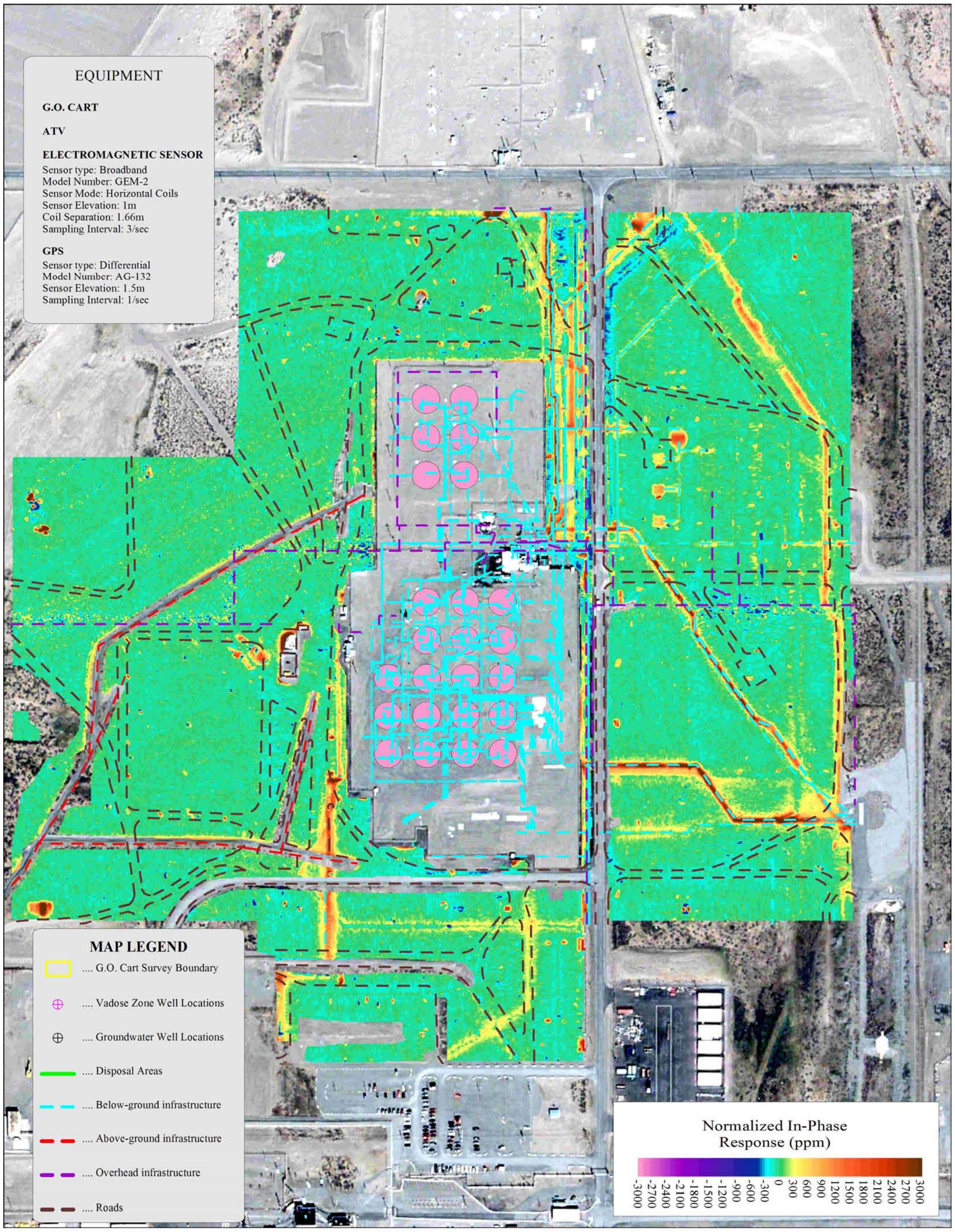


**Figure 24. Electrical In-Phase Gradient Showing Features That Correlate with Drawings.**

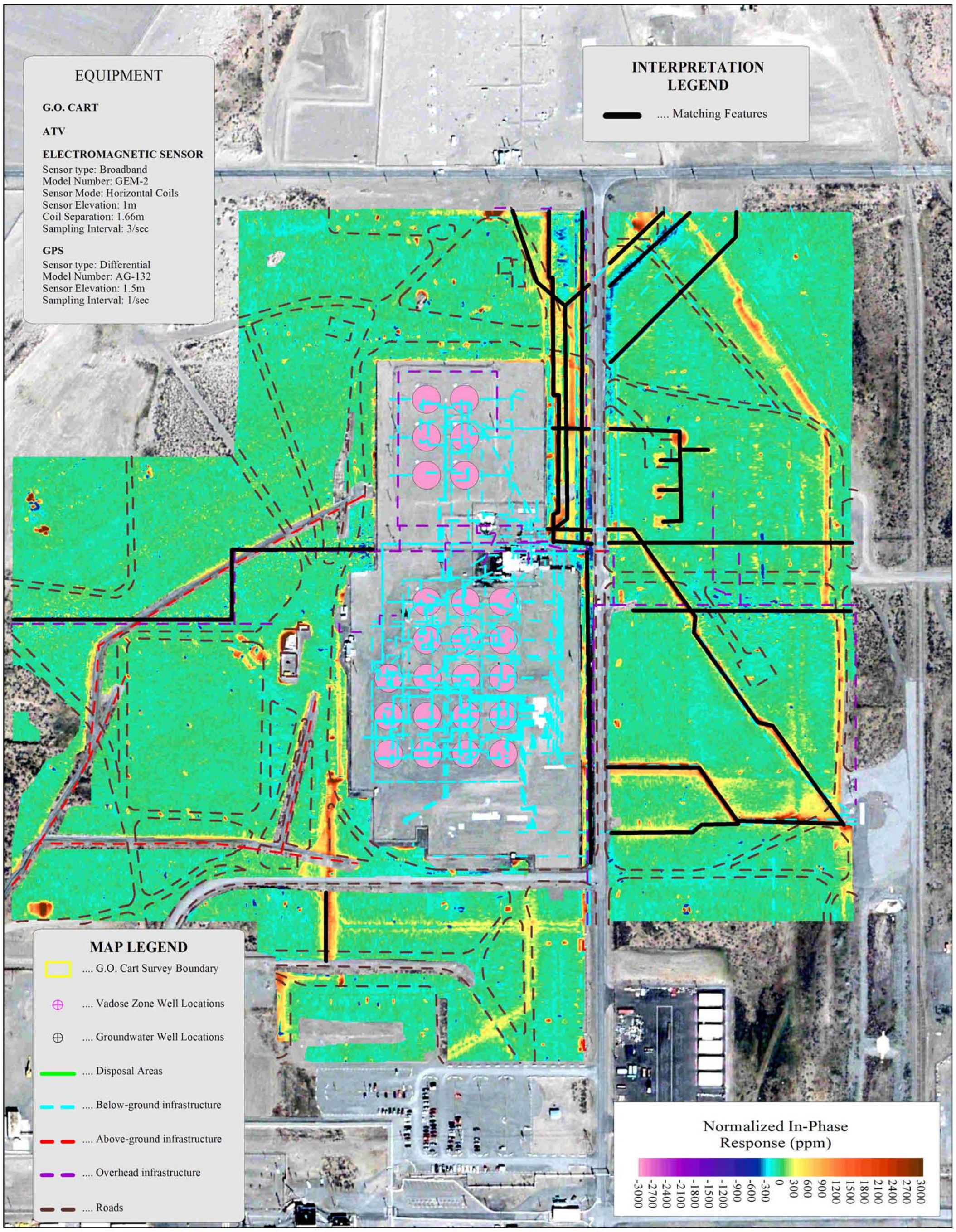


**Figure 25. Electrical In-Phase Showing Interpreted Features that Do Not Correlate with Drawings.**

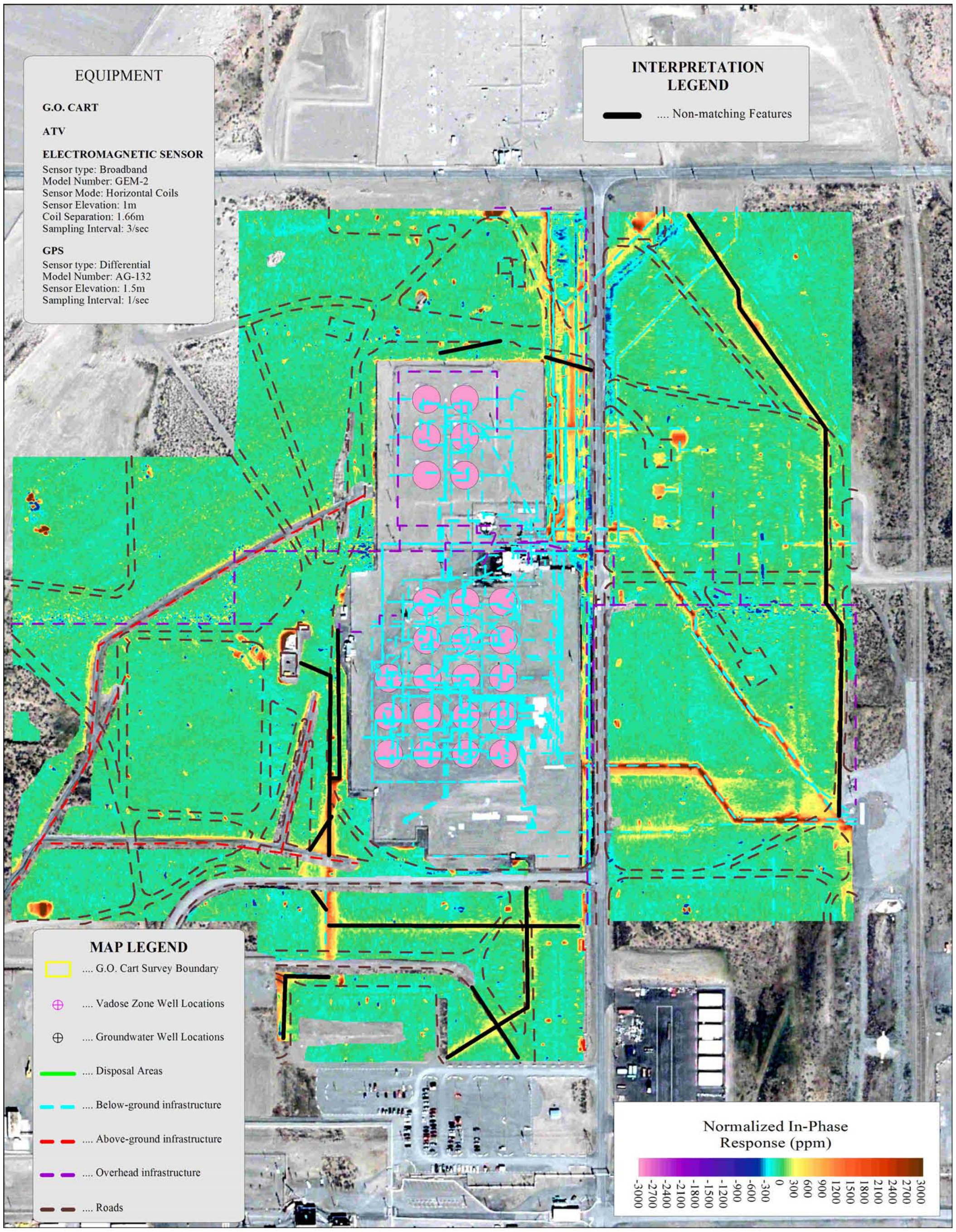
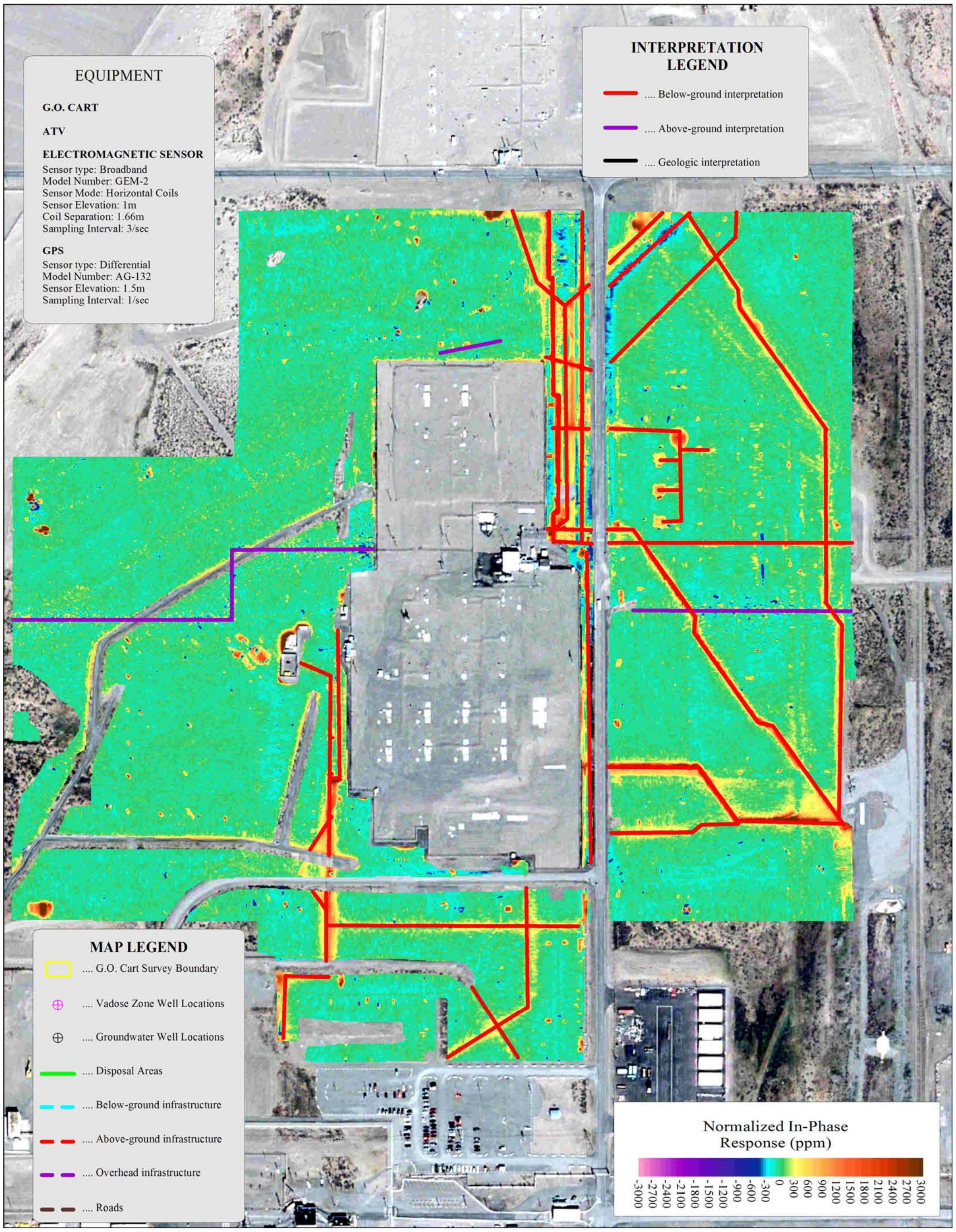


**Figure 26. Electrical In-Phase Showing Interpreted Features Grouped by Classification Type.**




## 6.2.2 Electrical Conductivity (9990Hz)

Electrical conductivity measurements were acquired for the frequencies of 5010, 9990, and 20010 Hz. The 9990 Hz frequency is representative of all three frequencies and is selected for presentation in this report. Plots for the additional frequencies can be viewed in appendix A. Unlike the Mag and EM In-Phase data, anomalous responses in the electrical conductivity could result from increased soil moisture or salt deposits, in addition to the presence of ferrous and non-ferrous metals. The data were contoured to show the spatial representation of relevant subsurface features.

In general, the figures show linear anomalies that correlate well with the EM In-phase and Magnetic results. However, the EM conductivity results also show features associated with overhead power lines that emanate from the center of TX-TY farm and continue west. Many of the linear features correlate well with available Hanford infrastructure maps. This provides confidence that most of the linear features detected by the EM survey, but are not shown on the available maps, are likely to be subsurface utilities. Several features were detected that were not recorded on available Hanford maps. These features are predominantly south of TY farm and north of the PFP facility. In contrast to the results the In-Phase survey; there is little evidence of response over the eastern crib area. The monitoring wells produce little response because the EM sensor was not placed directly over top of their locations. A more detailed view of each focus area (Figure 6) is presented in Appendix A.

The figures use a color scheme that best represents variations within the data. Hues ranging from dark orange to red represent high electrical conductivity values. Light green, yellows and light orange represent low electrical conductivity or background values. The series of color contour result maps are designed to allow direct interpretation. Electromagnetic data were collected in several grids that were normalized to each other to reduce drift between each data collection period. Therefore the results presented in this report reflect a normalized value following a data processing regimen discussed in Section 4.3.3 of this report.

NOTE: The color scale used for the electrical conductivity survey is specifically designed to distinguish subsurface features of interest that may influence resistivity results for the specific survey area. It is therefore not consistent with color scales used on previous Magnetic surveys conducted on the Hanford site.

A similar series of plots that correlate EM conductivity features to infrastructure are shown in Figures 27 through 30. Figure 27 shows the results for EM conductivity with infrastructure layers from available infrastructure drawings. Figure 28 shows the interpreted results for the EM conductivity survey that correlate with infrastructure drawings within +/- 2.5 meters (bold black line). Figure 29 shows the remaining EM conductivity features that do not correlate with infrastructure drawings within +/- 2.5 meters (bold black line). Interpreted EM features were then classified into the same interpretation groups as mentioned above for the Magnetic Total Field: interpreted above ground features, interpreted bellow ground features, and interpreted geologic features. Figure 30 shows a summary of interpreted EM conductivity features and the associated interpretation grouping as discussed in the Total Magnetic Field section above.

**Figure 27. Electrical Conductivity Shown with Infrastructure from Drawings.**

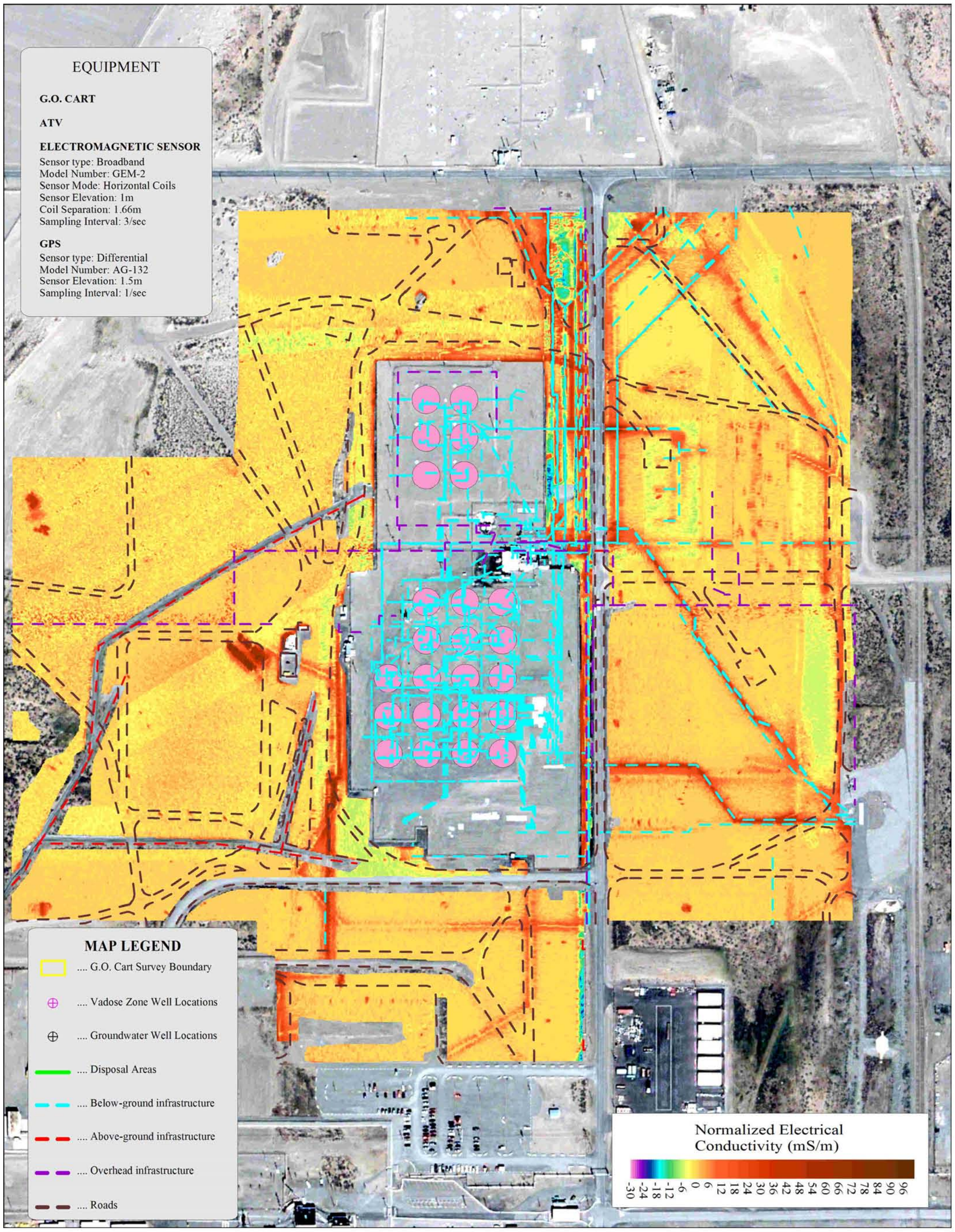


**Figure 28. Electrical Conductivity Shown with Infrastructure from Drawings.**

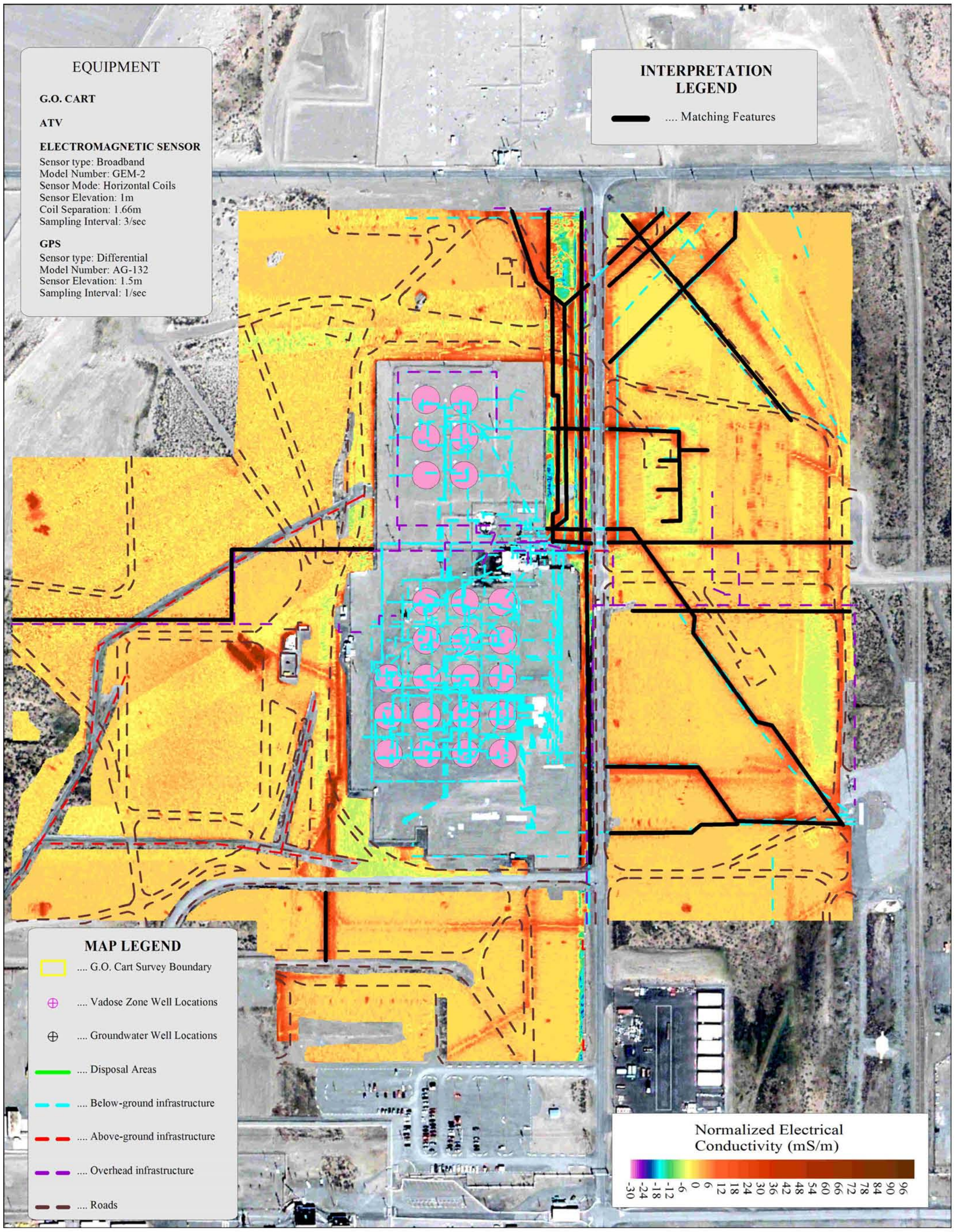


**Figure 29. Electrical Conductivity Showing Interpreted Features that Do Not Correlate with Drawings.**

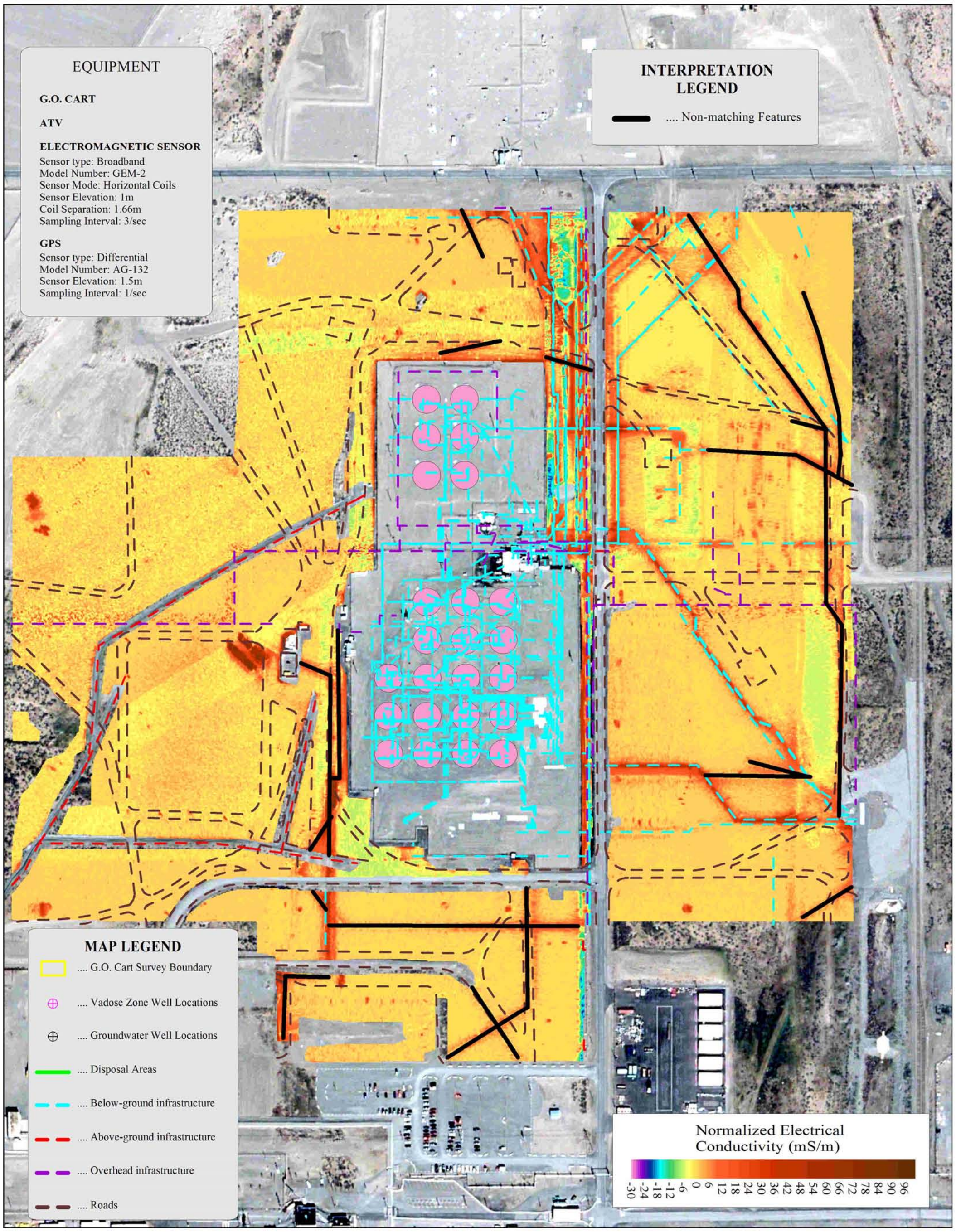


**Figure 30. Electrical Conductivity Showing Interpreted Features Grouped by Classification Type.**

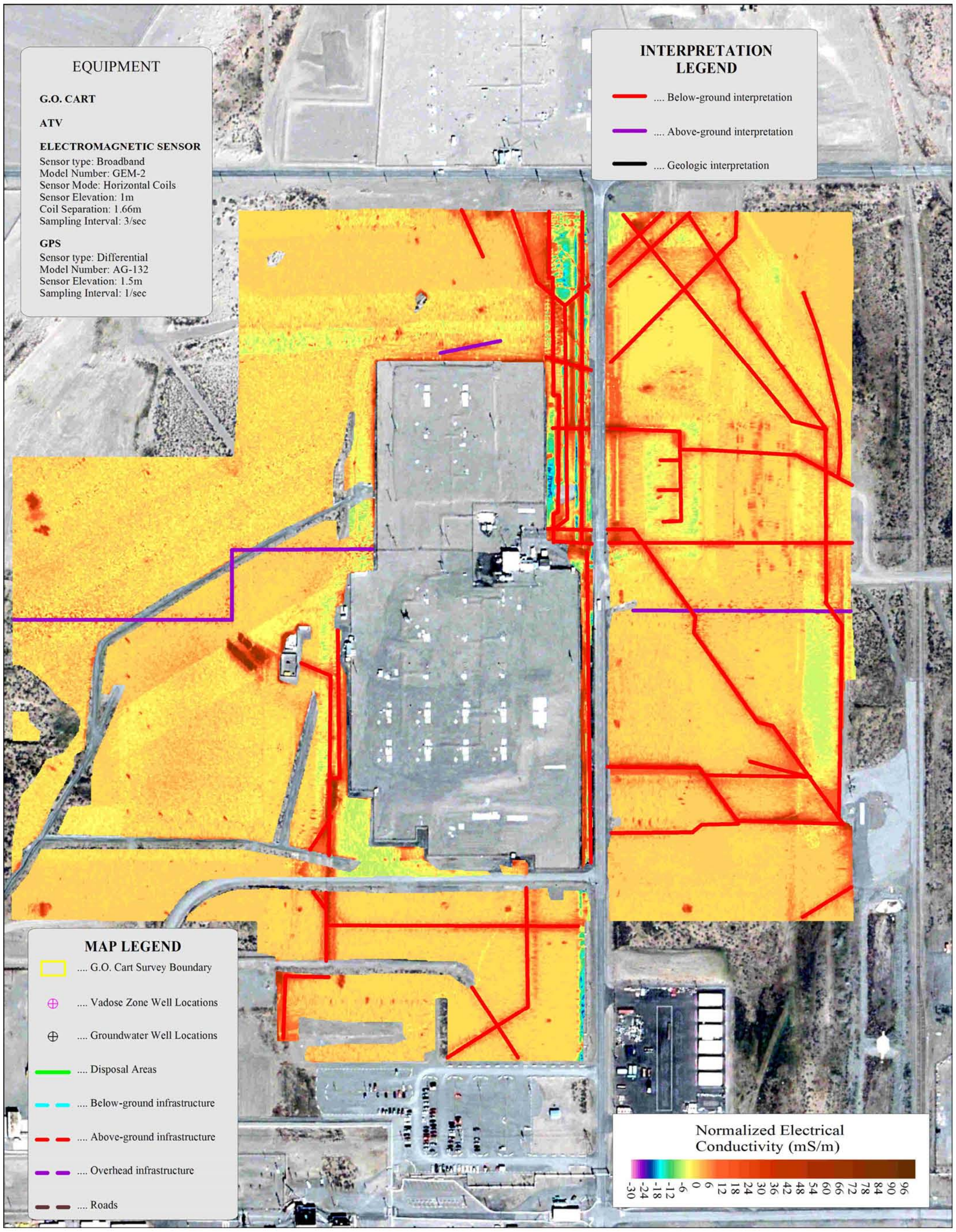
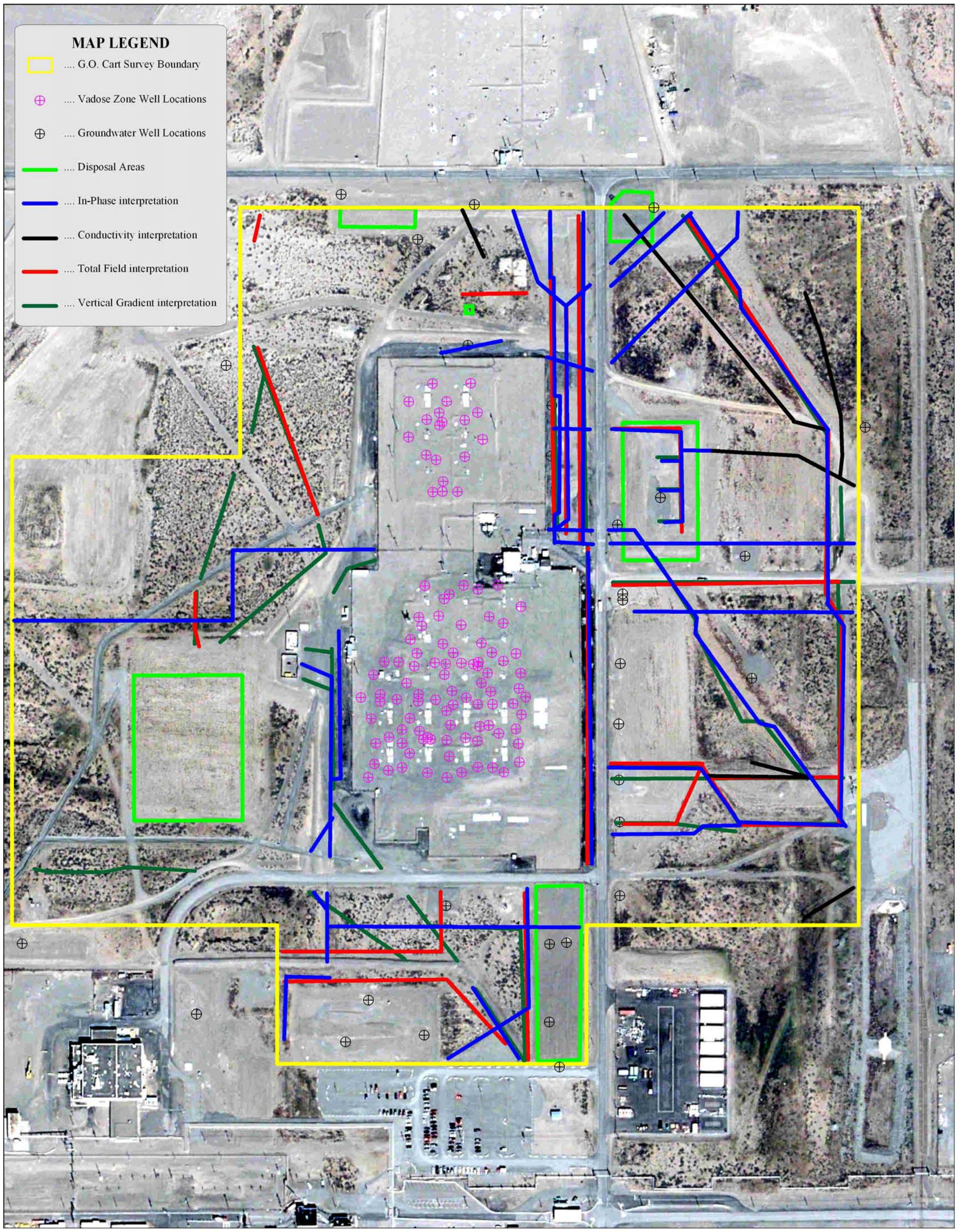



Figure 31 shows a summary of features identified from the Mag and EM Interpretation after correlation to available Hanford utility maps. The map shows positive agreement between the methods for the majority of features. Features that do not correlate between the EM and Mag surveys provide additional segregation of material properties that will be used to support resistivity data interpretation. The geophysical features from this map in conjunction with the infrastructure drawings are digitized into a GIS data base that is linked to the resulting resistivity contour maps. In this process, a direct comparison between resistivity response and any associated infrastructure can be made.

**Figure 31. Summary of Interpreted Features from G.O.Cart™ Survey.**



# 7.0 CONCLUSIONS

Results of the surveying revealed several subsurface features that are interpreted as buried pipes. The contoured data from electromagnetics provided the best data for delineating continuous linear features that are indicative of subsurface infrastructure such as pipes or utilities. The contoured magnetic data provided additional agreement for many of the linear features while also providing information about soil properties, surface structures that have metallic grounding and sporadic surface metal debris.

Survey results show a high concentration of infrastructure that will likely influence resistivity results in several areas including:

- between Camden road and the east TX farm fence,
- over the eastern crib area ( 216-T-26 through 216-T-28),
- between the south TY farm fence and the PFP facility,
- towards the southeast corner at the intersection of Camden and 23rd Street,
- along the western TY farm fence, and
- west of Camden road and east of TY farm.

Results of the G.O. Cart™ survey and associated interpreted linear feature or pipe locations are used in the interpretation of resistivity inversion modeling results. Comparison of inversion results with plots of interpreted features based on the EM and Mag data allows for consideration of the potential effects of these artifacts in the interpretations of inverted resistivity results.

If, for example, a low resistivity target is seen directly beneath a grouping of several pipes, then the resistivity results should be viewed carefully with anticipated uncertainty in an interpreted electrolytic conduction phenomenon.

# 8.0 REFERENCES

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Won, I.J., 1980. A wideband electromagnetic exploration method – Some theoretical and experimental results. Geophysics 45 (3):928-940.

# APPENDIX A

# SUPPLEMENTAL PLOTS

**Figure A-1. Electrical Conductivity 5kHz for the Tx-Ty Study Area**

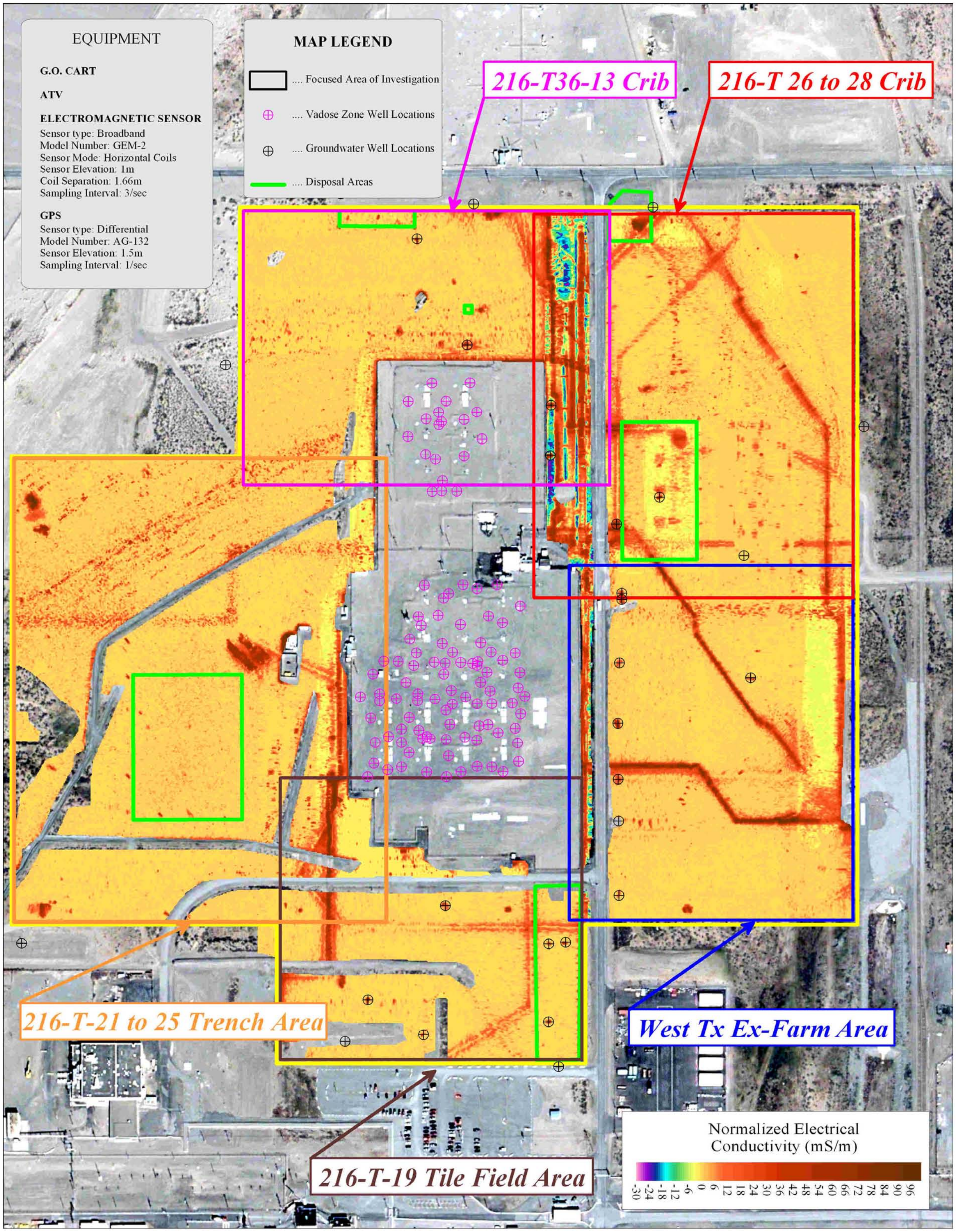


**Figure A-2. Electrical Conductivity 5kHz for the 216-T-19 Tile Field Area**

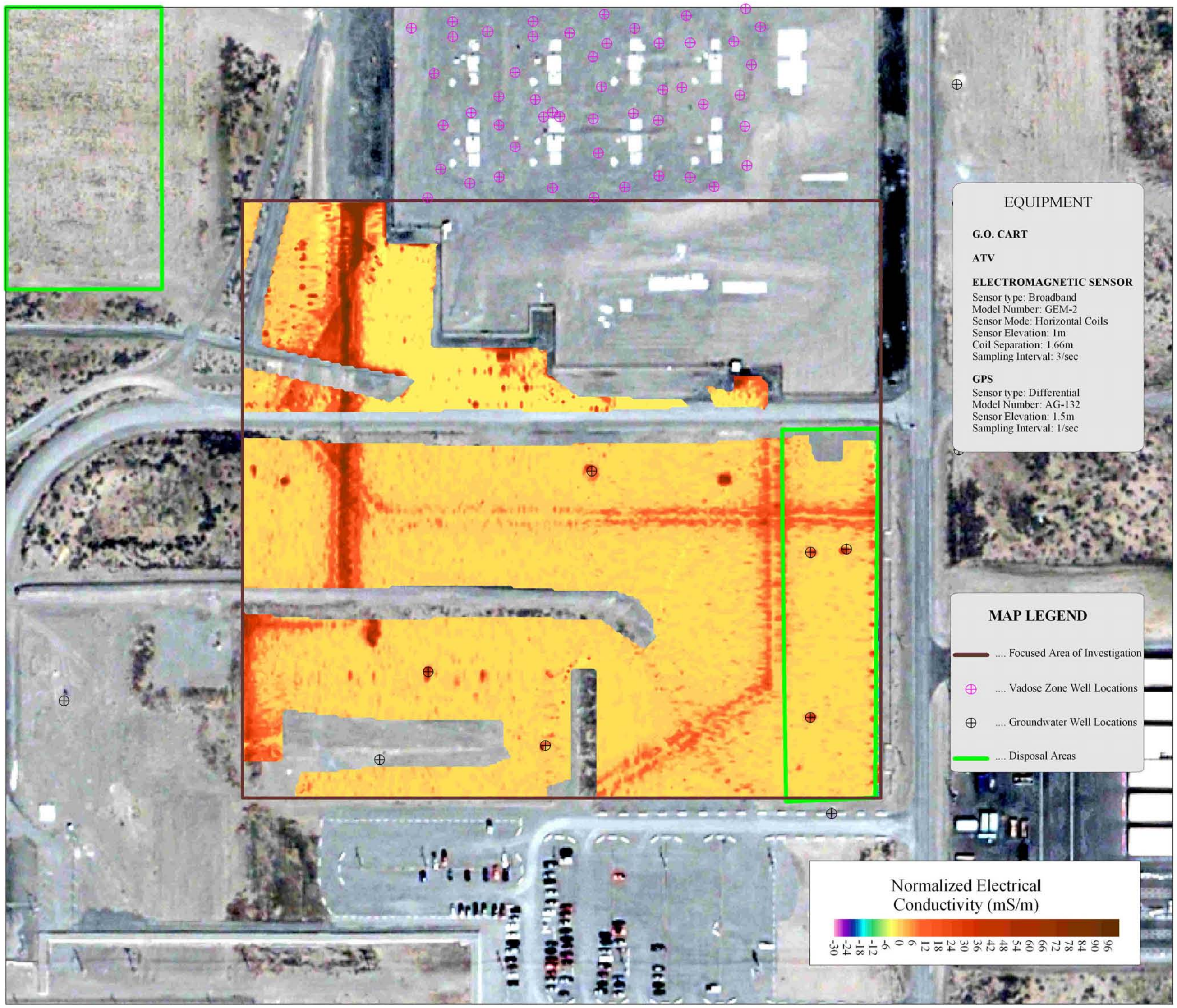


**Figure A-3. Electrical Conductivity 5kHz for the 216-T-21 to 25 Trench Area**

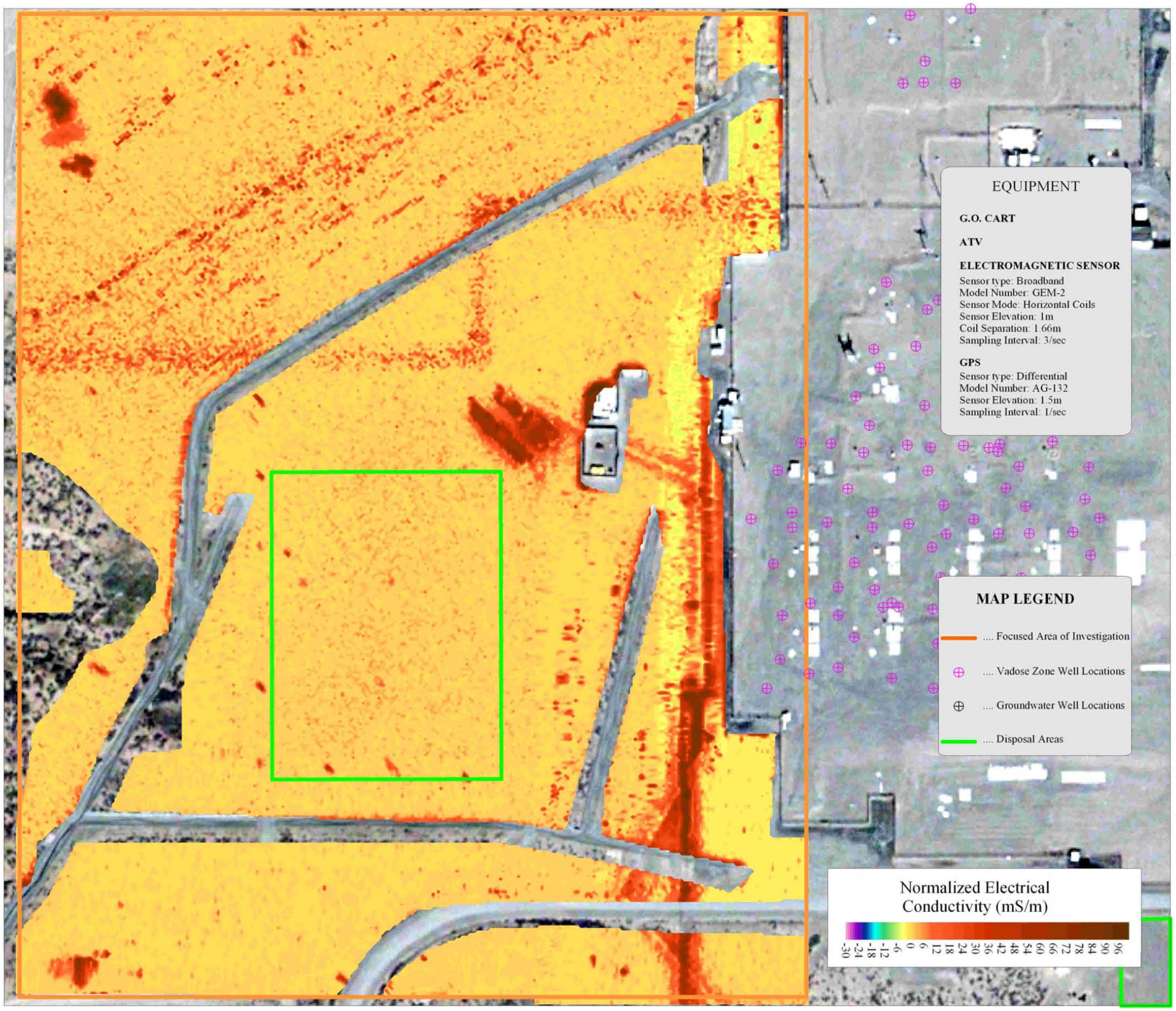


**Figure A-4. Electrical Conductivity 5kHz for the 216-T-26 to 28 Crib**

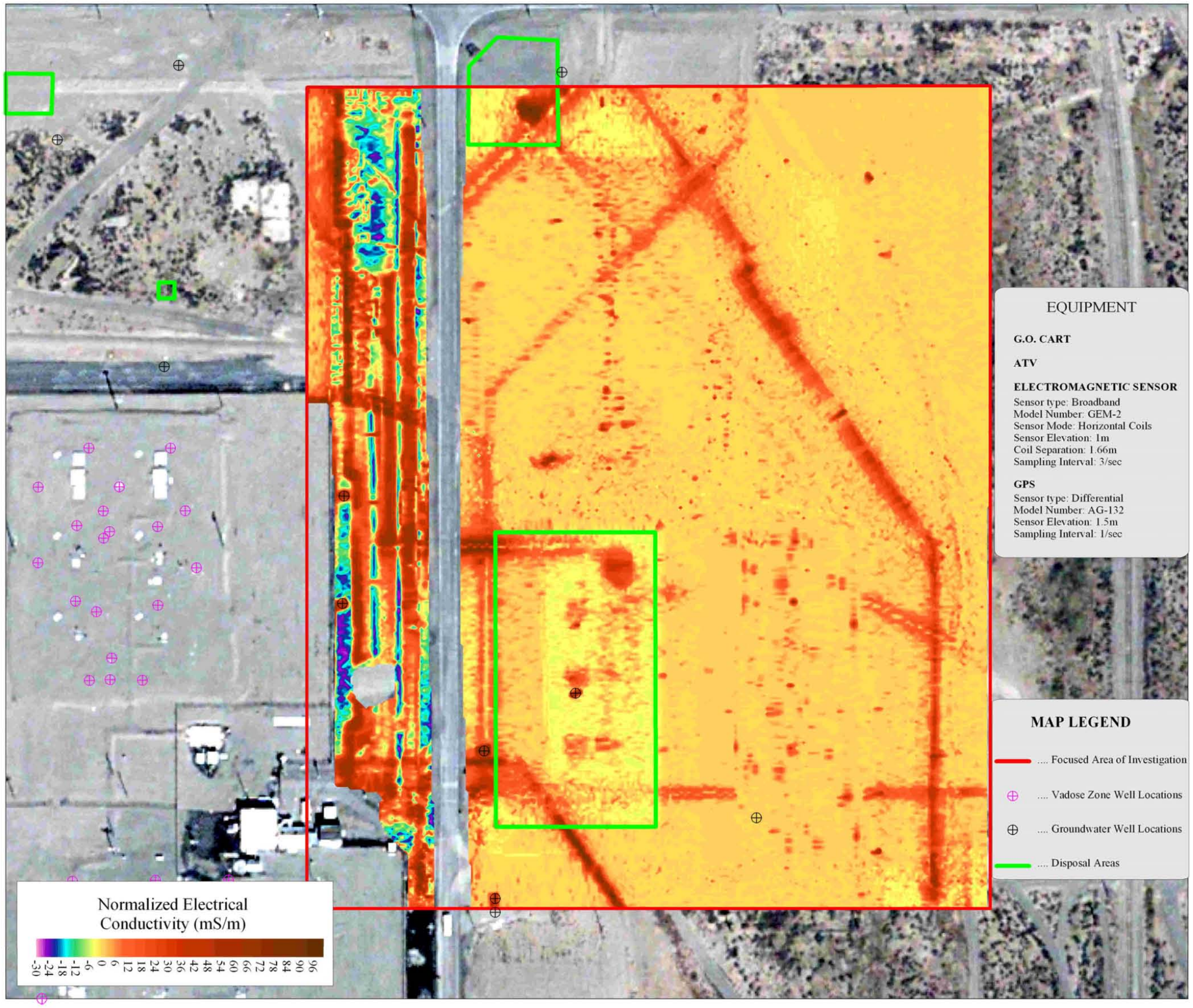


**Figure A-5. Electrical Conductivity 5kHz for the 216-T36-13 Crib**

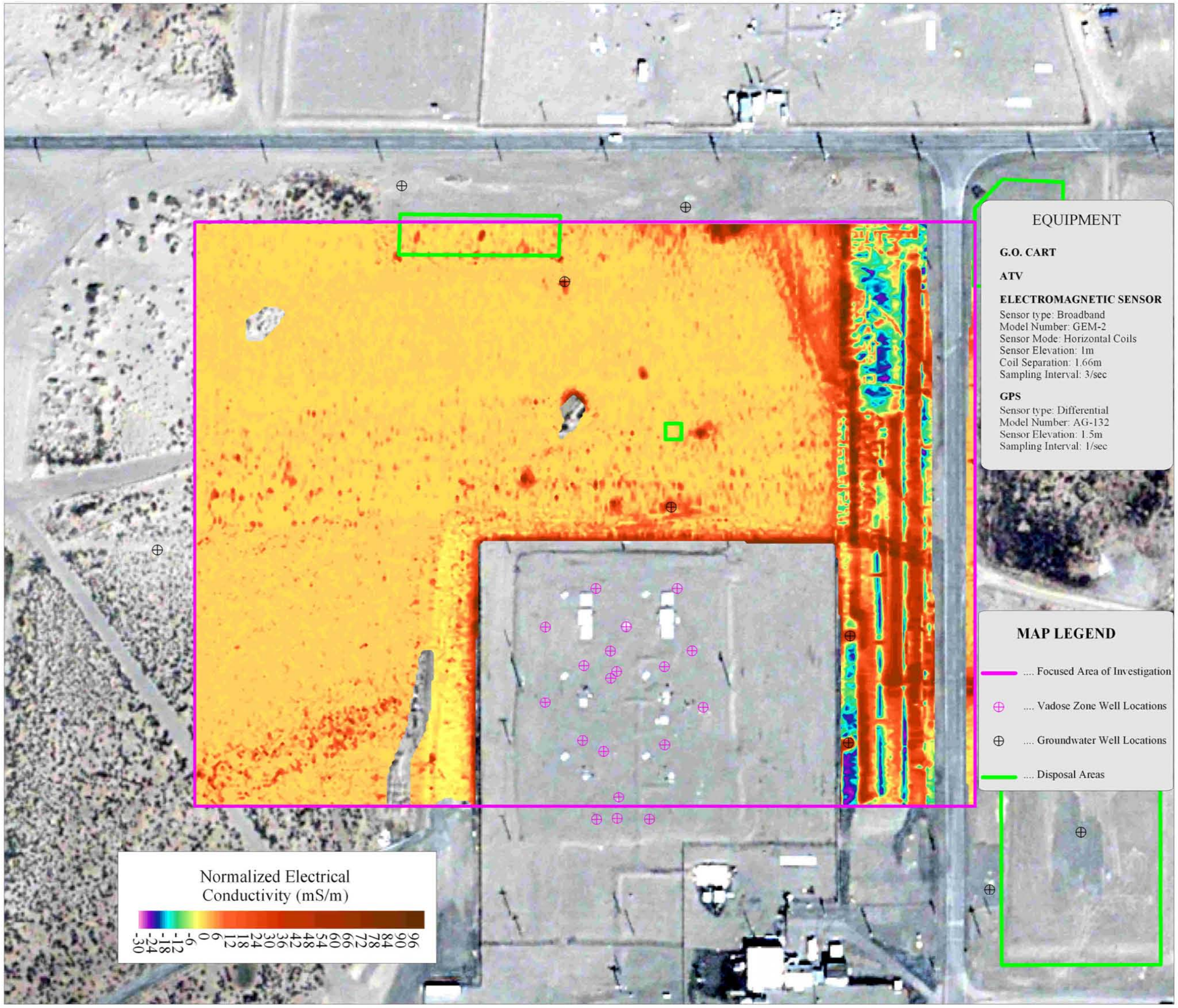


**Figure A-6. Electrical Conductivity 5kHz for the West Tx Ex-Farm Area**

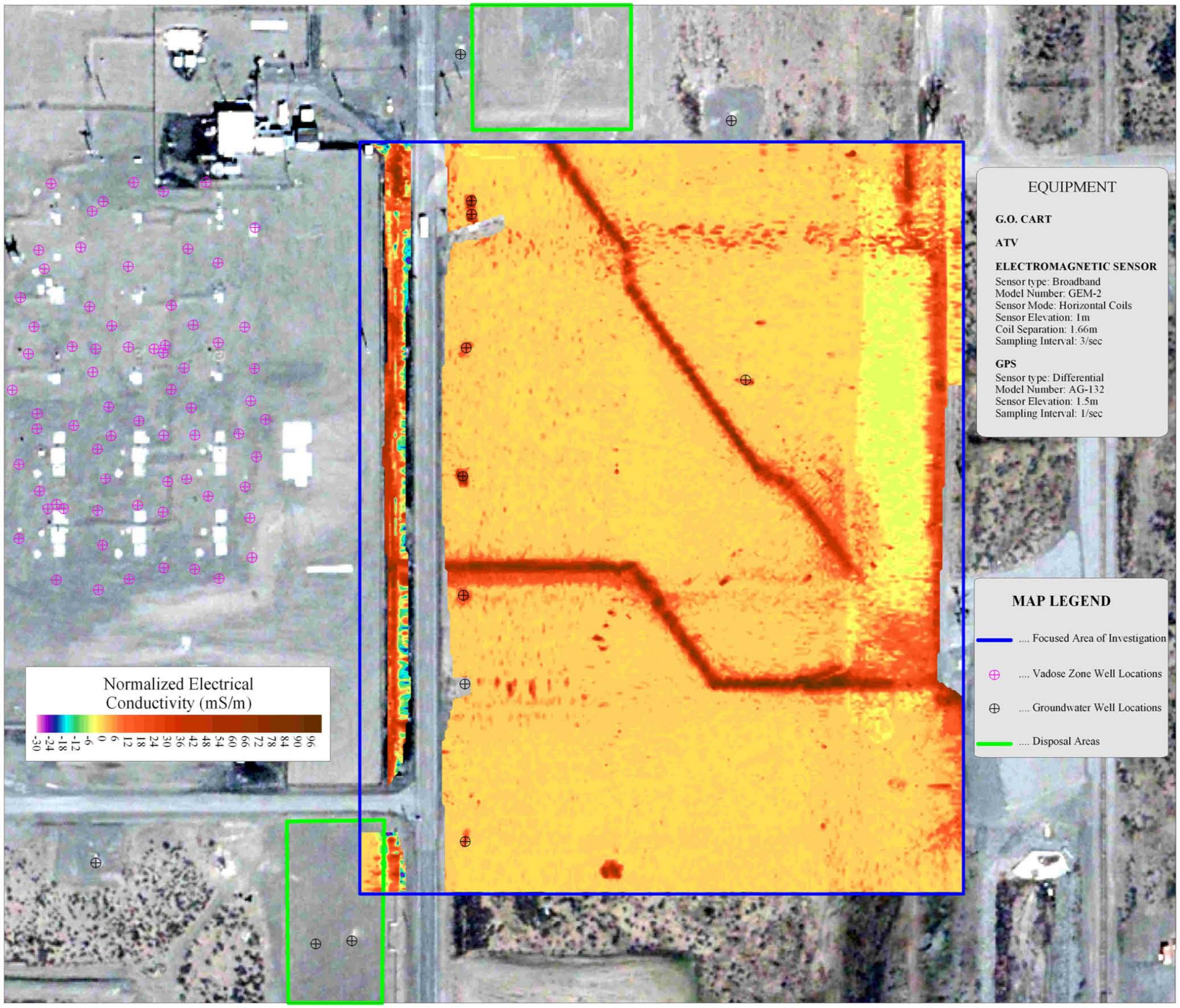


**Figure A-7. In Phase Electromagnetic Response at 5kHz for the Tx-Ty Farm Study Area**

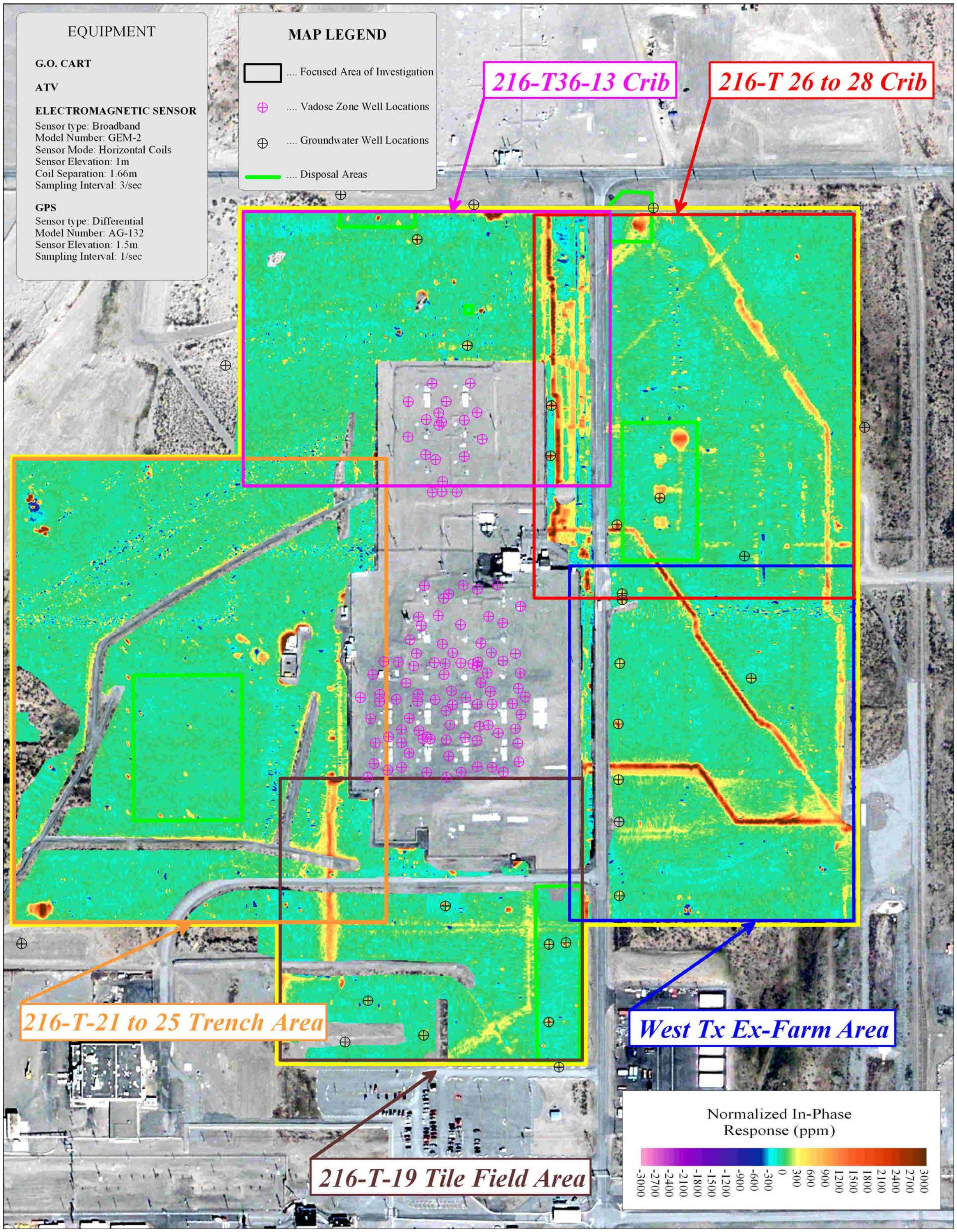


**Figure A-8. In Phase Electromagnetic Response at 5kHz for the 216-T-19 Tile Field Area**

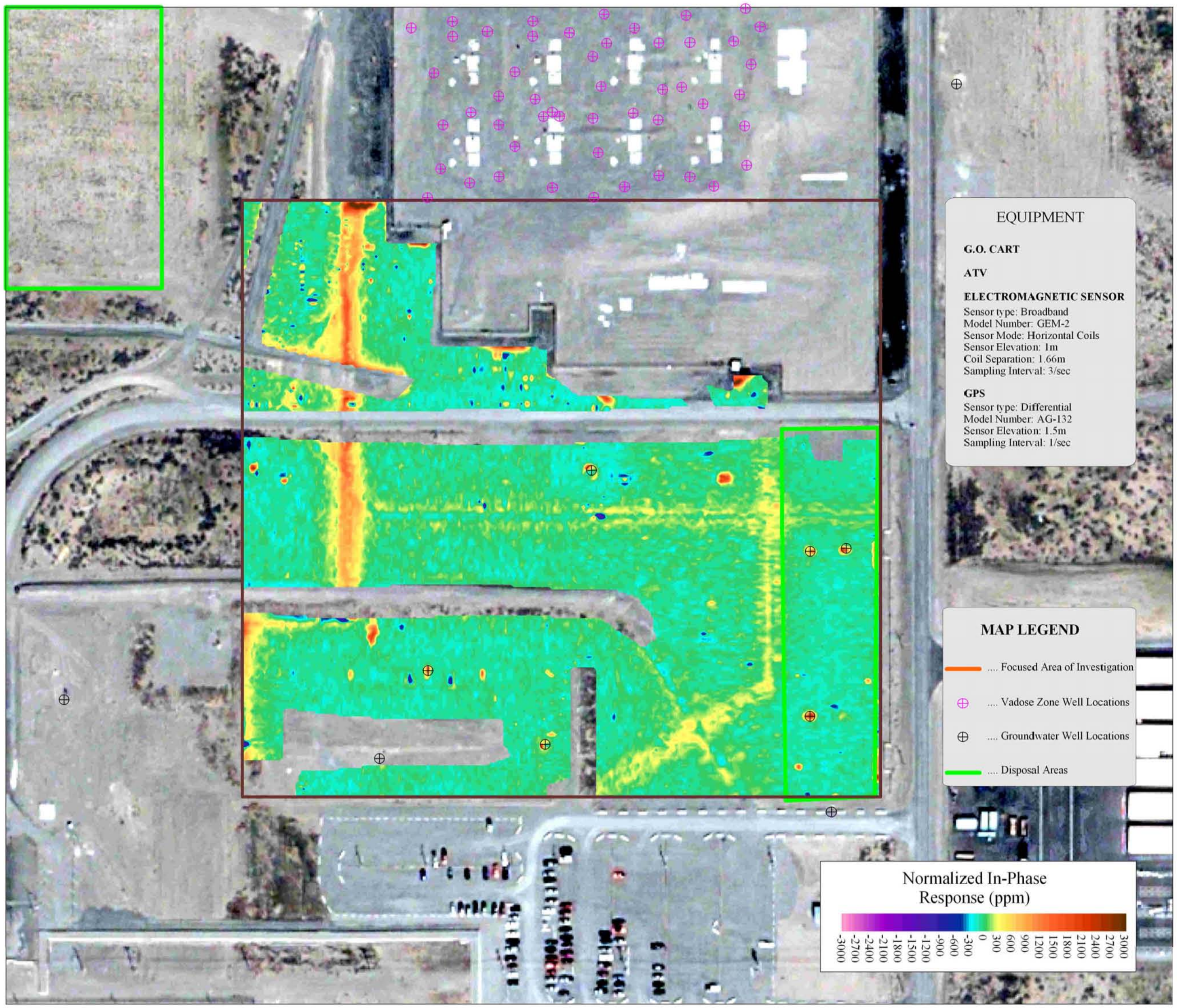


**Figure A-9. In Phase Electromagnetic Response at 5kHz for the 216-T-21 to 25 Trench Area**

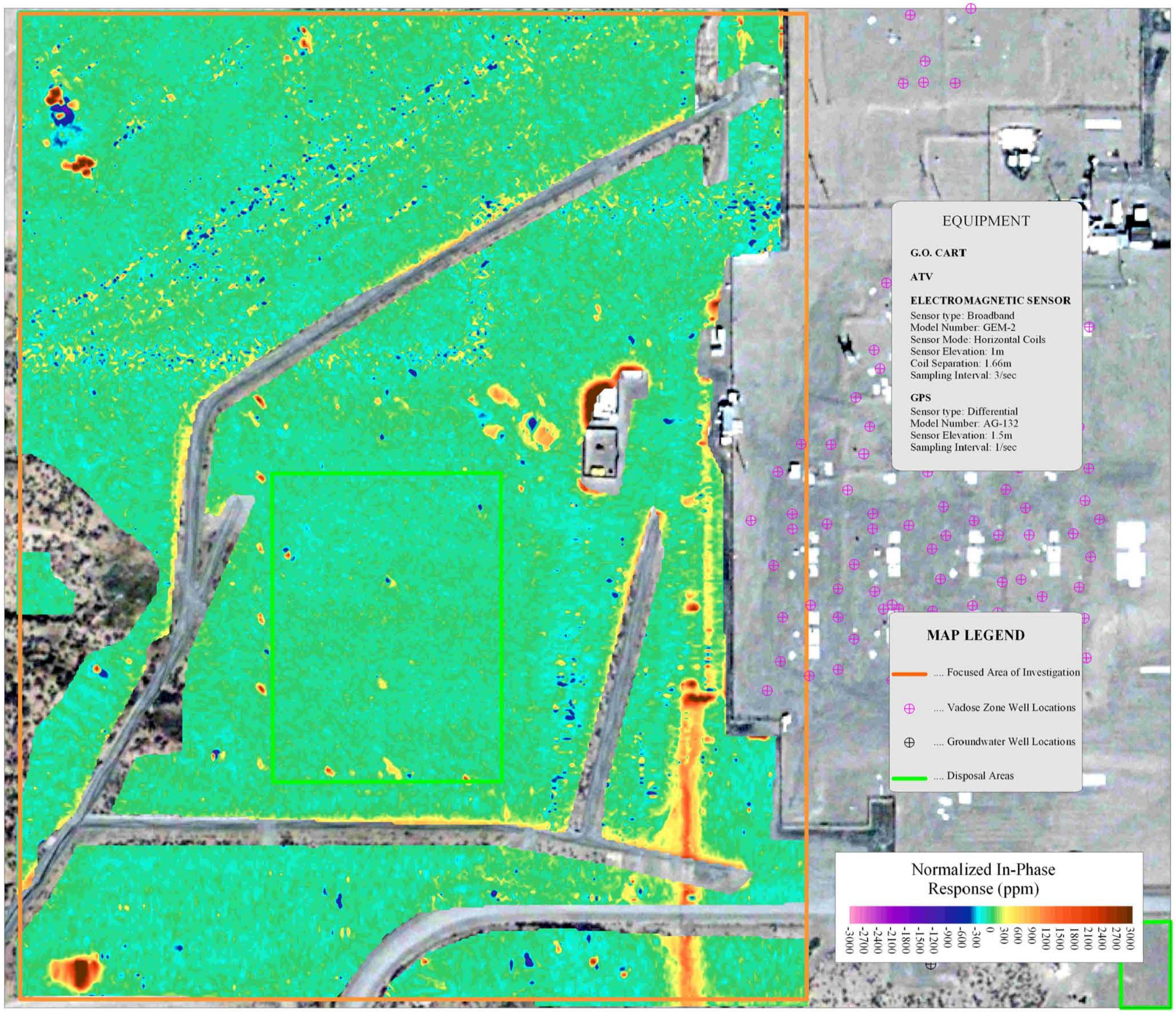


**Figure A-10. In Phase Electromagnetic Response at 5kHz for the 216-T-26 to 28 Crib**

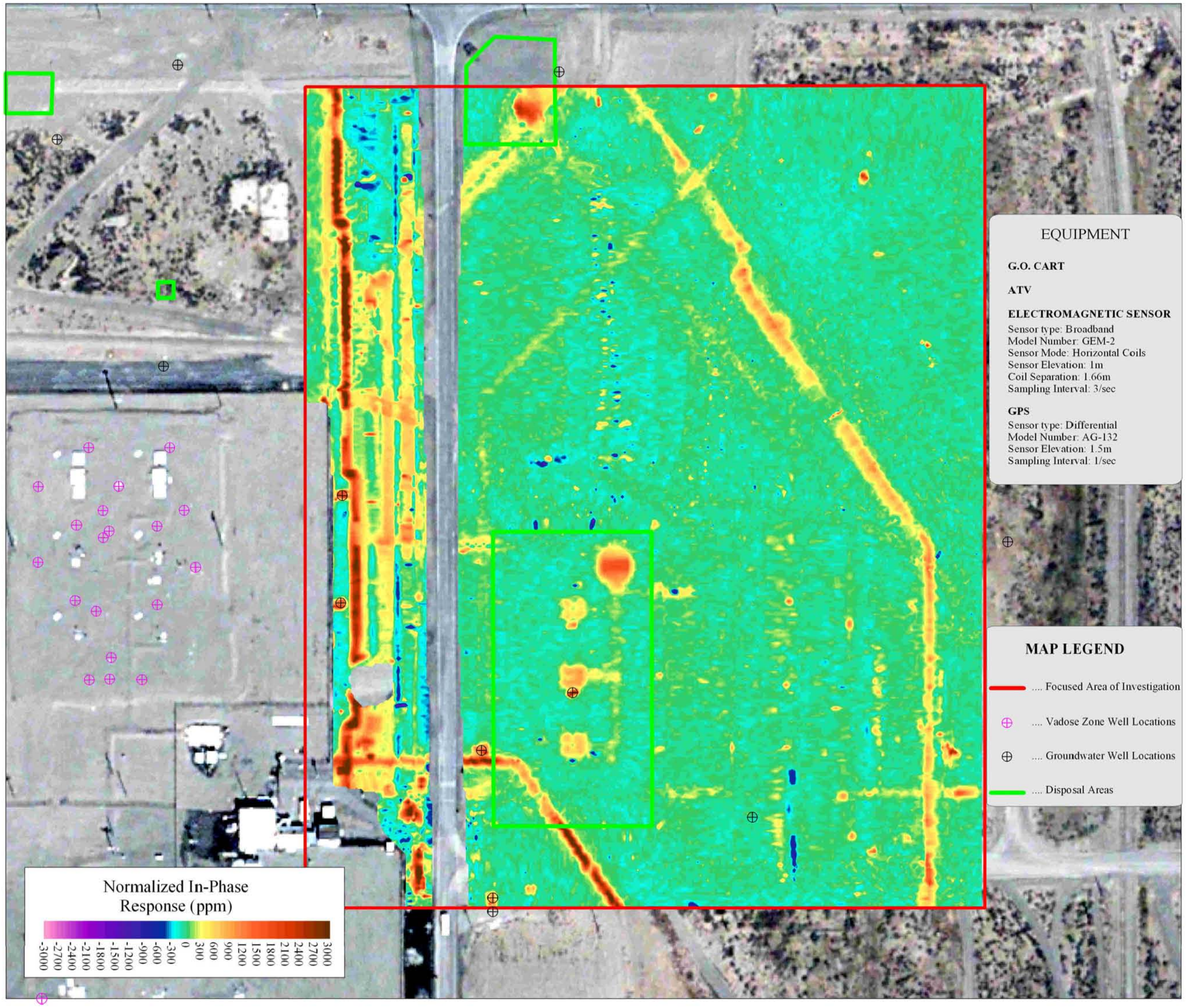


**Figure A-11. In Phase Electromagnetic Response at 5kHz for the 216-T36-13 Crib**

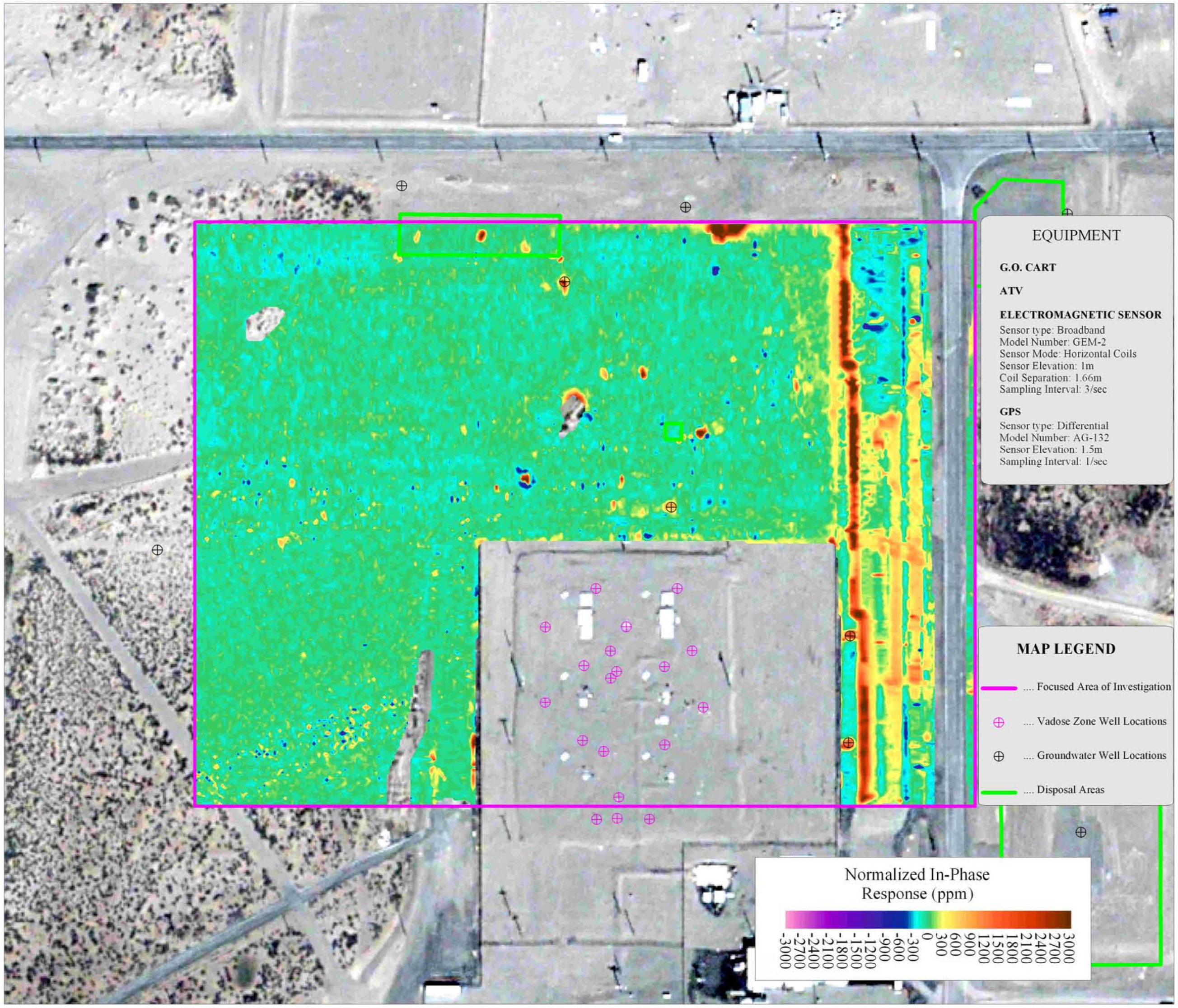


**Figure A-12. In Phase Electromagnetic Response at 5kHz for the West Tx Ex-Farm Area**

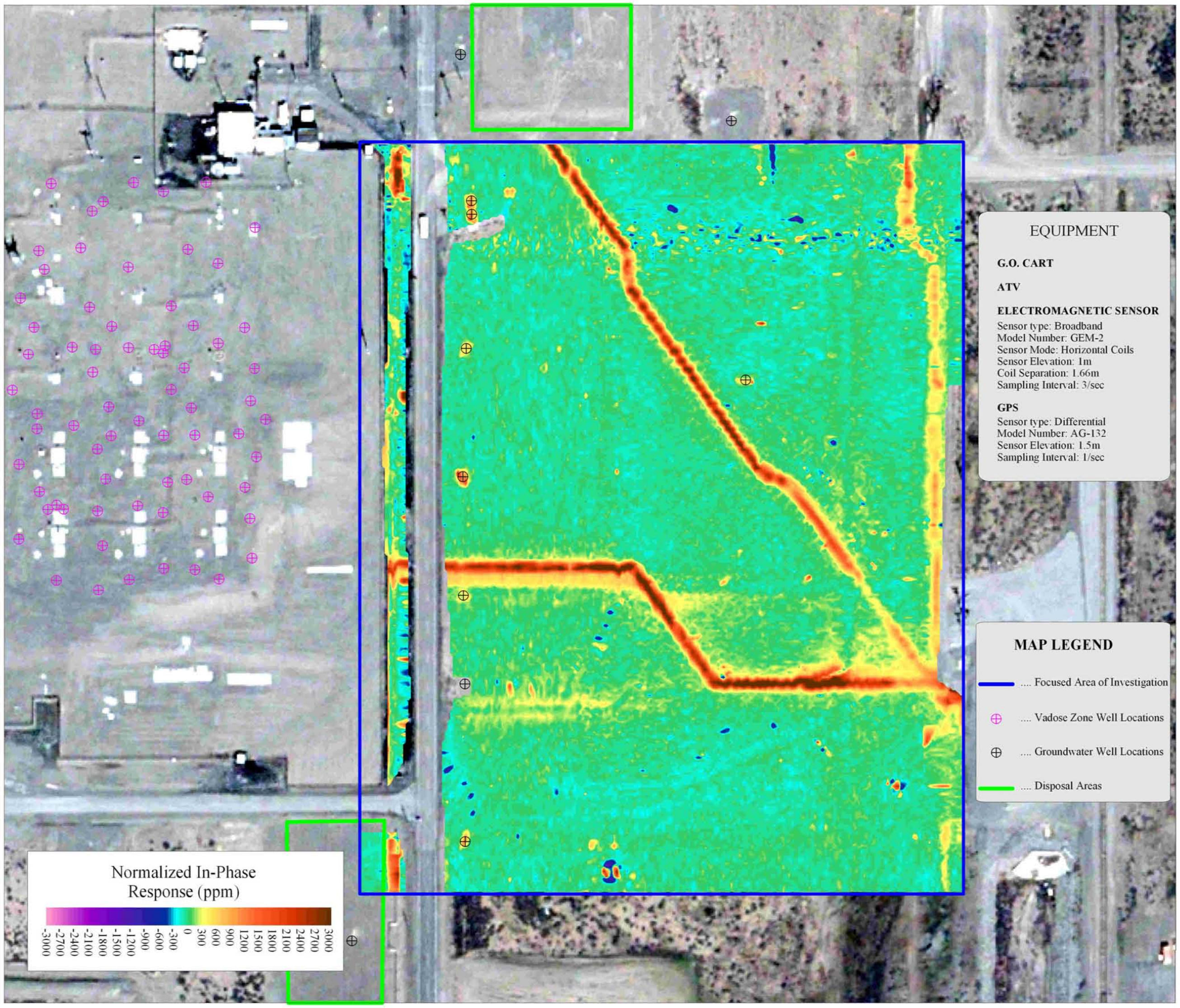


**Figure A-13. Electrical Conductivity 10kHz for the Tx-Ty Farm Study Area**

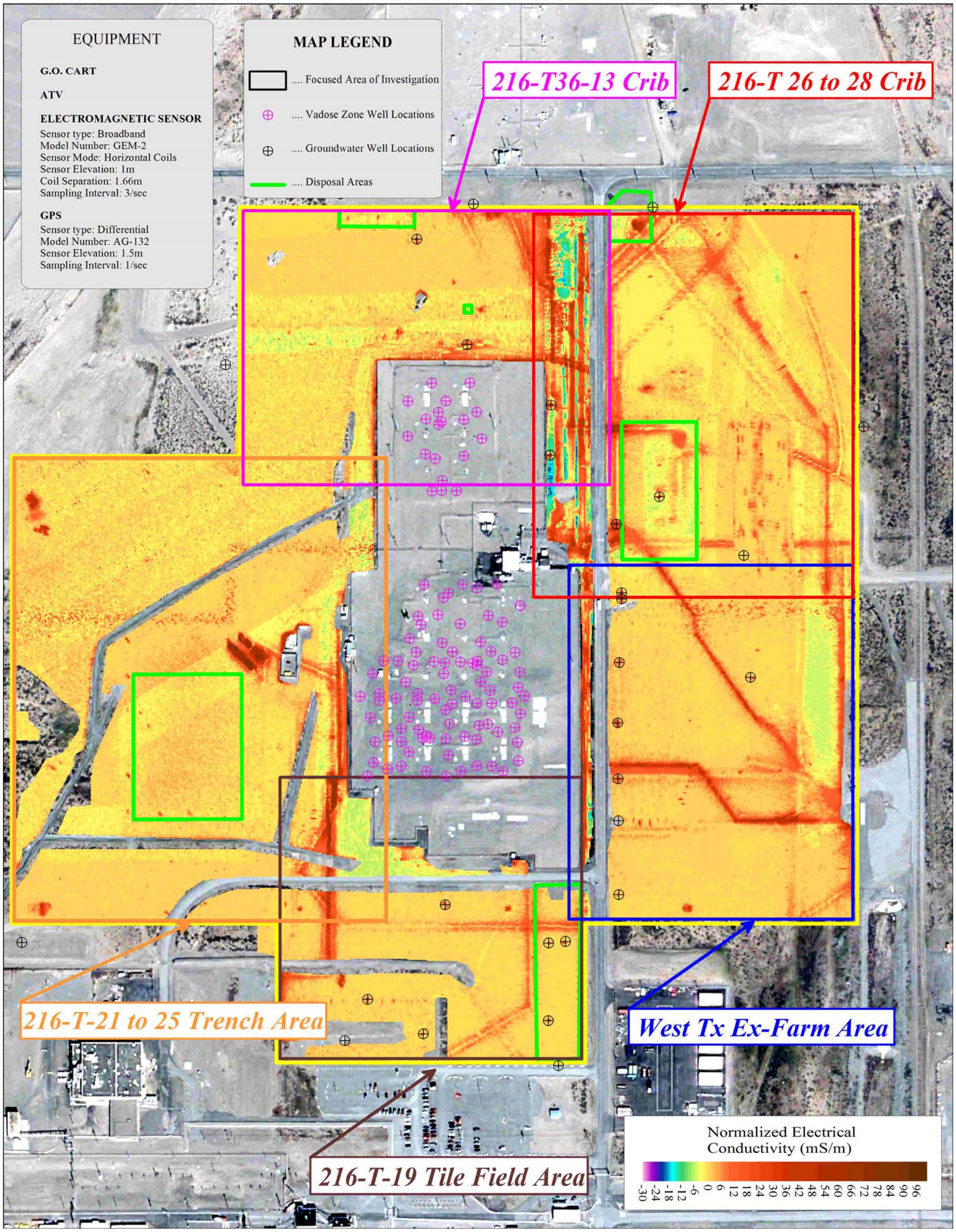


**Figure A-14. Electrical Conductivity 10kHz for the 216-T-19 Tile Field Area**

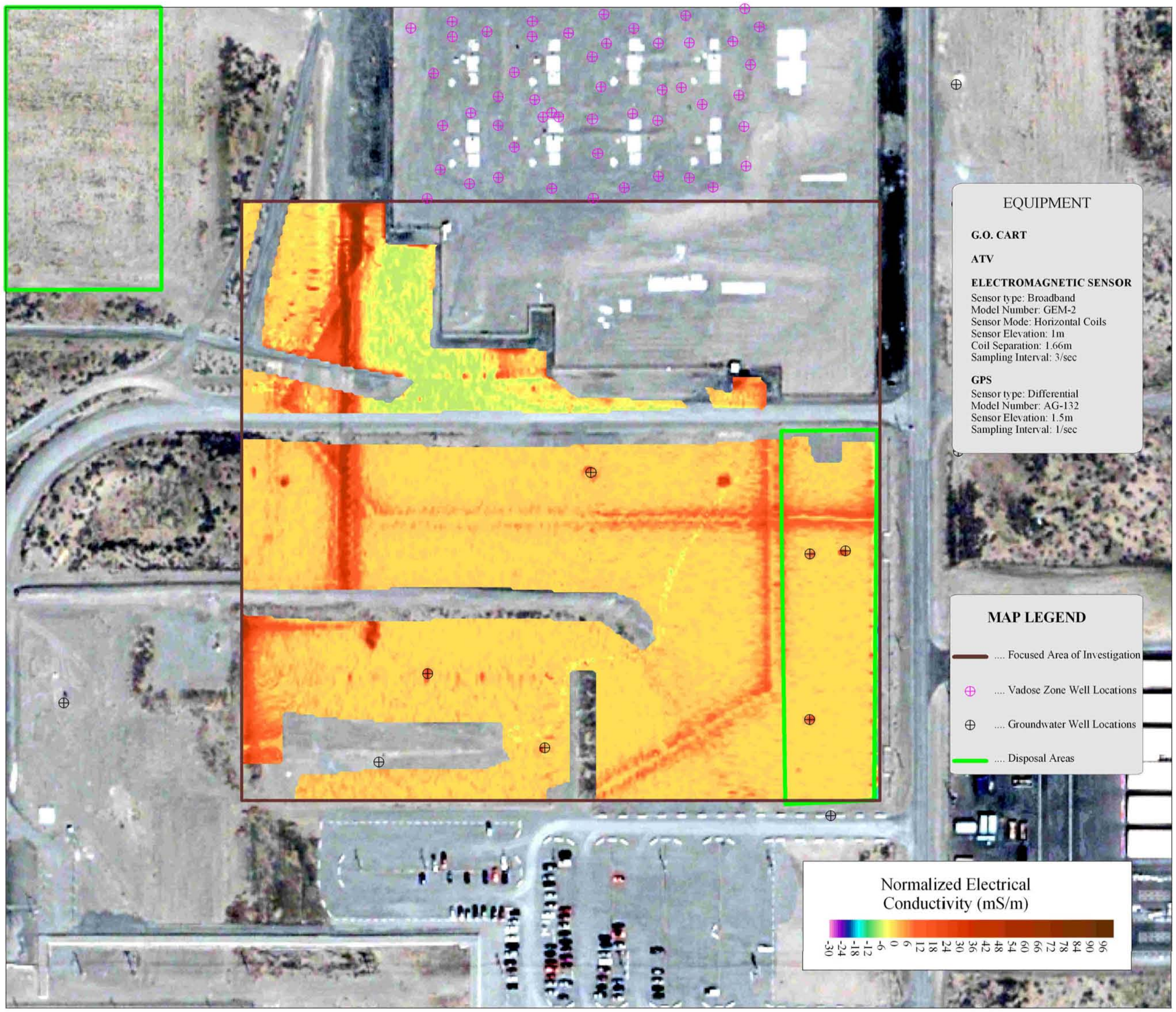


**Figure A-15. Electrical Conductivity 10kHz for the 216-T-21 to 25 Trench Area**

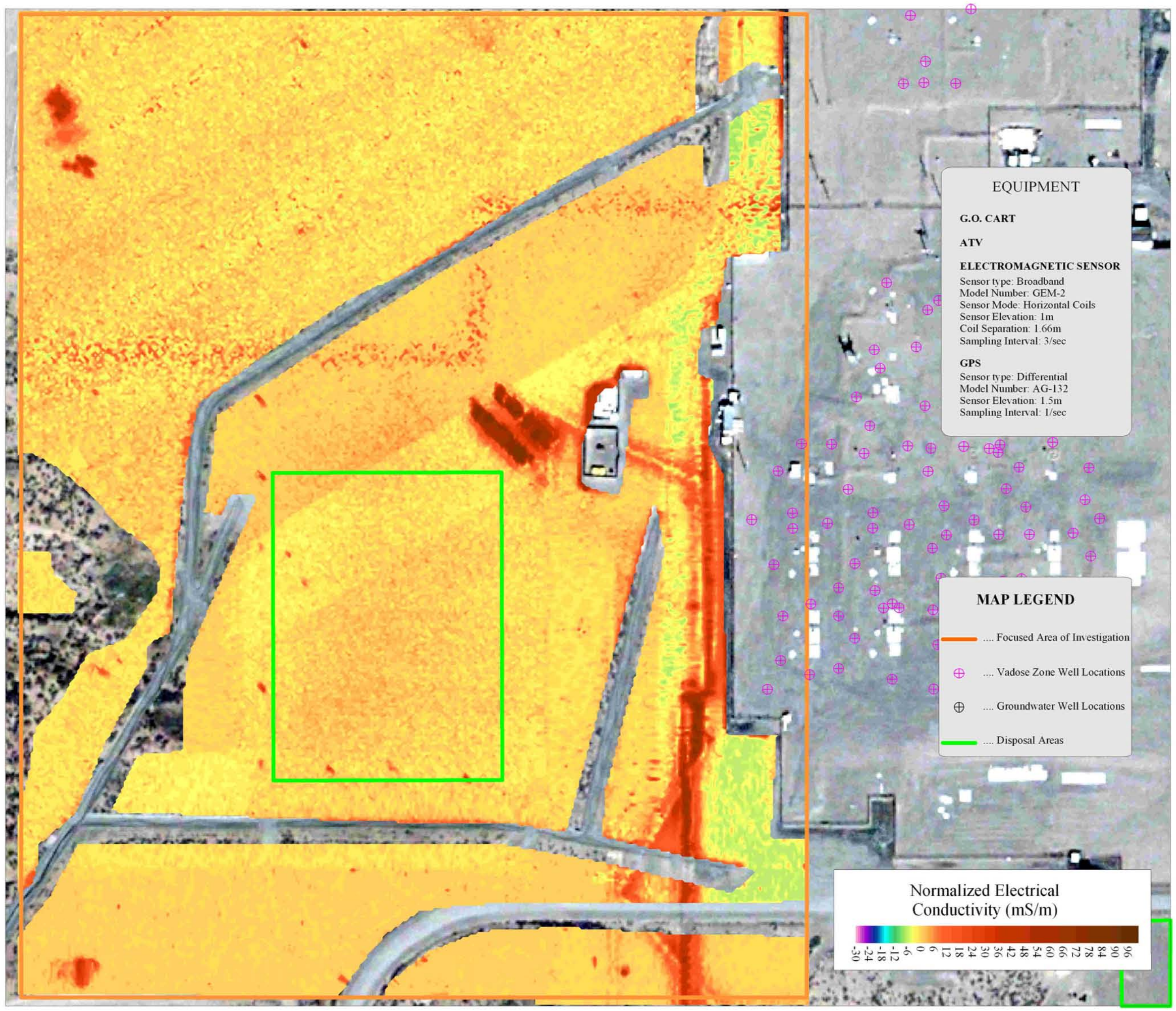


**Figure A-16. Electrical Conductivity 10kHz for the 216-T 26 to 28 Crib**

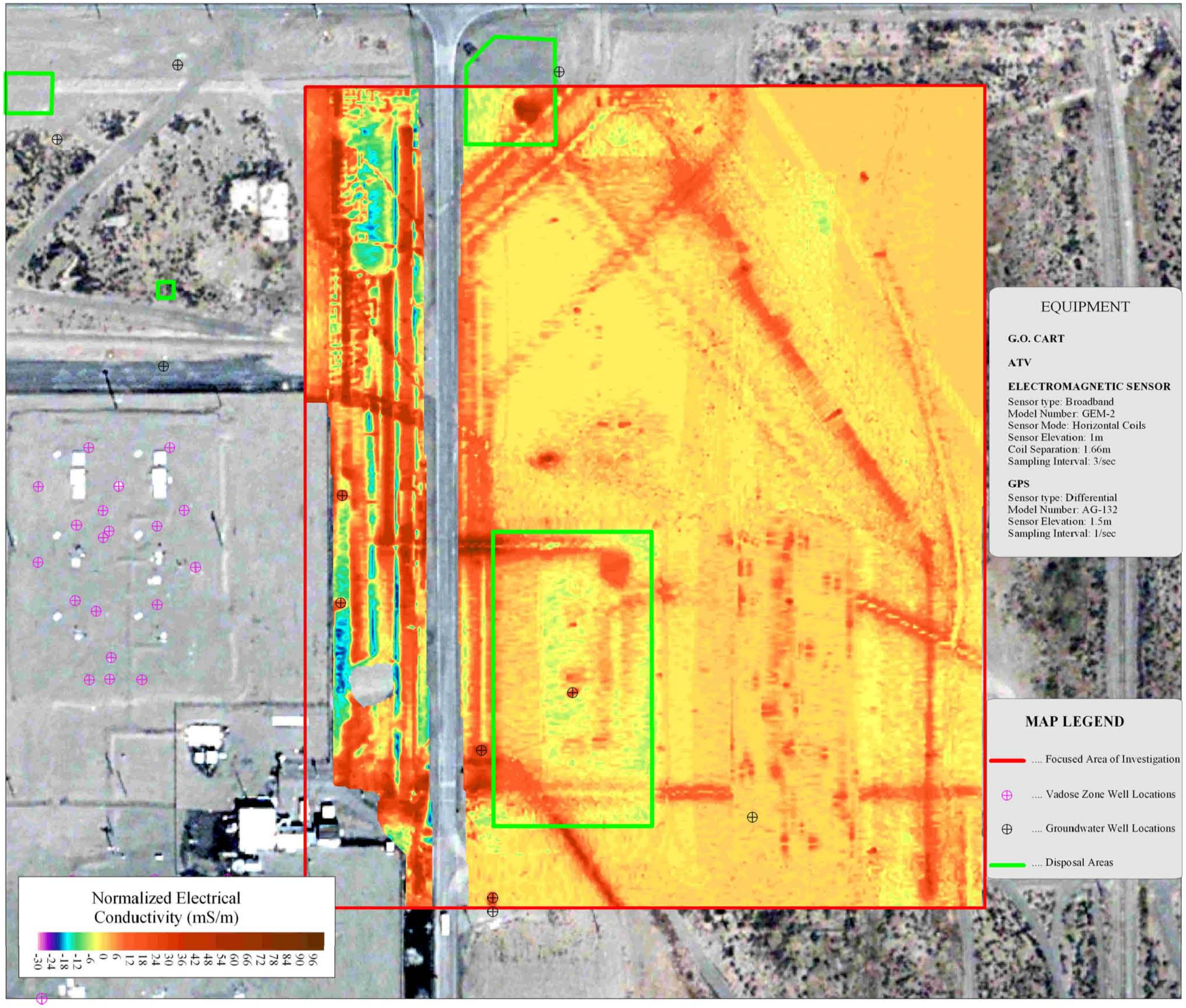


**Figure A-17. Electrical Conductivity 10kHz for the 216-T36-13 Crib**

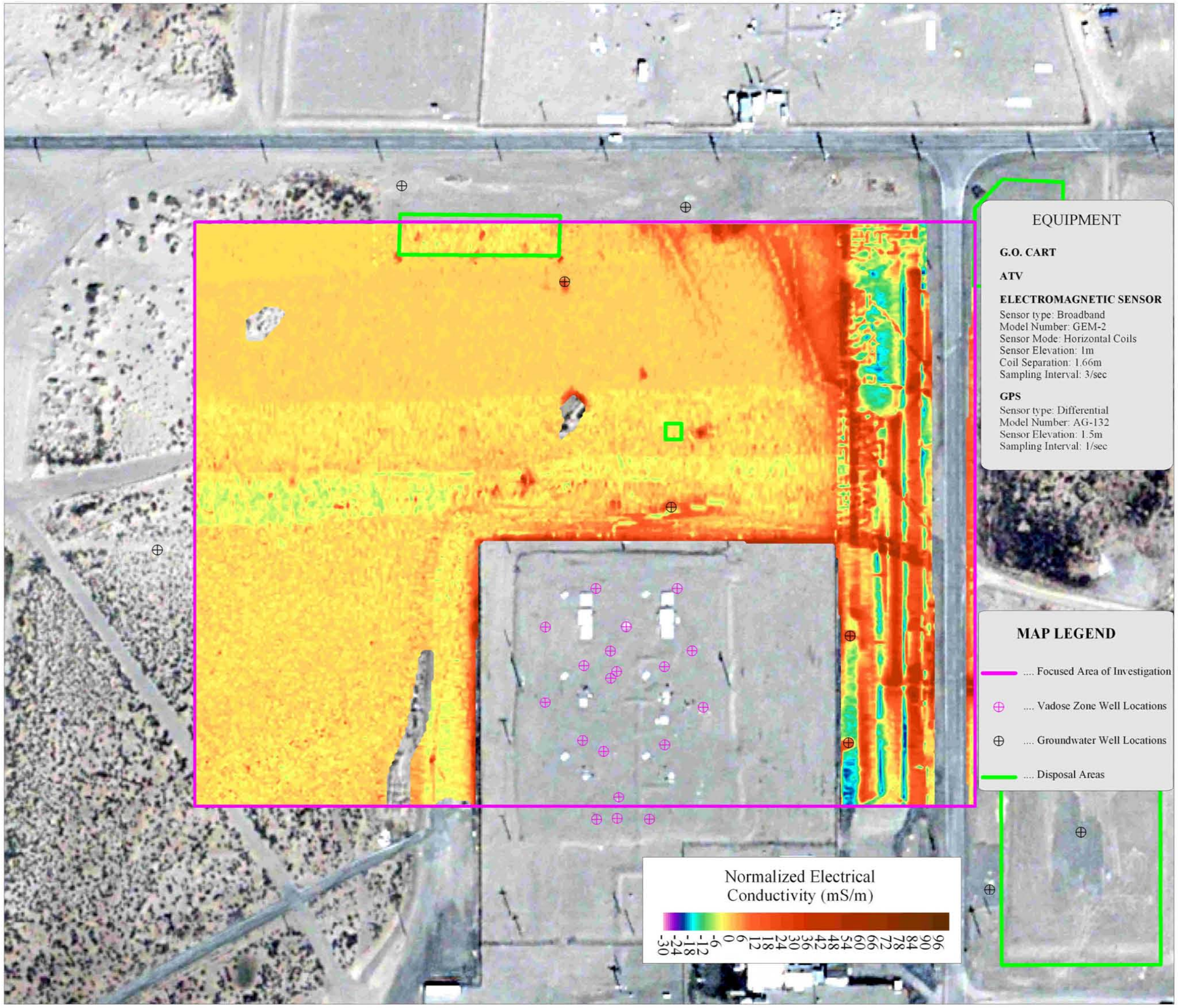


**Figure A-18. Electrical Conductivity 10kHz for the West Tx Ex-Farm Area**

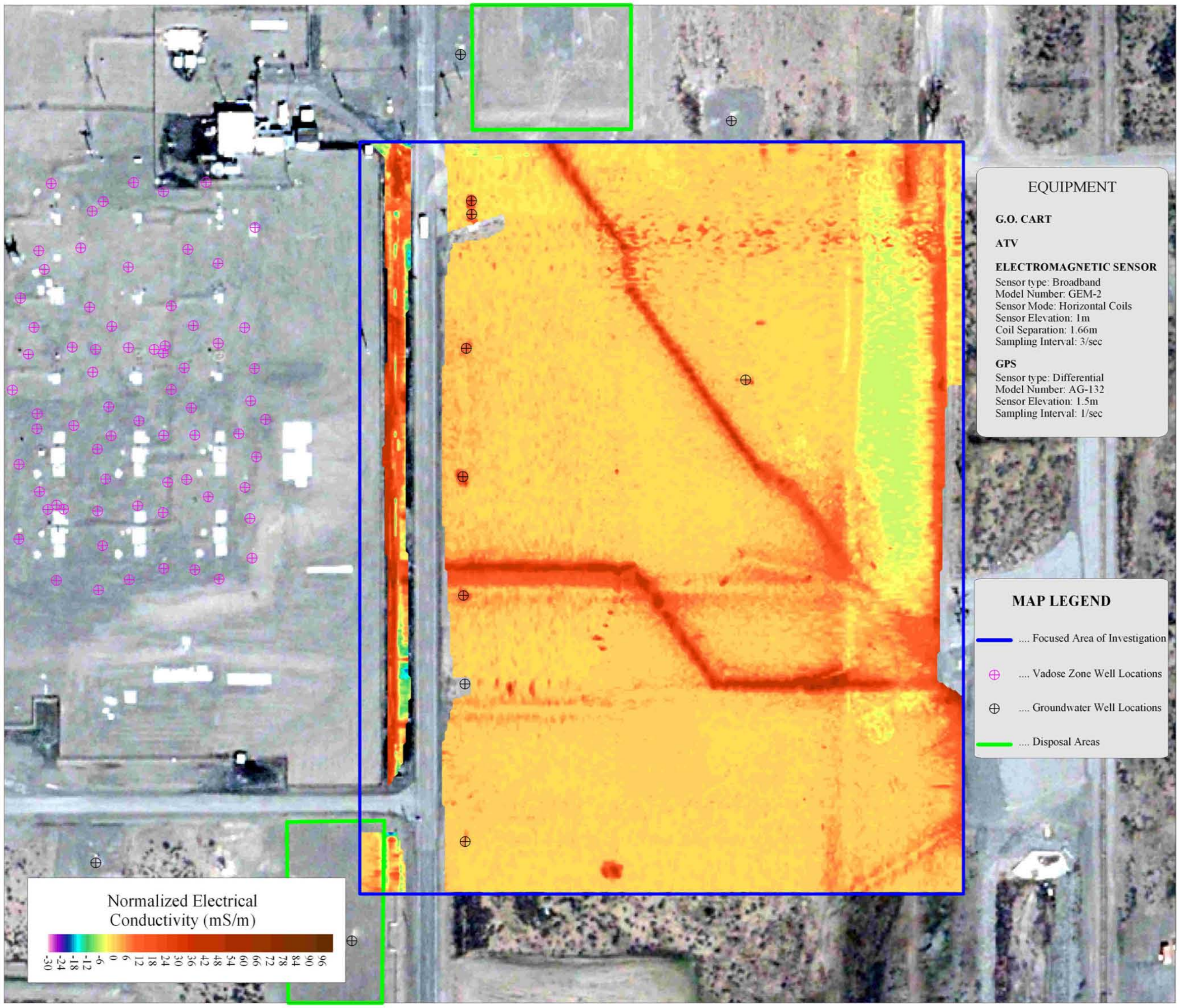


**Figure A-19. In Phase 10kHz for the Tx-Ty Farm Study Area**

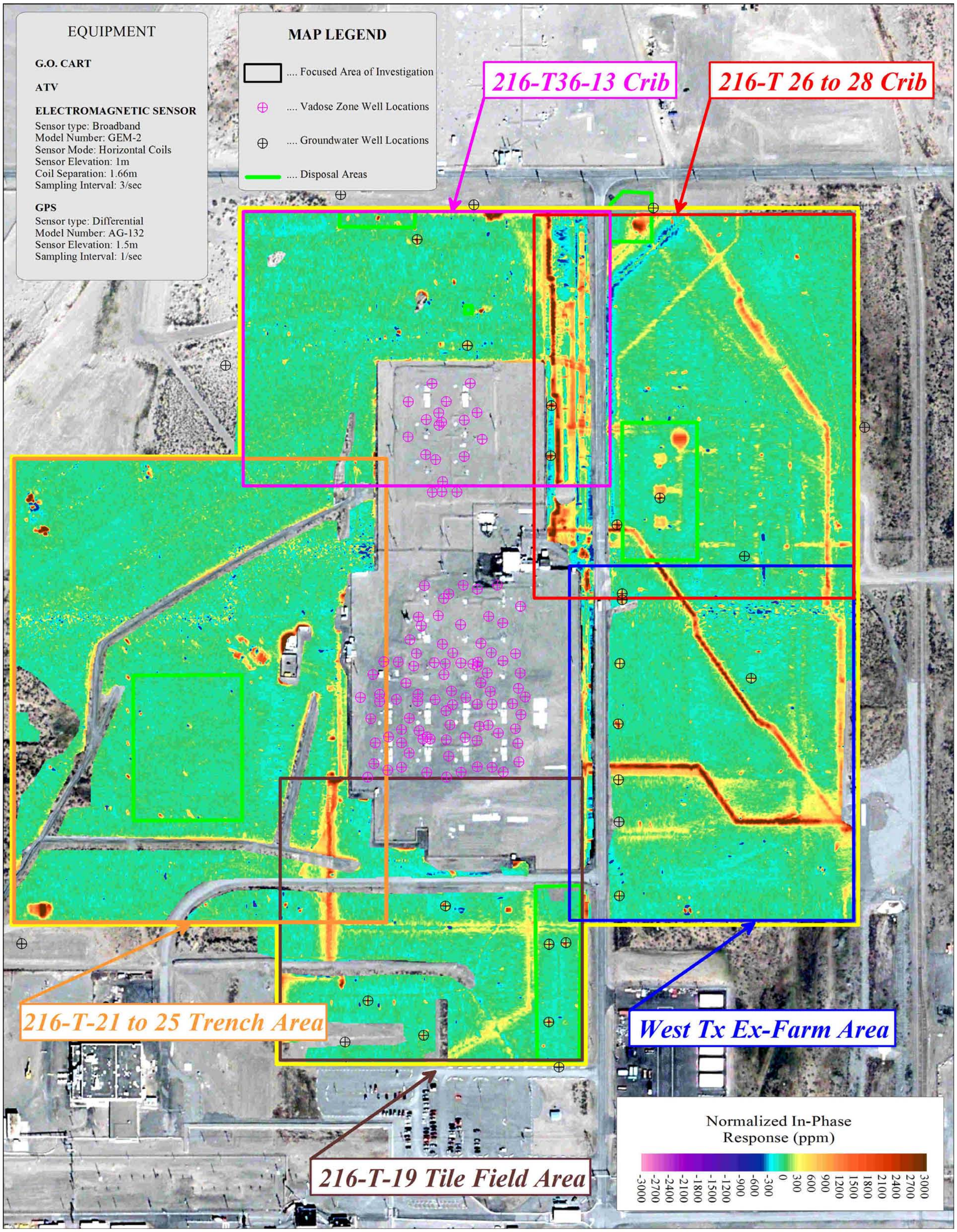


**Figure A-20. In Phase 10kHz for the 216-T-19 Tile Field Area**

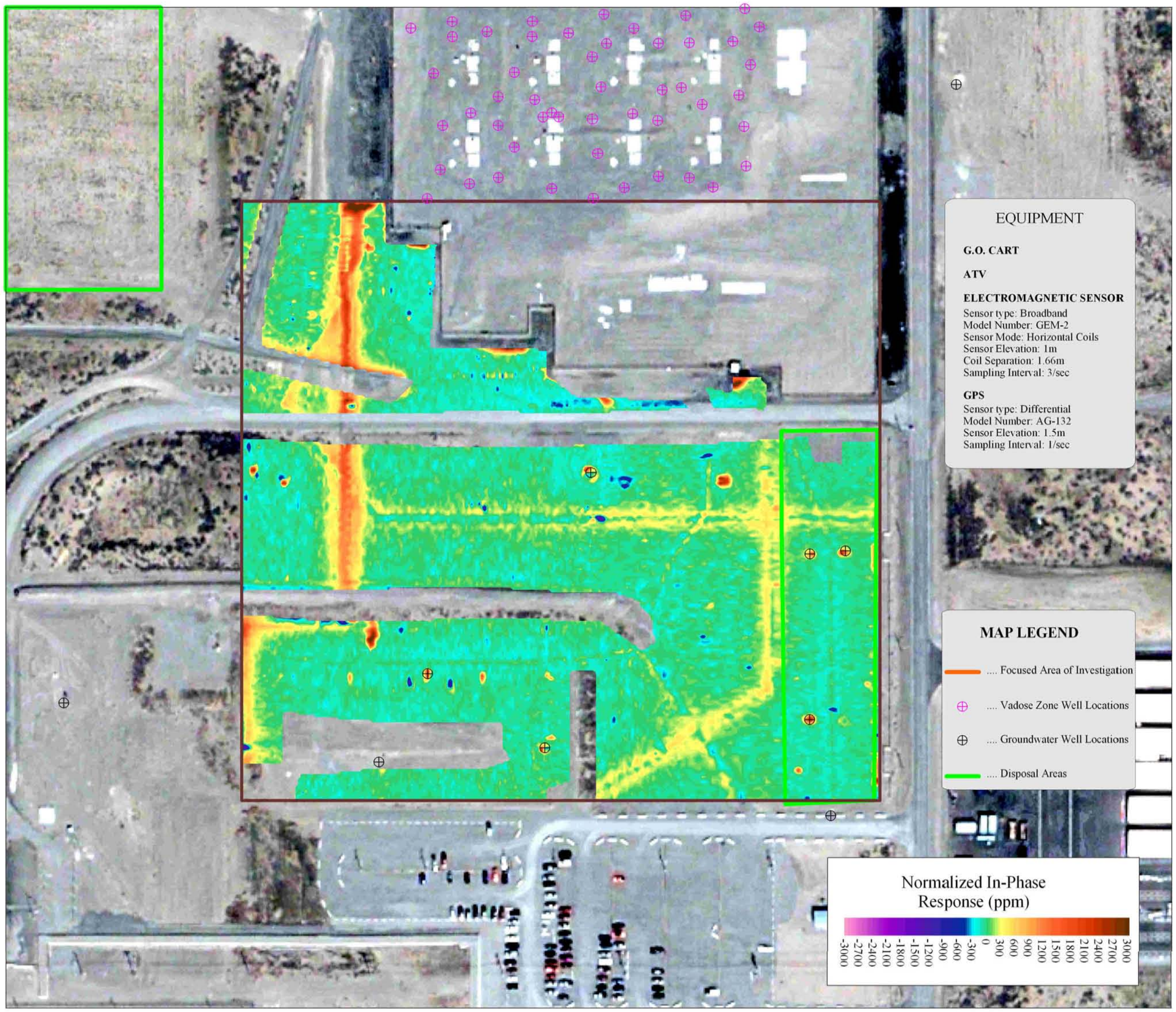


**Figure A-21. In Phase 10kHz for the 216-T-21 to 25 Trench Area**

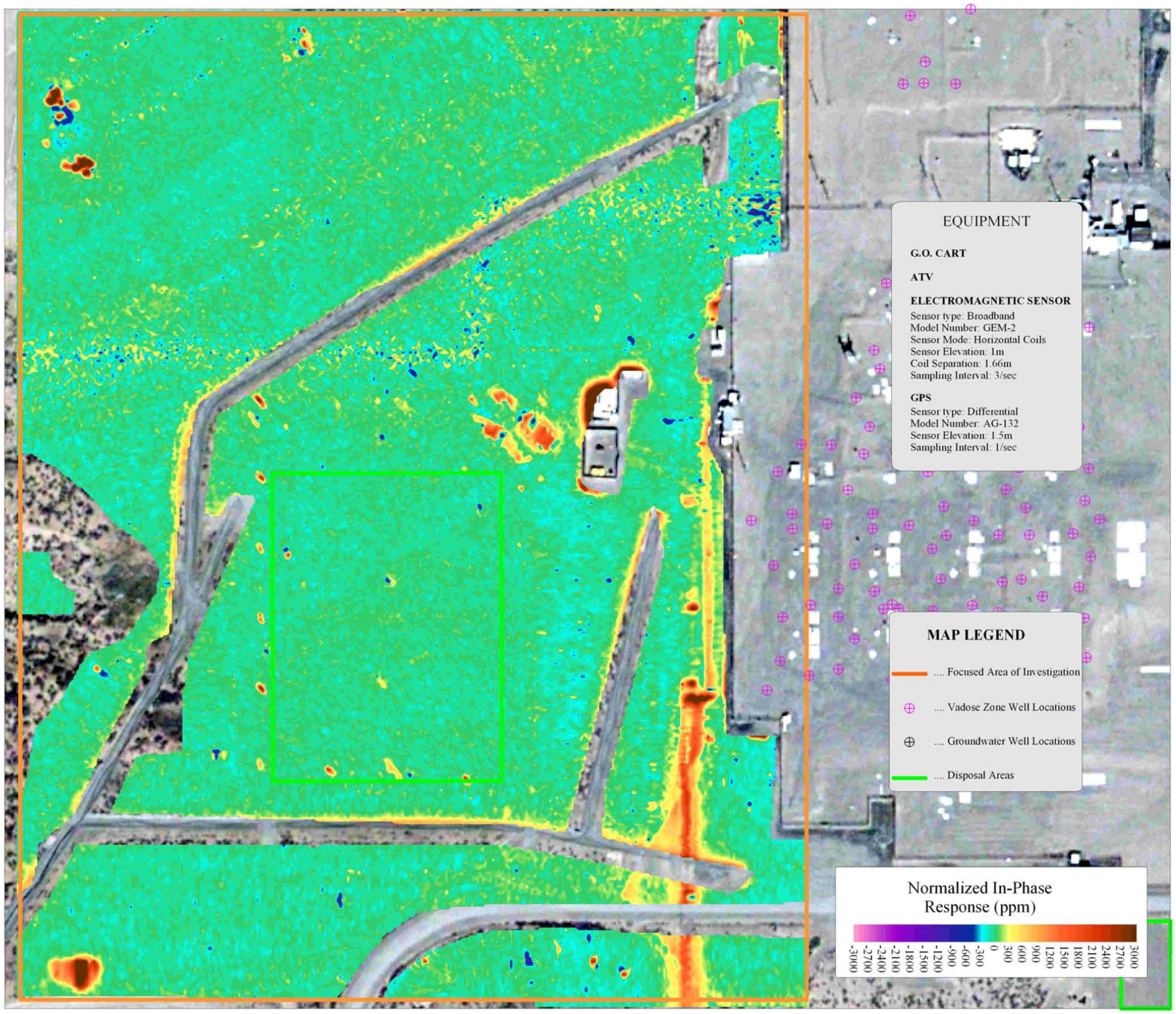


**Figure A-22. In Phase 10kHz for the 216-T 26 to 28 Crib**

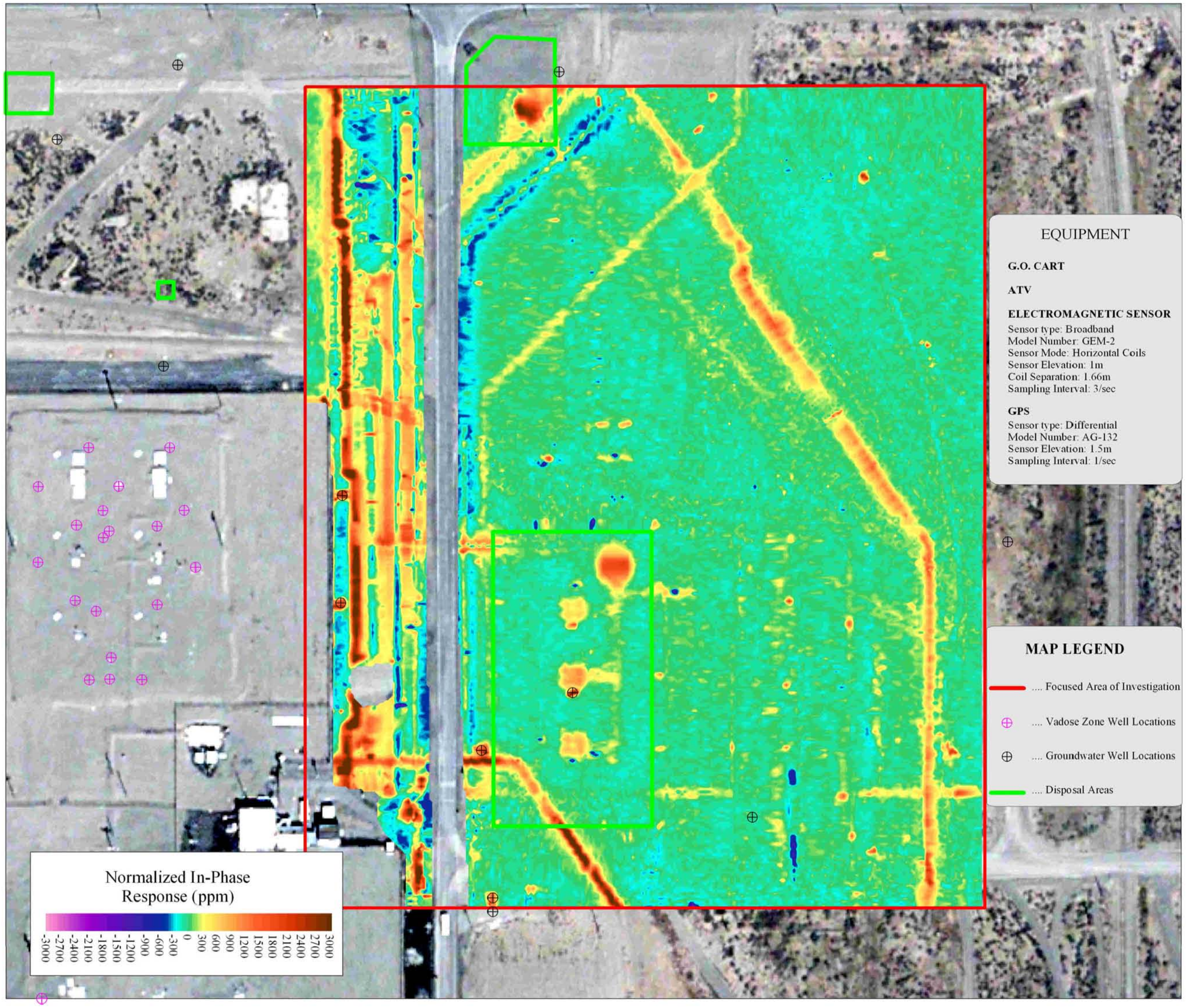


**Figure A-23. In Phase 10kHz for the 216-T36-13 Crib**

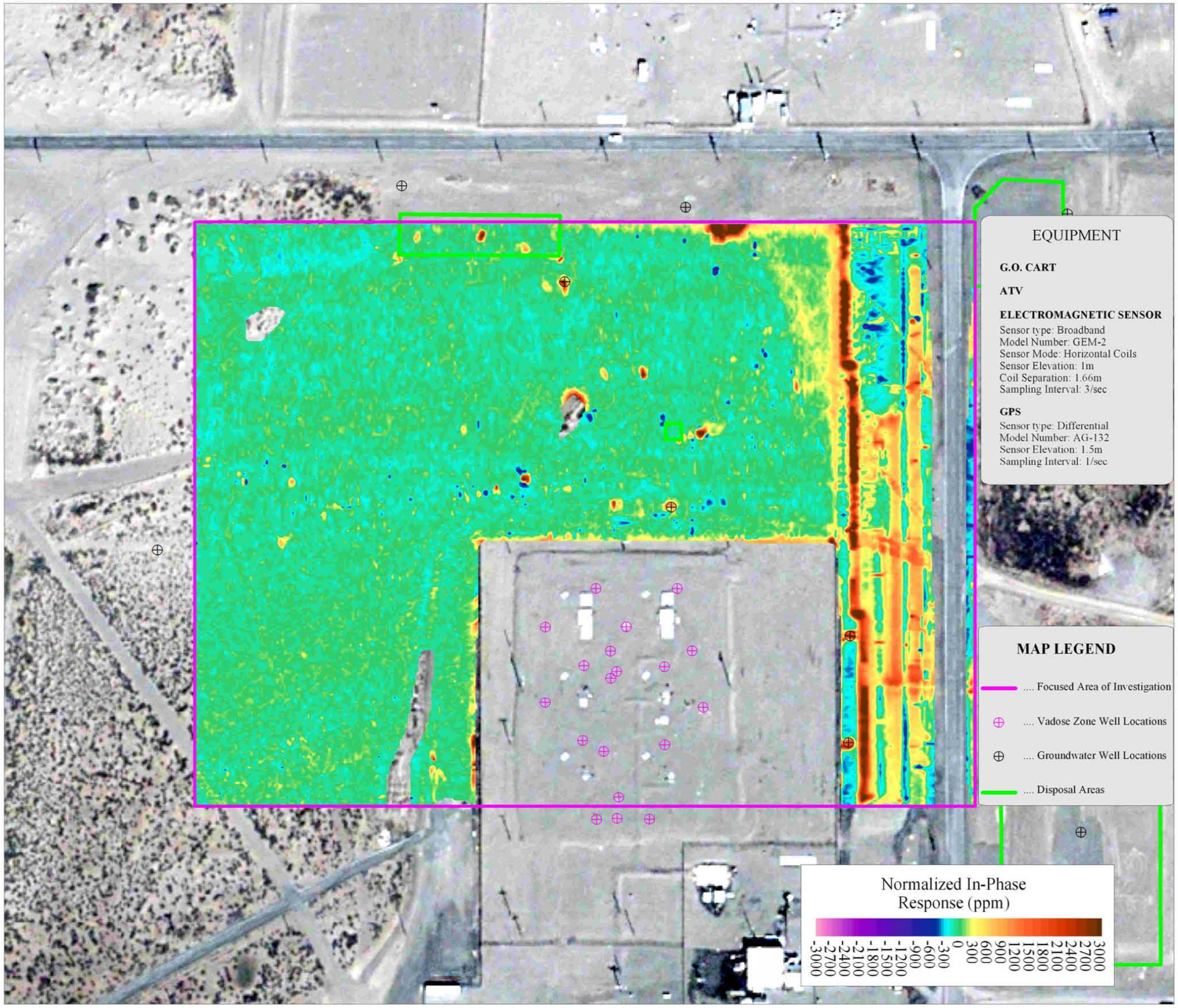


**Figure A-24. In Phase 10kHz for the 216-T36-13 West Tx Ex-Farm Area**

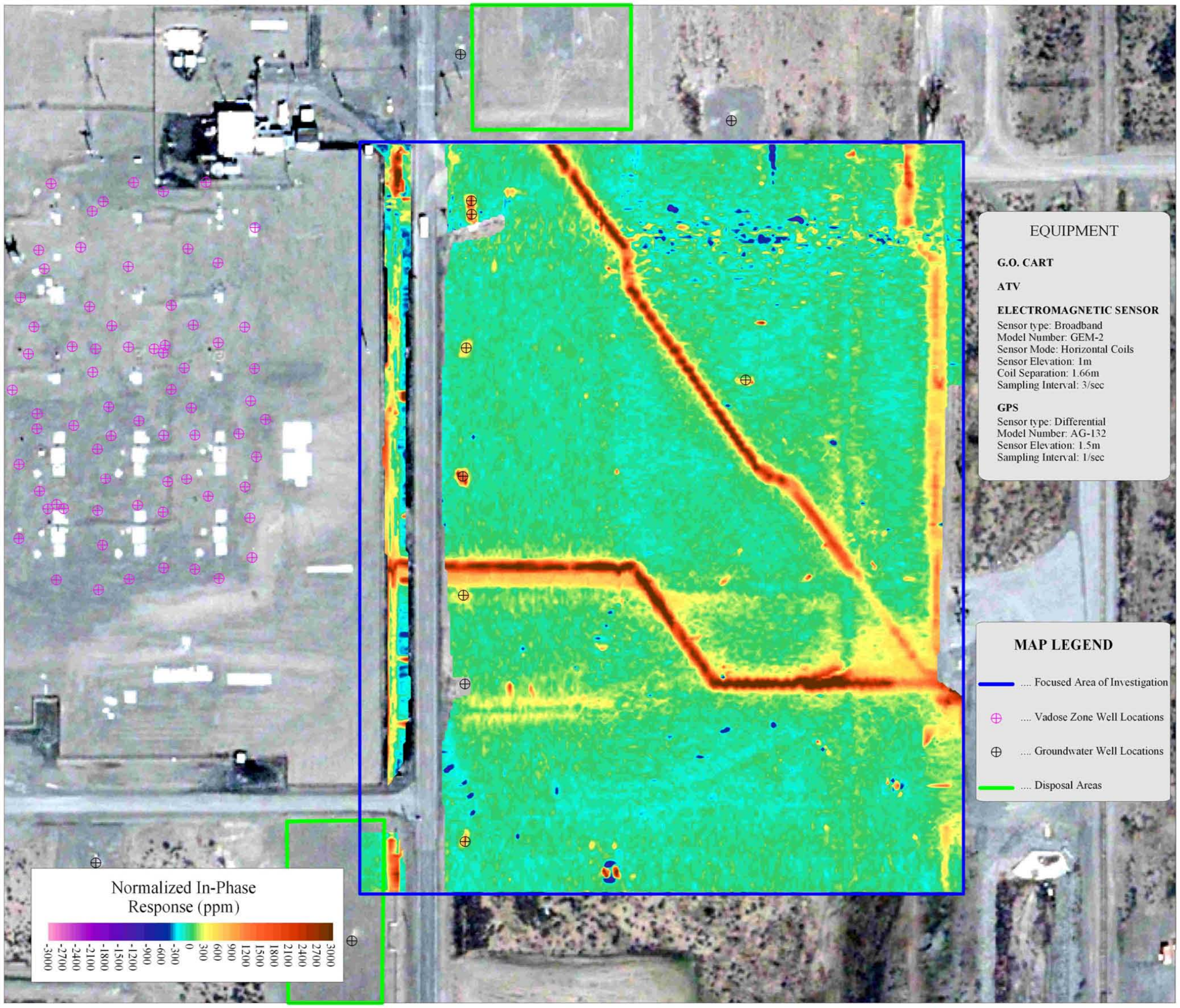


**Figure A-25. Electrical Conductivity 20kHz for the Tx Ty-Farm Area**

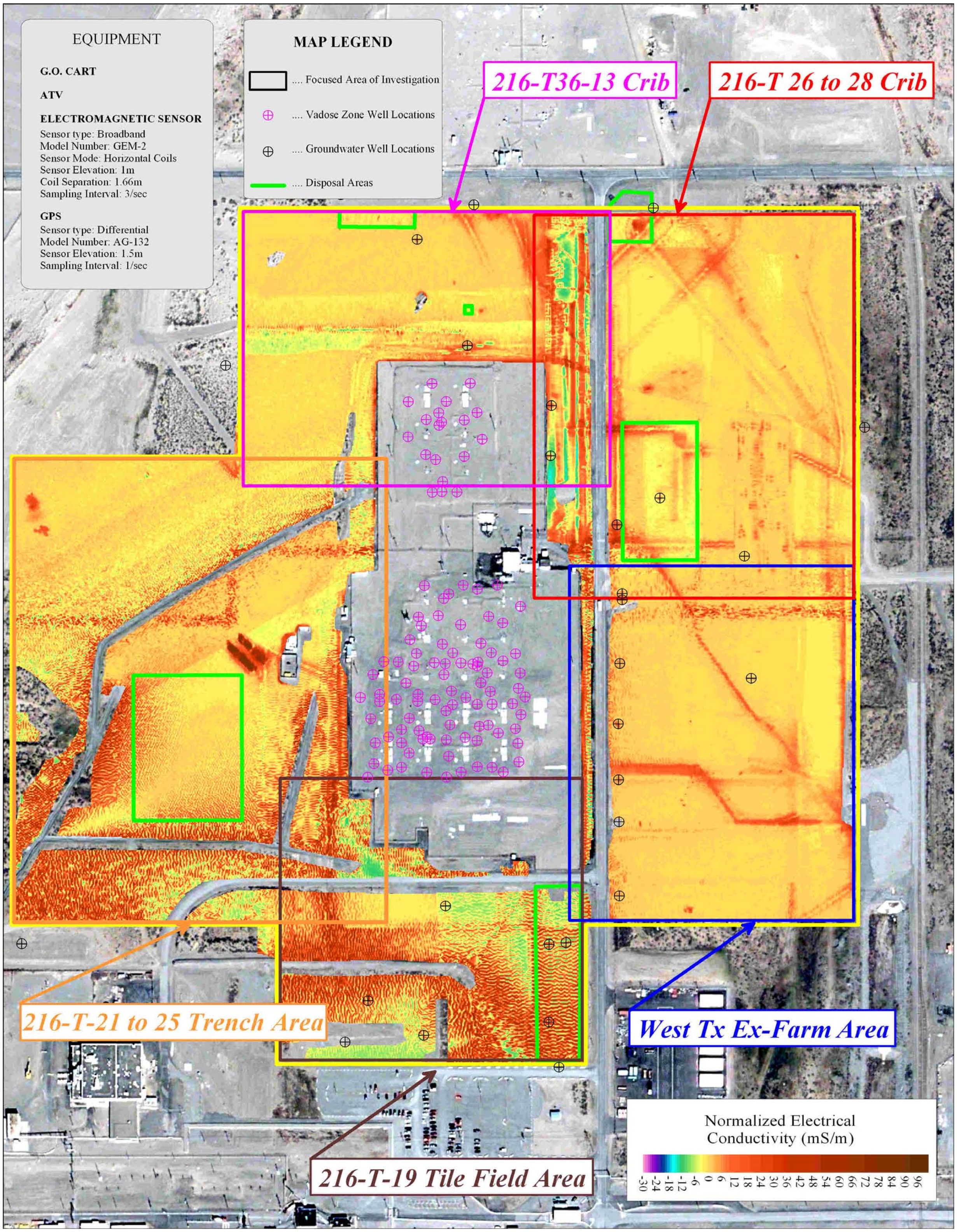


**Figure A-26. Electrical Conductivity 20kHz for the 216-T-19 Tile Field Area**

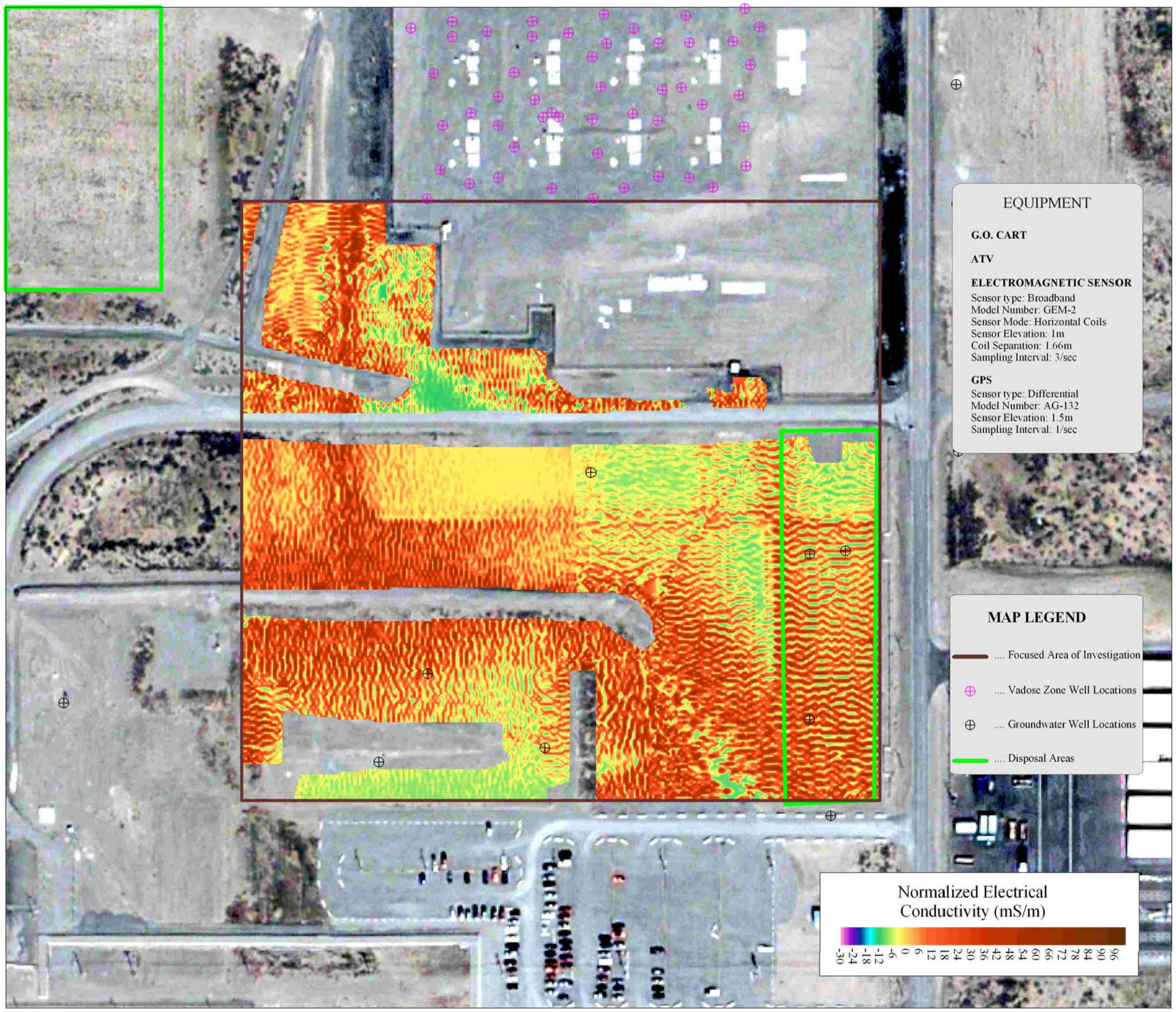


**Figure A-27. Electrical Conductivity 20kHz for the 216-T-21 to 25 Trench Area**

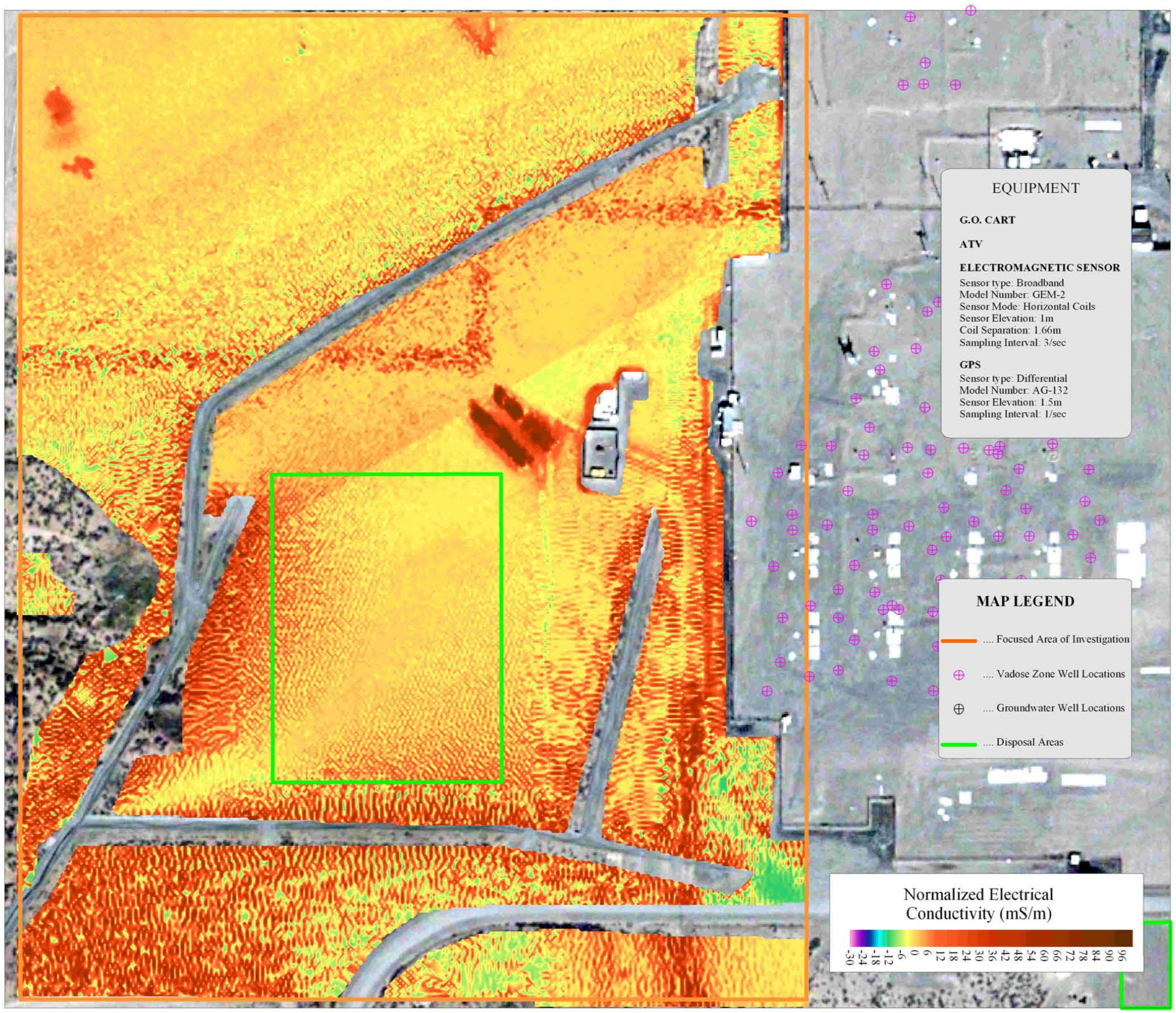


**Figure A-28. Electrical Conductivity 20kHz for the 216-T 26 to 28 Crib**

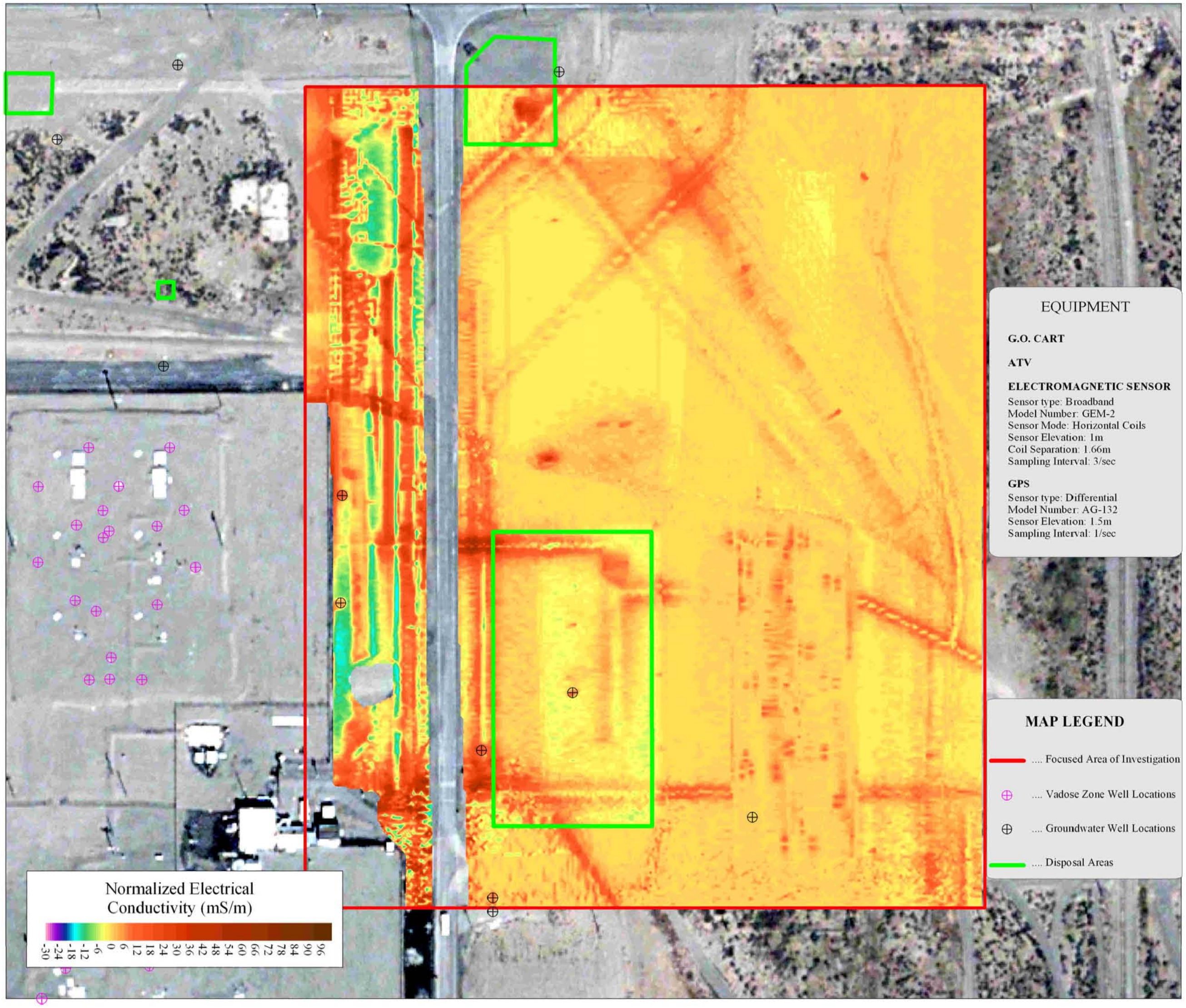


**Figure A-29. Electrical Conductivity 20kHz for the 216-T36-13 Crib**

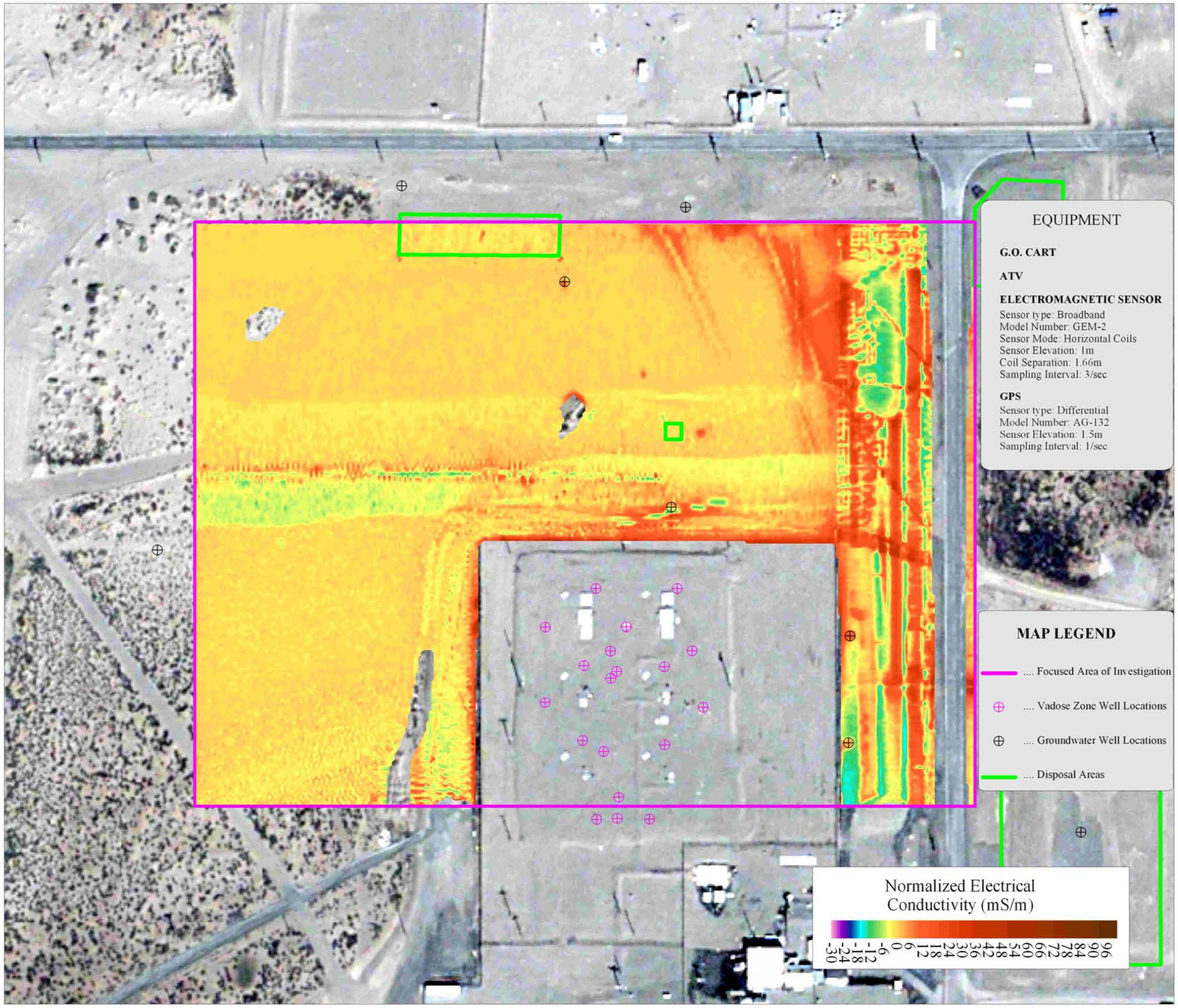


**Figure A-30. Electrical Conductivity 20kHz for the West Tx Ex-Farm Area**

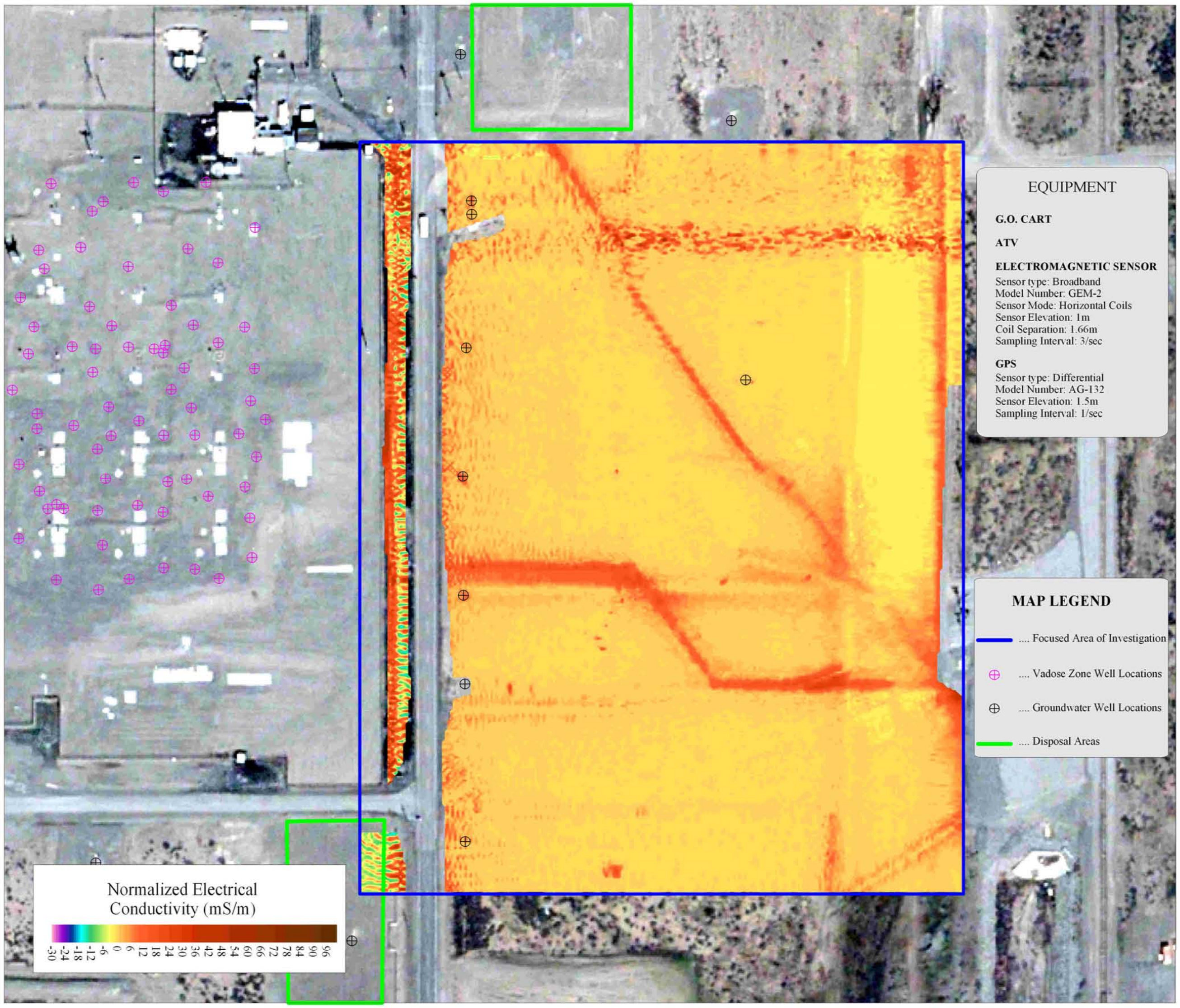


**Figure A-31. In Phase 20kHz for the TxTy Farm Study Area**

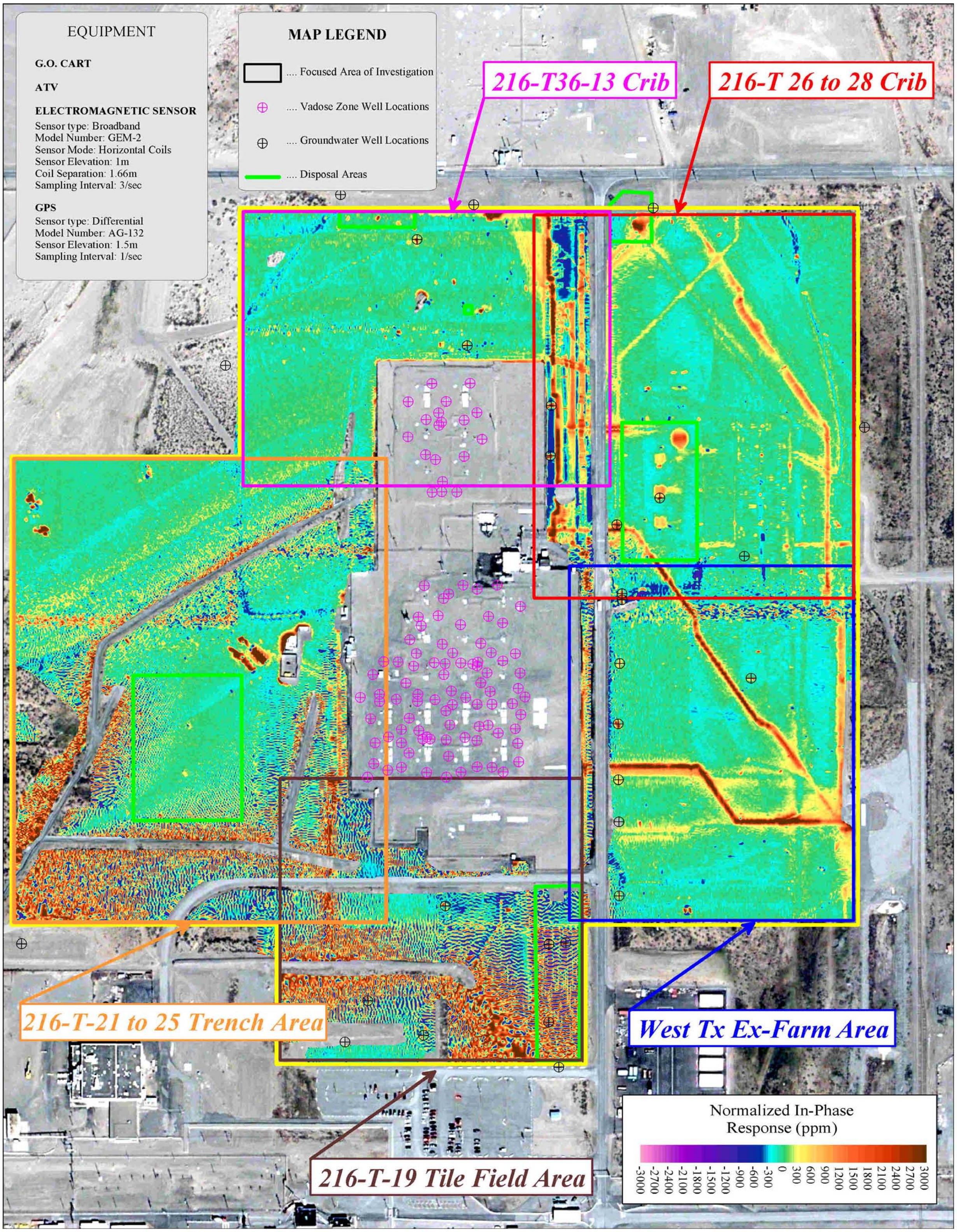


**Figure A-32. In Phase 20kHz for the 216-T-19 Tile Field Area**

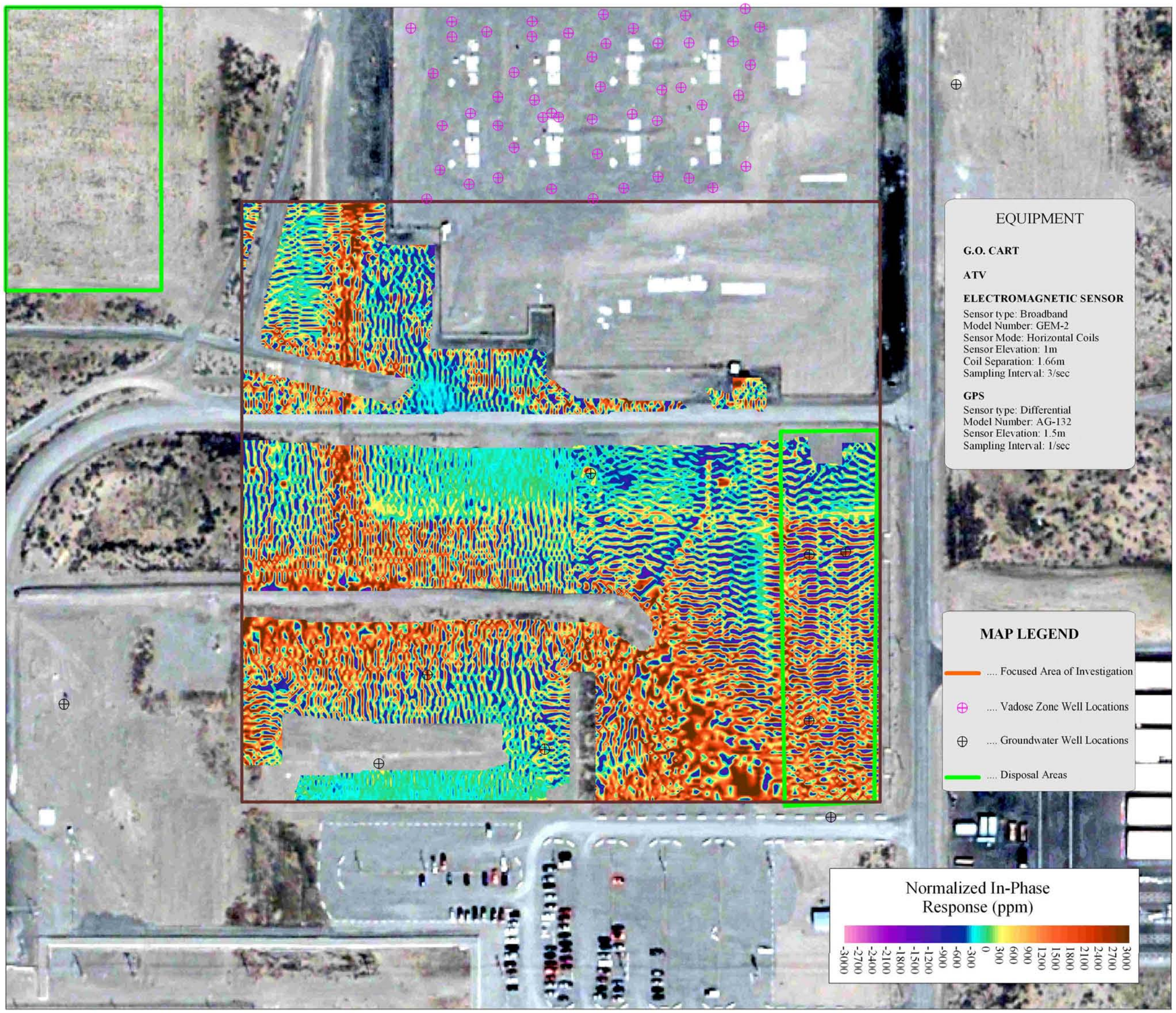


**Figure A-33. In Phase 20kHz for the 216-T-21 to 25 Trench Area**

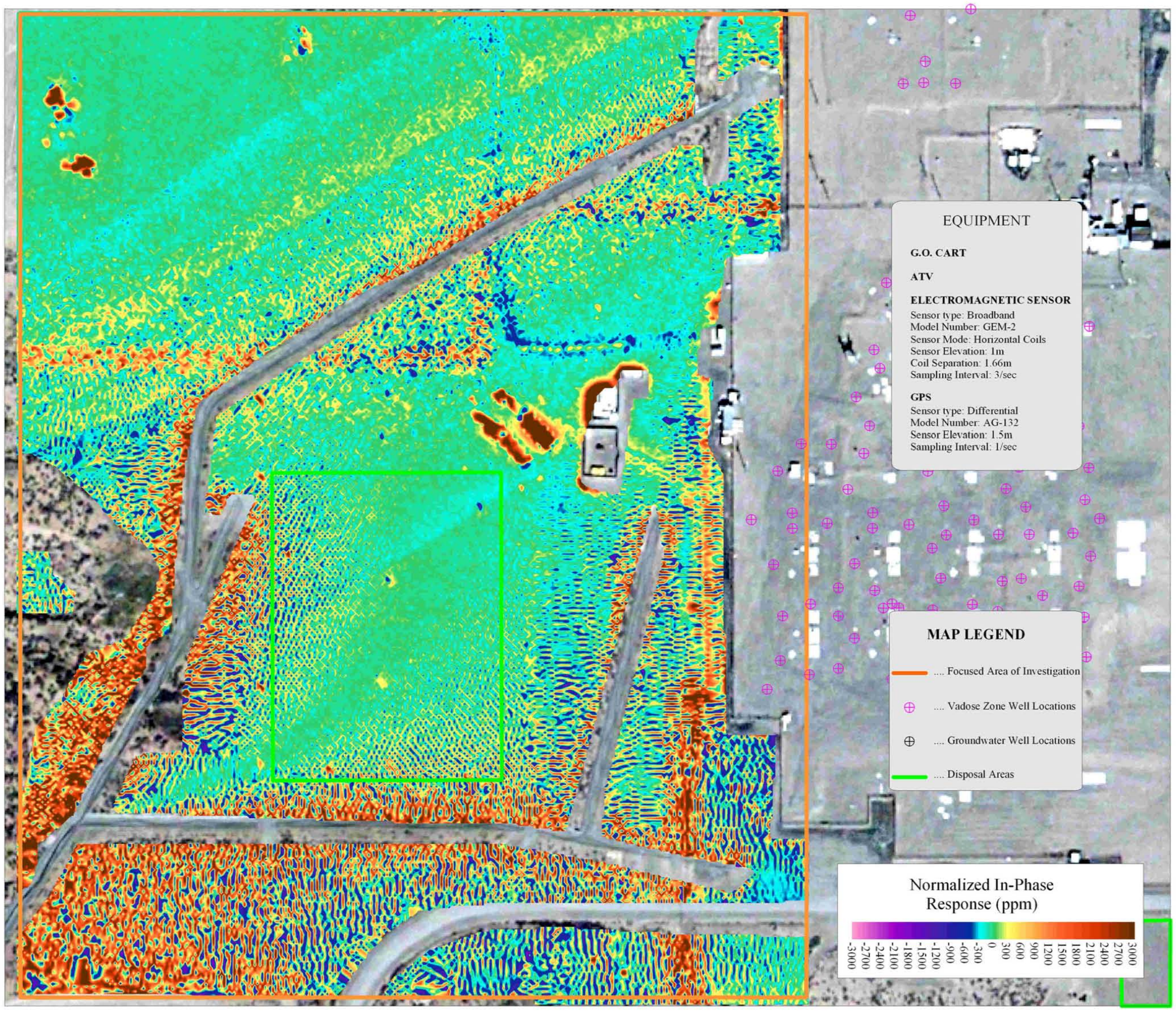


**Figure A-34. In Phase 20kHz for the 216-T 26 to 28 Crib**

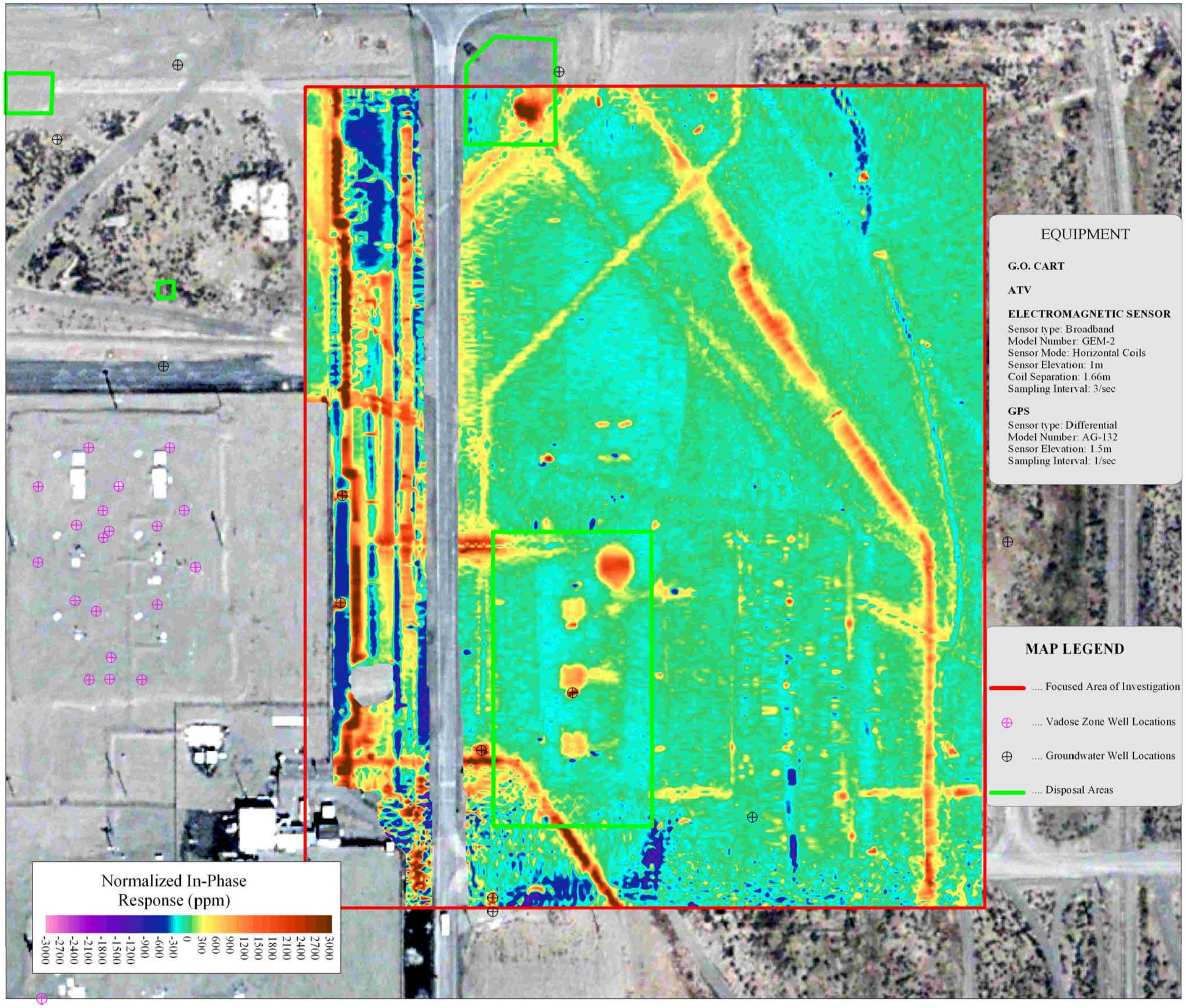
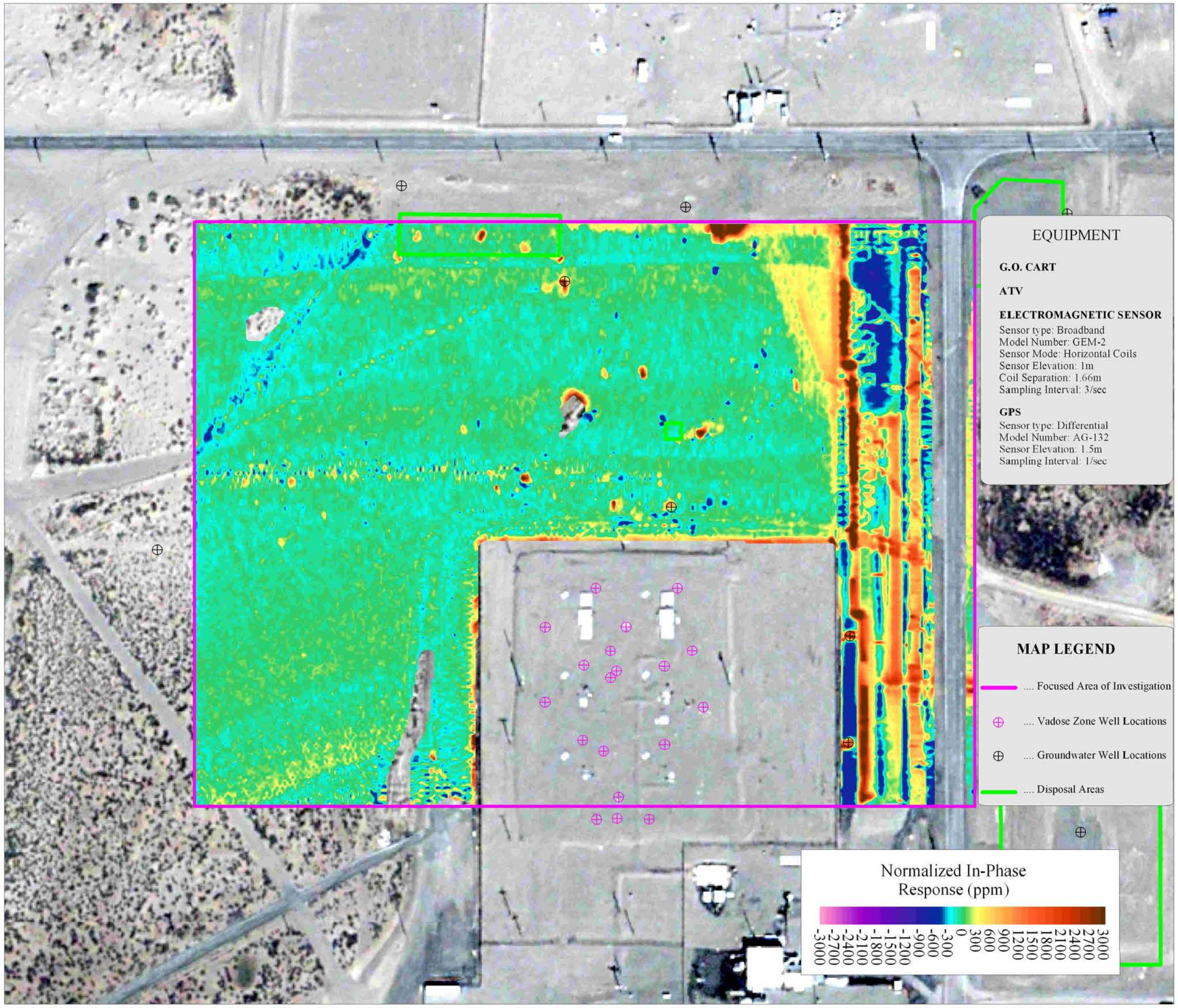


**Figure A-35. In Phase 20kHz for the 216-T36-13 Crib**



## Figure A-36. In Phase 20kHz for the West Tx Ex-Farm Area

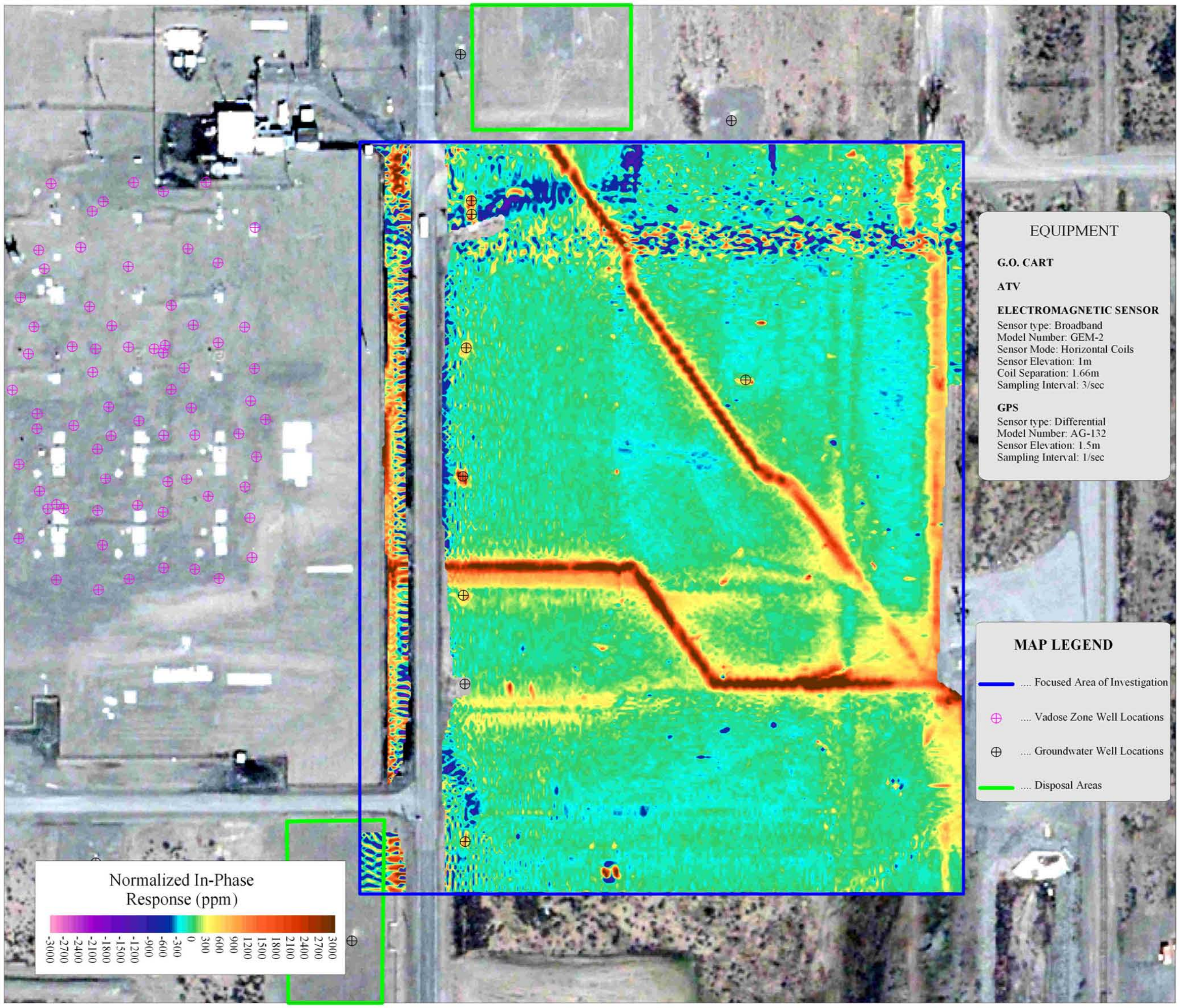
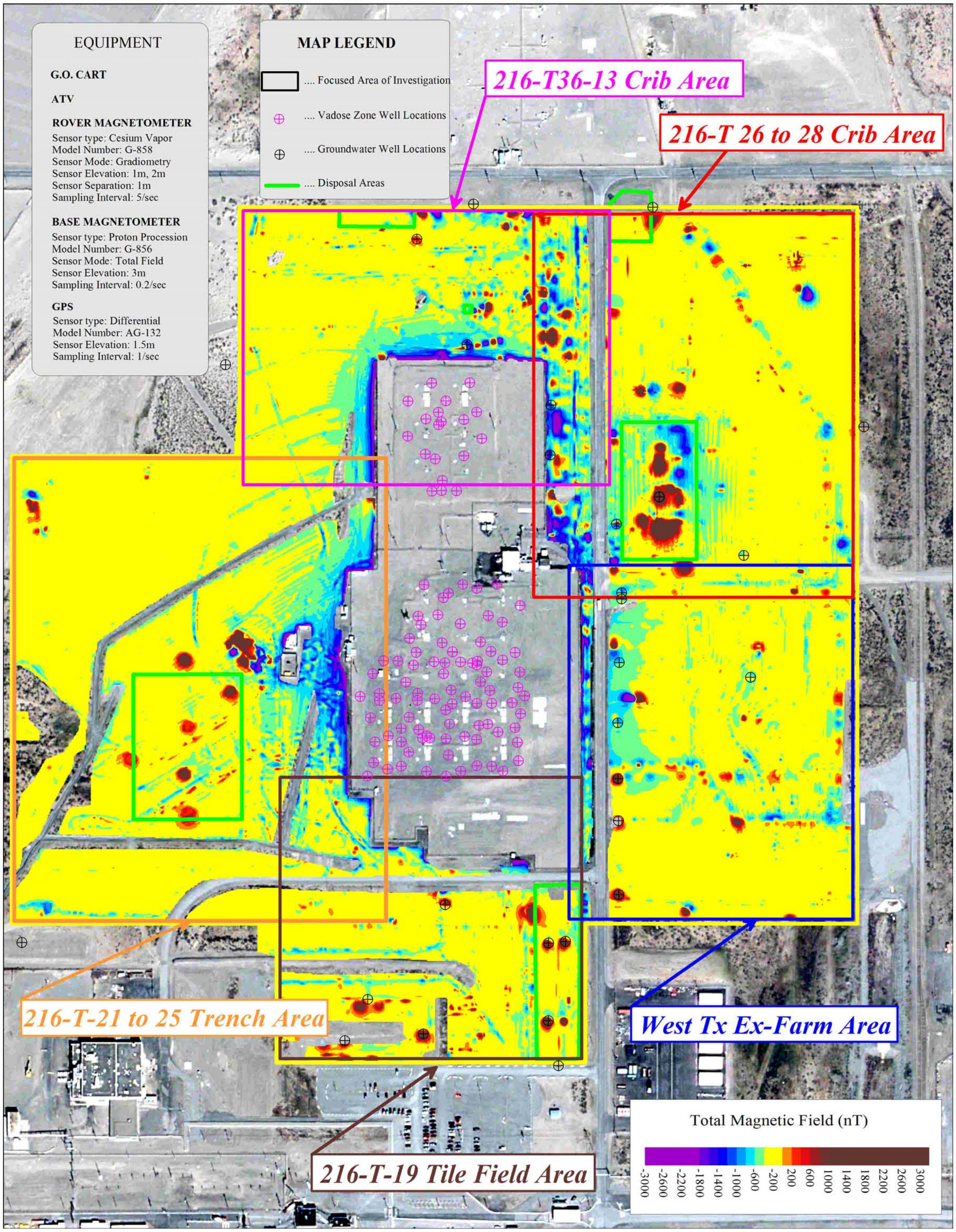


**Figure A-37 Total Field TxTy Farm Study Area**



## Figure A-38 Total Field for the 216-T-19 Tile Field Area

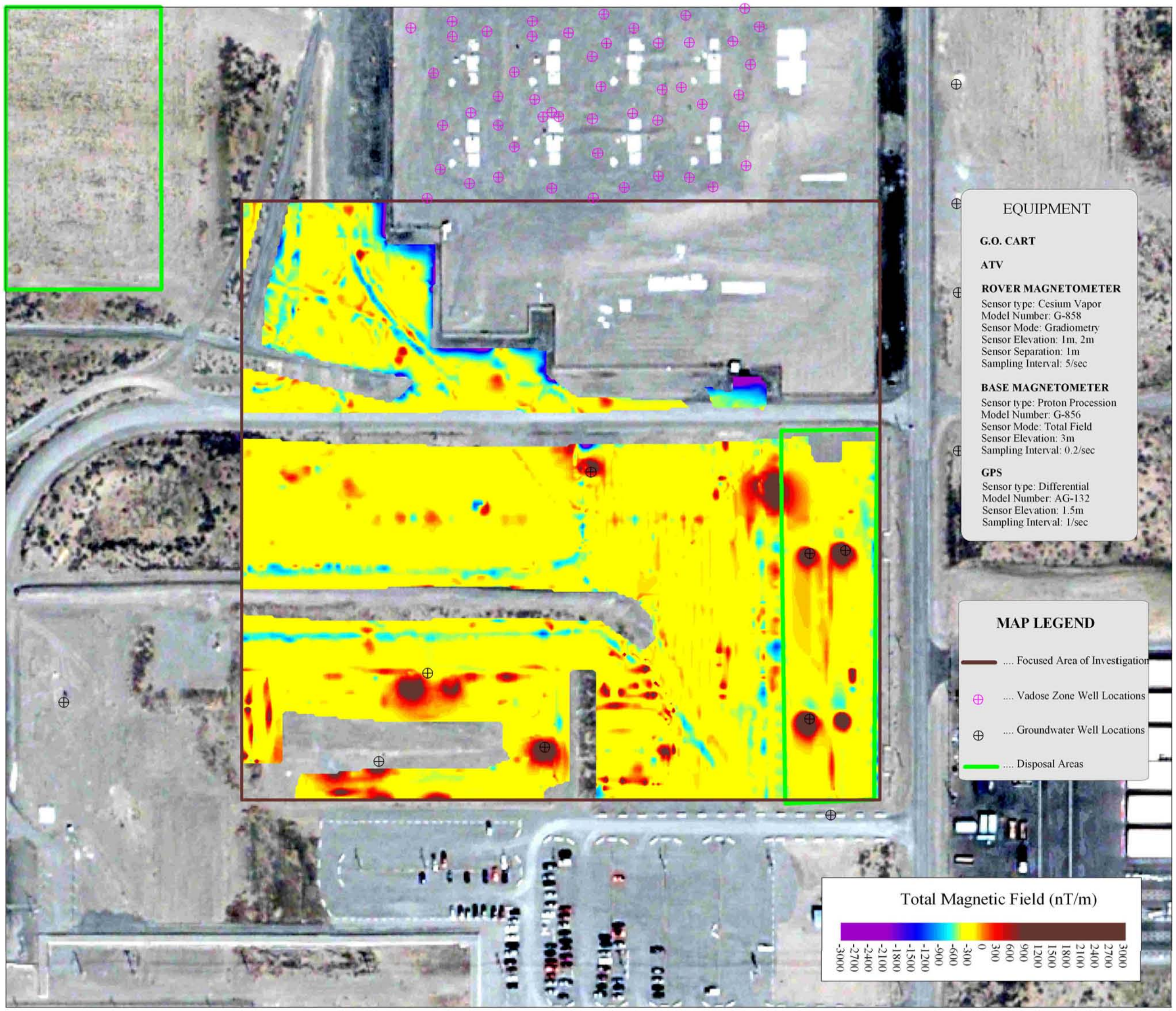


**Figure A-39 Total Field for the 216-T-21 to 25 Trench Area**

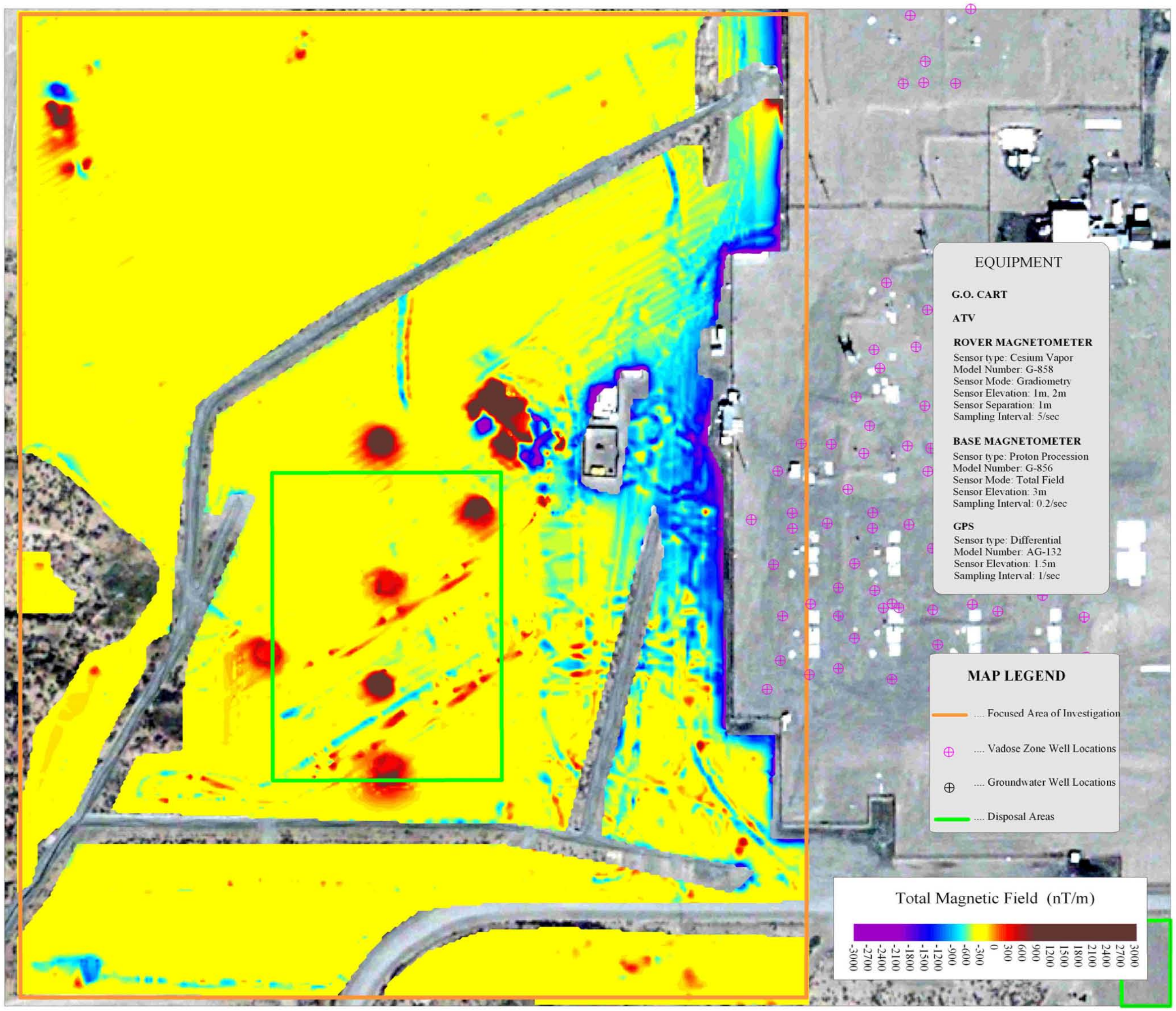


**Figure A-40 Total Field for the 216-T 26 to 28 Crib**

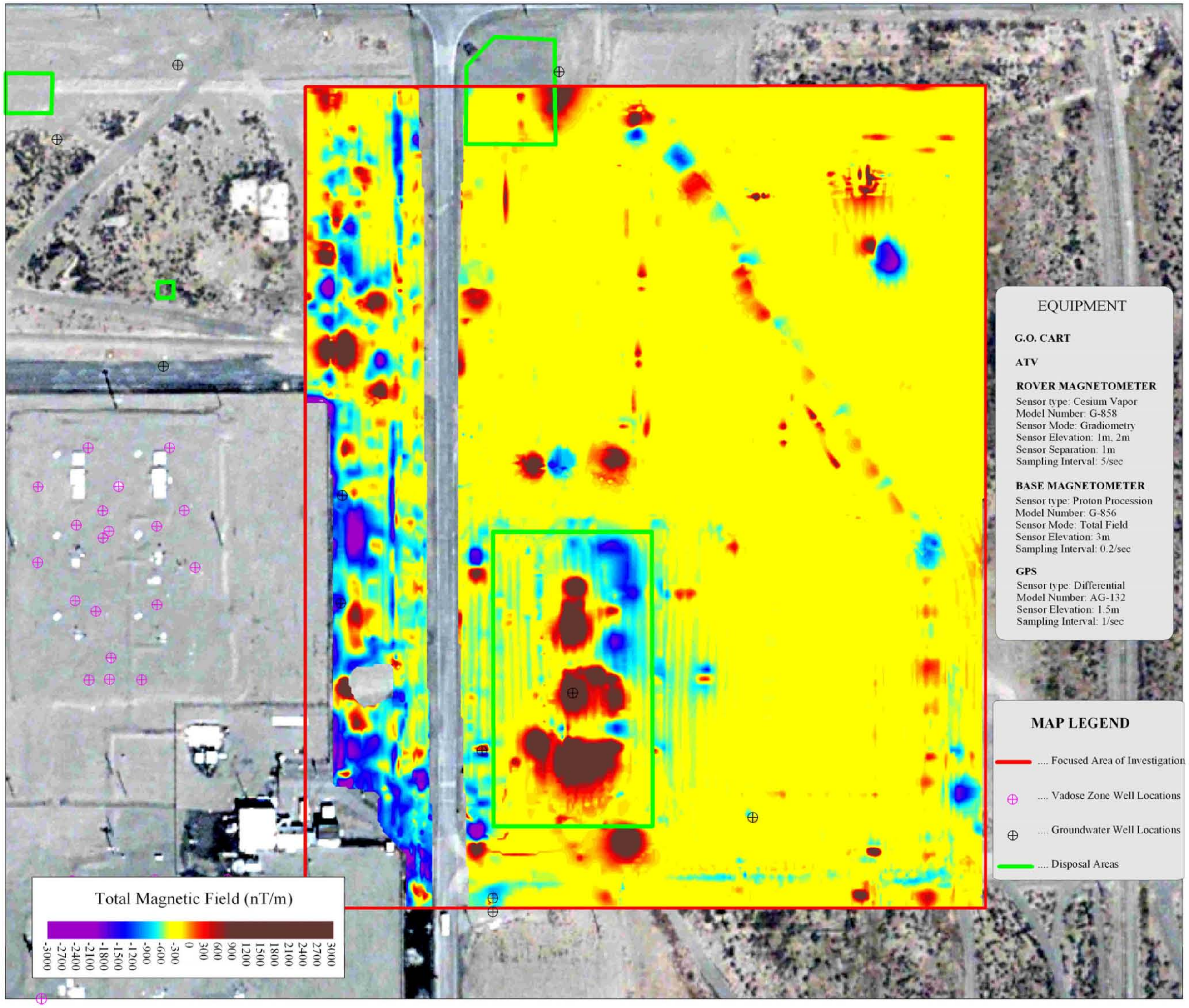
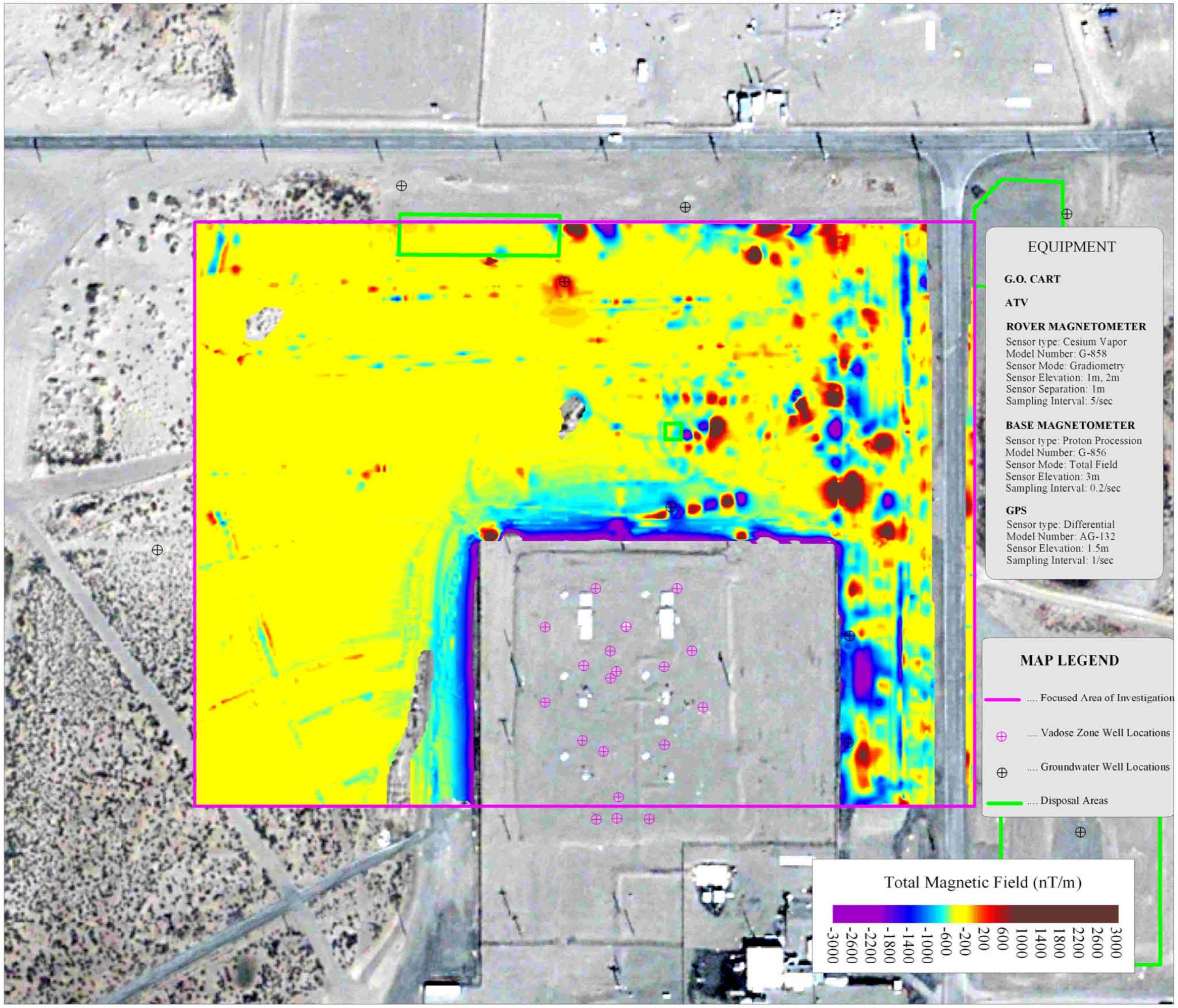


**Figure A-41 Total Field for the 216-T36-13 Crib**



## Figure A-42 Total Field for the West Tx Ex-Farm Area

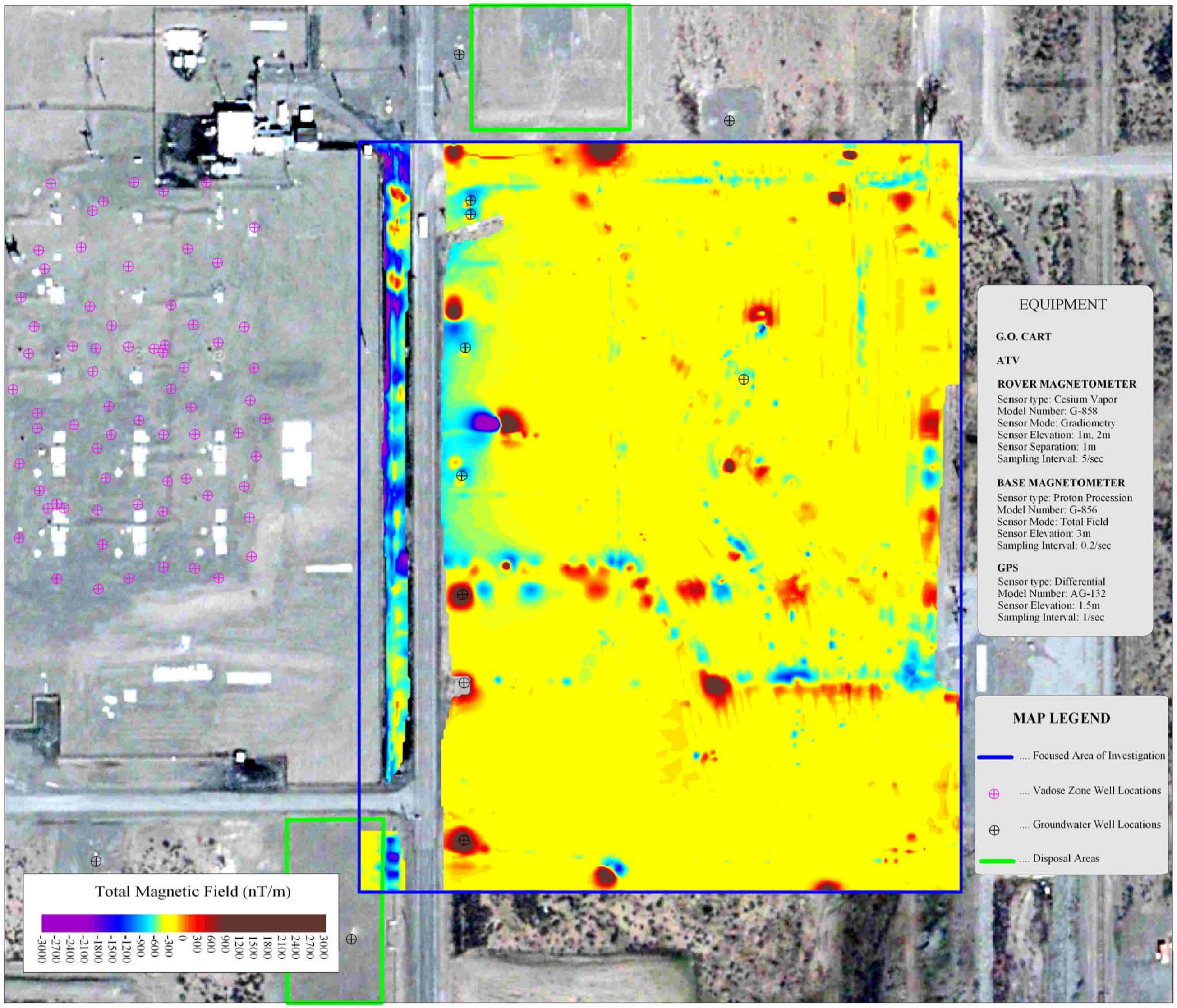


**Figure A-43 Vertical Gradient for the Tx-Ty Farm Study Area**

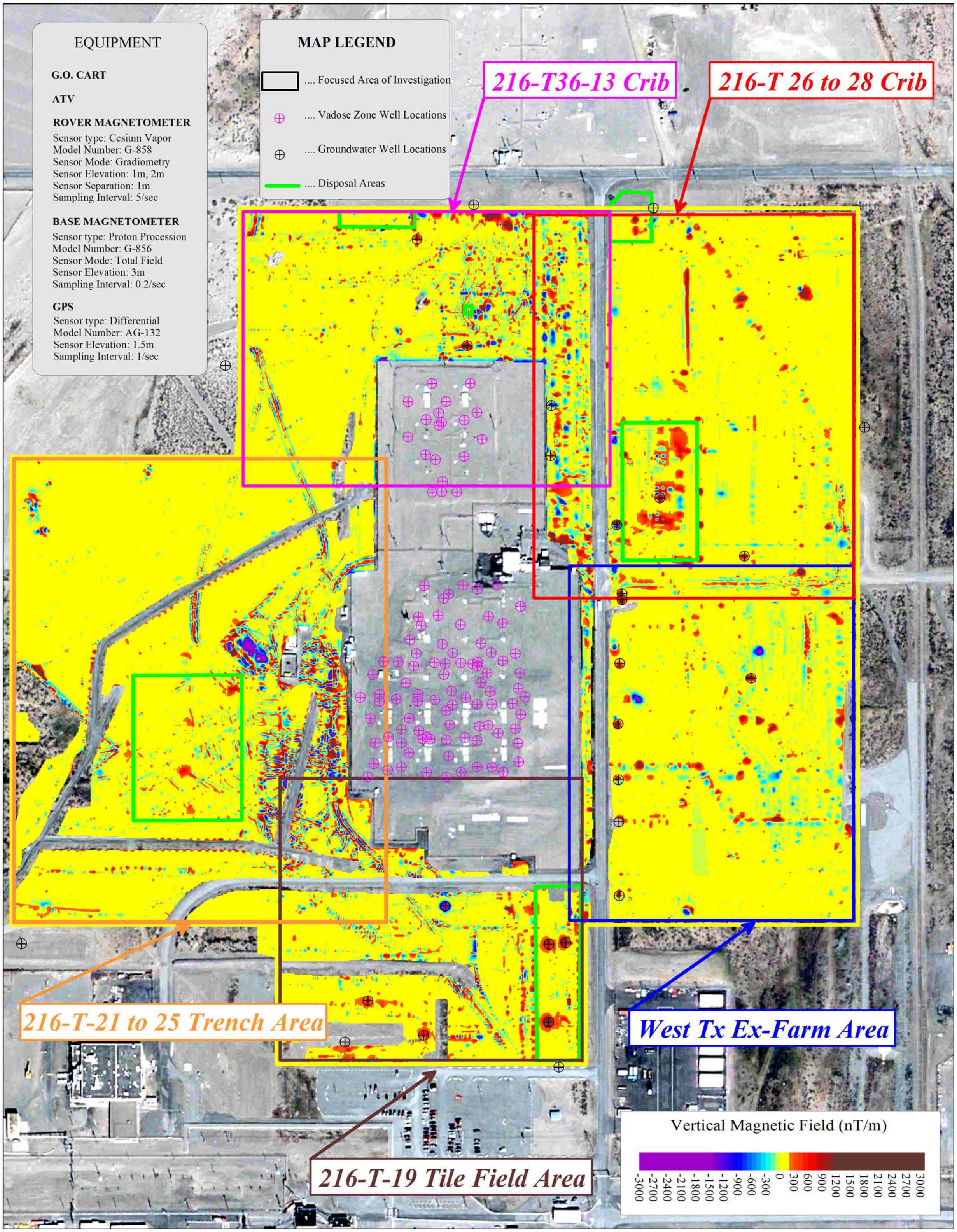


**Figure A-44 Vertical Gradient for the 216-T-19 Tile Field Area**

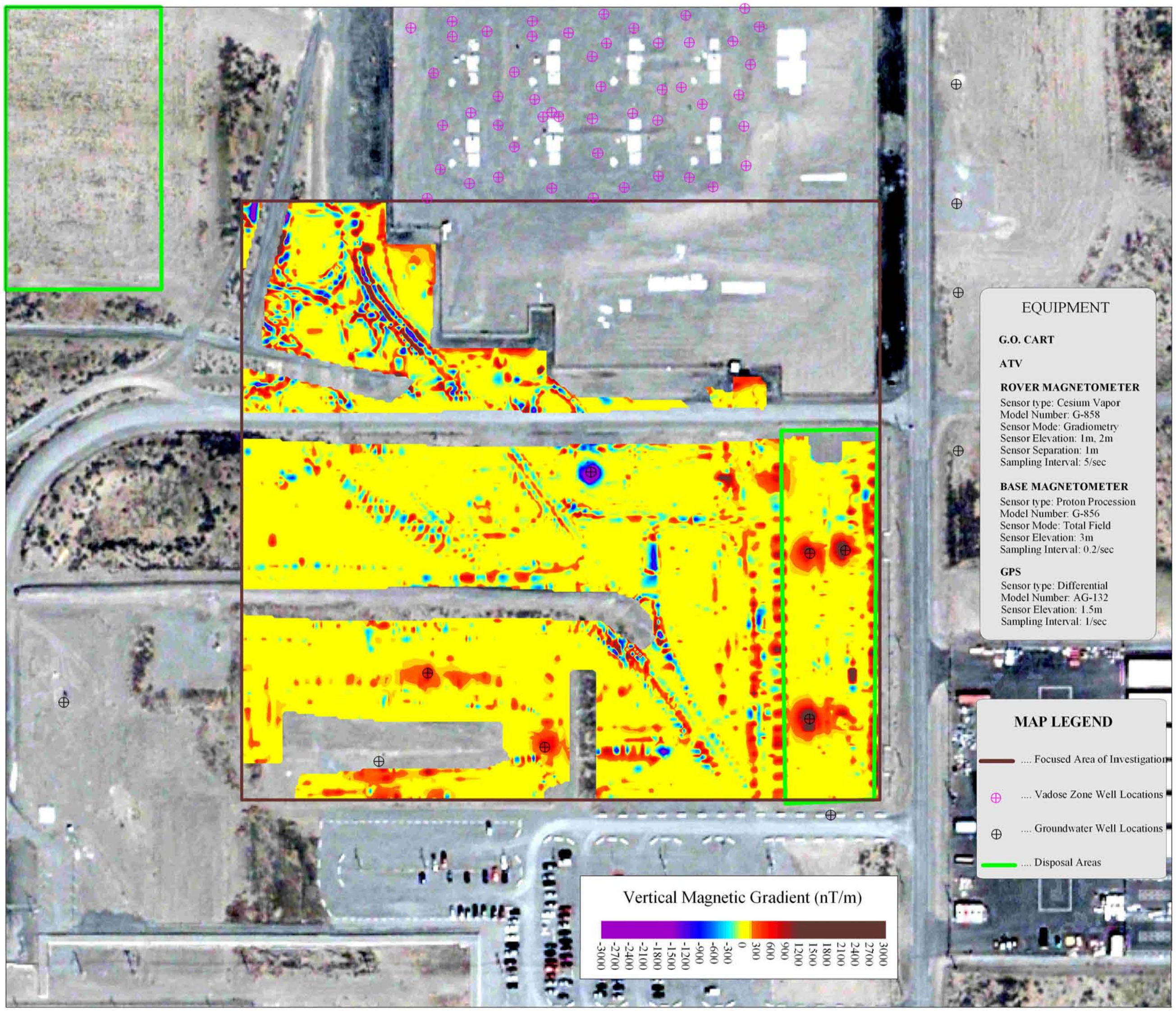
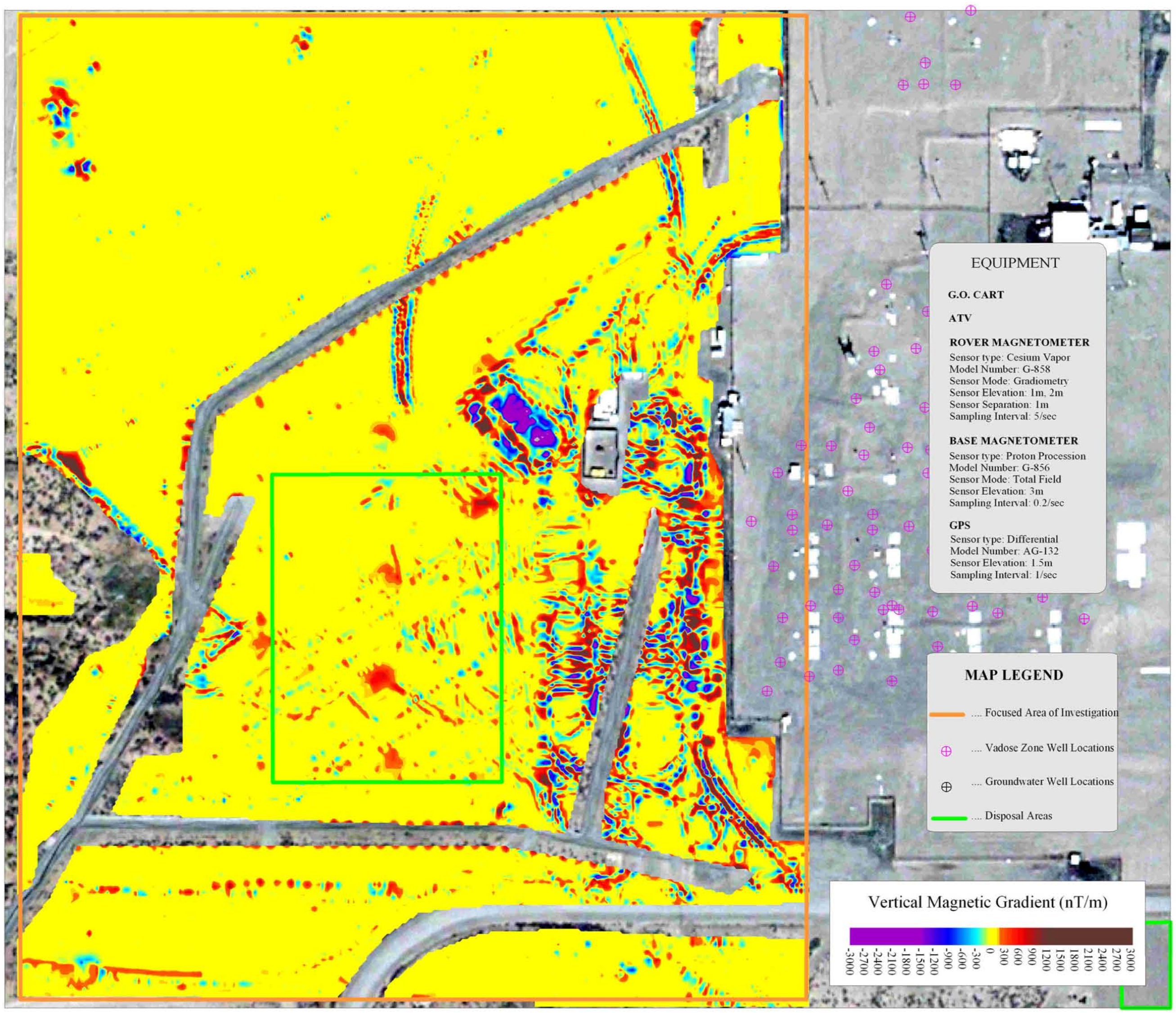


**Figure A-45 Vertical Gradient for the 216-T-21 to 25 Trench Area**



# Figure A-46 Vertical Gradient for the 216-T 26 to 28 Crib

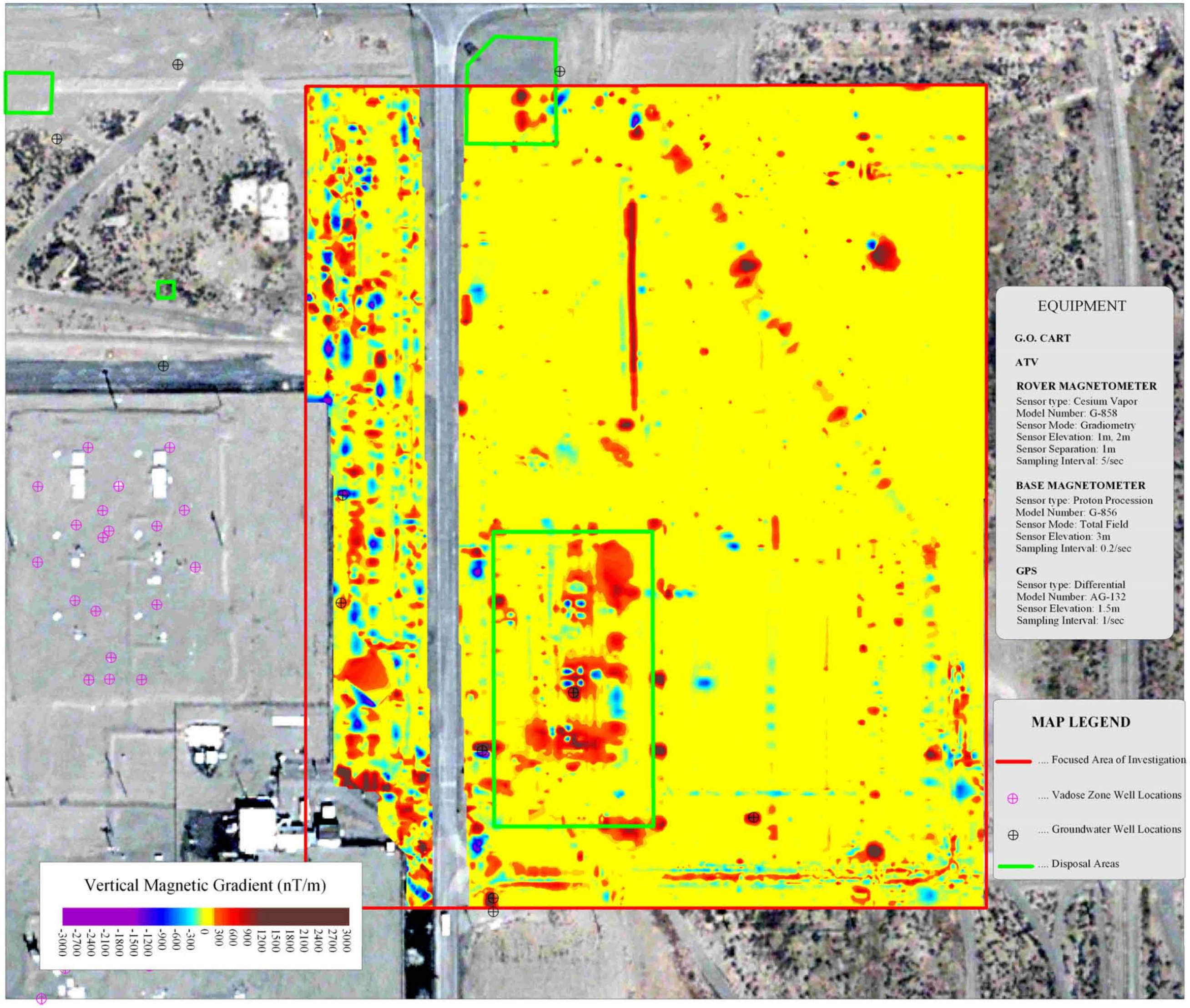


**Figure A-47 Vertical Gradient for the 216-T36-13 Crib**

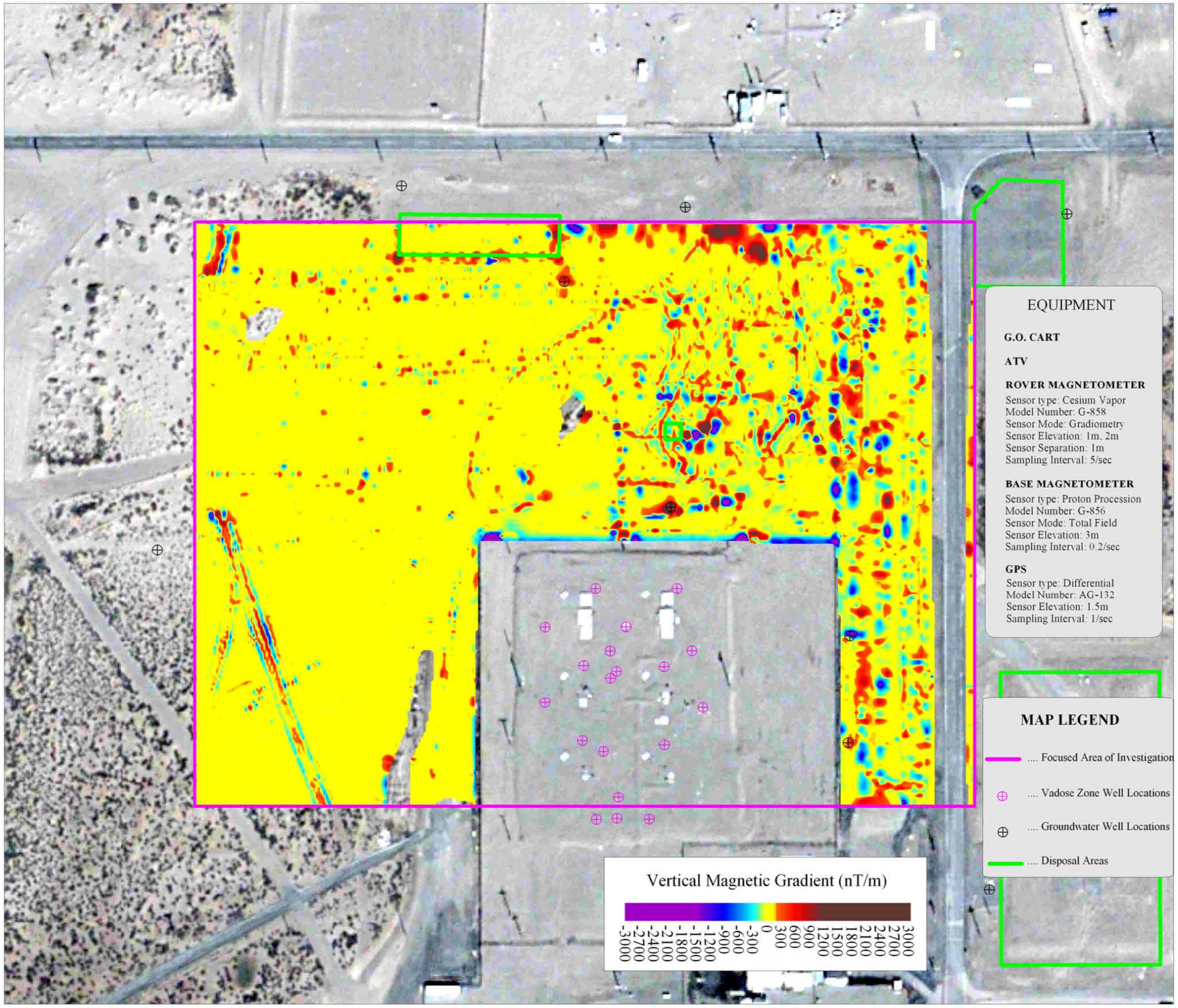
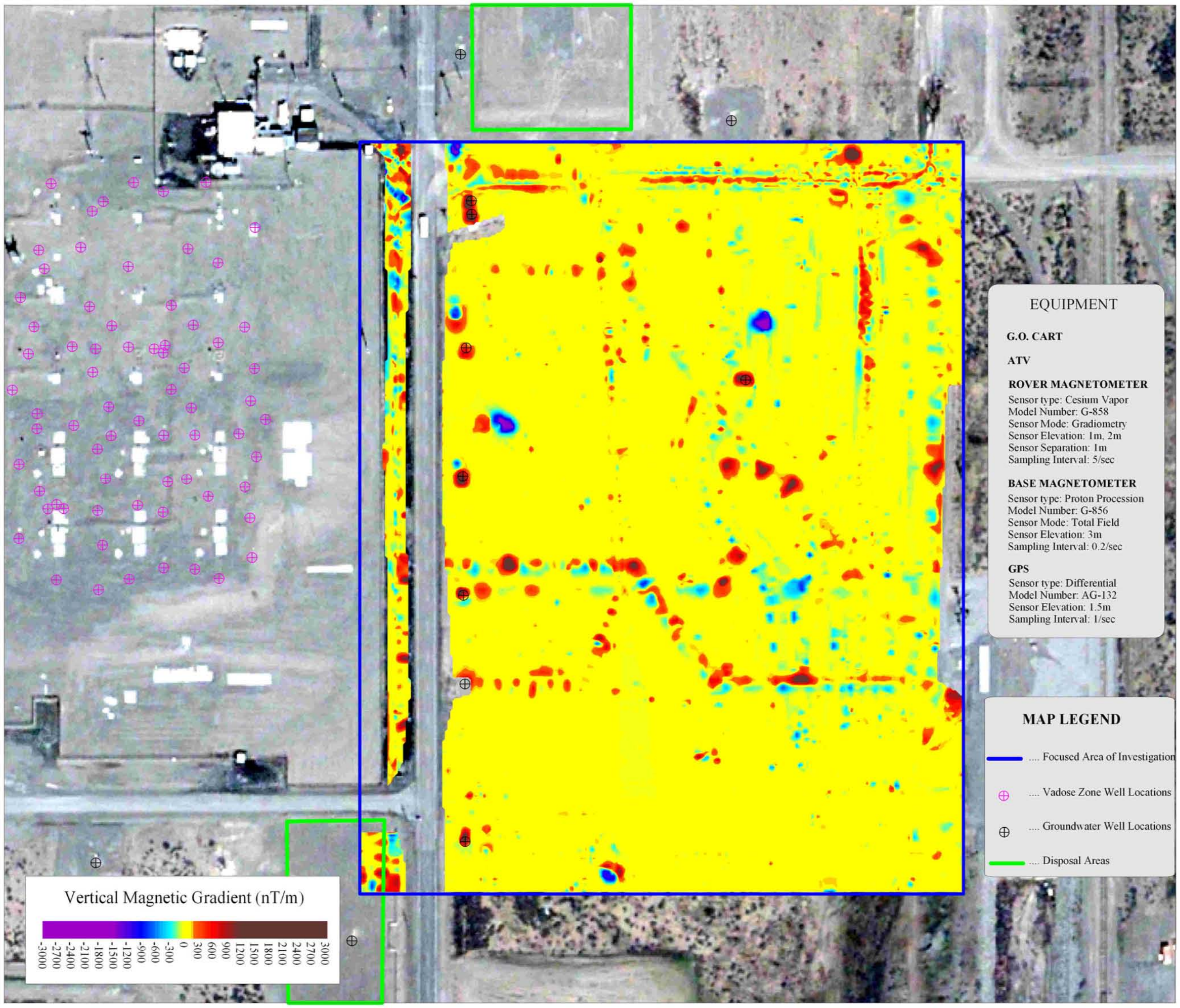


**Figure A-48 Vertical Gradient for the West Tx Ex-Farm Area**



# APPENDIX B

# QUALITY ASSURANCE

# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** | **Start Time:** | **End Time:** |
| 9/26/2007 | 8:00 a.m. | 2:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ **RTK** ☒ **DGPS** ☒ **WAAS**

**Model:** AG-132 **Out Data Frequency:** 1Hz

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM-2

**Manufacturer:** Geophex

**Serial Number:** 1400

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
sunny, clear, windy

**Survey Area Notes** (Infrastructure Location, etc.):
Area to the west of TxTy going parallel to the pipes which are above ground, crossing under a number of power lines

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
Top sensor was collecting a lot of bad data.

**Resolution of Equipment Failure:**
None at end of day

# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** | **Start Time:** | **End Time:** |
| 9/27/2007 | 8:00 a.m. | 2:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ RTK ☒ DGPS ☒ WAAS

**Model:** AG-132 **Out Data Frequency:** 1Hz

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM-2

**Manufacturer:** Geophex

**Serial Number:** 1400

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
sunny, clear, windy

**Survey Area Notes** (Infrastructure Location, etc.):
Area to the west of TxTy going parallel to the pipes which are above ground, crossing under a number of power lines

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
Top sensor was collecting a lot of bad data.

**Resolution of Equipment Failure:**
Think that the top sensor is being messed up when it travels past the tranformers just west of the farm, decide to begin surveying area east of TxTy

hydroGEOPHYSICS

# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** | **Start Time:** | **End Time:** |
| 9/28/2007 | 8:00 a.m. | 12:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ **RTK** ☒ **DGPS** ☒ **WAAS**

**Model:** AG-132 **Out Data Frequency:** 1Hz

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM-2

**Manufacturer:** Geophex

**Serial Number:** 1400

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
cold, raining, windy

**Survey Area Notes** (Infrastructure Location, etc.):
Area east of TxTy along the road

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
Couldn't download the data from the GEM-2, however, the mag data looked reasonable.

**Resolution of Equipment Failure:**
Plan on shipping the GEM-2 (SN1400) back to Geophex for data retrieval, a new GEM would be arriving at the office on Saturday, and would be ready to be used on Monday morning.

# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** 10/01/2007 | **Start Time:** 8:00 a.m. | **End Time:** 2:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ RTK ☒ DGPS ☒ WAAS

**Model:** AG-132 **Out Data Frequency:** 1Hz

**Manufacturer:** Trimble

**Serial Number:** 132002

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM-2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
cold, clear, windy

**Survey Area Notes** (Infrastructure Location, etc.):
Area east of TxTy along the road

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
Data collected prior to lunch was determined to be bad based on problems with the top sensor once again. For collection after lunch, the positions of the top and bottom sensor were switched, and the second data collected was acceptable.

**Resolution of Equipment Failure:**
The sensors will stay in this setup for the rest of the survey.

# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** | **Start Time:** | **End Time:** |
| 10/03/2007 | 8:00 a.m. | 2:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ **RTK** ☒ **DGPS** ☒ **WAAS**

**Model:** AG-132 **Out Data Frequency:** 1Hz

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM-2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
warm, sunny, clear

**Survey Area Notes** (Infrastructure Location, etc.):
Area east of TxTy along the road, but west of main pipe before lunch. Area east of pip after lunch.

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
Data collected prior to lunch was good, first third of data collected after lunch was determined to be bad.

**Resolution of Equipment Failure:**
The bad data file was removed.

# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** | **Start Time:** | **End Time:** |
| 10/04/2007 | 8:00 a.m. | 2:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ RTK ☒ DGPS ☒ WAAS

**Model:** AG-132 **Out Data Frequency:** 1 HZ

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM-2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
☒ **Verify Operational Status of GPS System**
☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
☒ **Check Operational Status of EM Instrument**
☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
warm, sunny, clear

**Survey Area Notes** (Infrastructure Location, etc.):
Area east of TxTy along the road, but west of main pipe before lunch. Area east of pipe after lunch.

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
During collection of the third and fourth data set, the bottom sensor stopped collecting data in the same spot along the survey line

**Resolution of Equipment Failure:**
Spoke to Dale Rucker (HGI) to determine if cathodic protection might be causing the problem (survey area was near cathodic protection). Dale didn't think that this was the case, however attempted to contact Colin Henderson at CEES to determine if cathodic protection was on. No resolution of cathodic impact by end of day.

# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** | **Start Time:** | **End Time:** |
| 10/08/2007 | 8:00 a.m. | 2:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ **RTK** ☒ **DGPS** ☒ **WAAS**

**Model:** AG-132 **Out Data Frequency:** 1 Hz

**Manufacturer:** Trimbel

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM-2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
warm, sunny, clear

**Survey Area Notes** (Infrastructure Location, etc.):
Areas east of main road, south of previously surveyed area

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
GEM had incorrect frequencies set.

**Resolution of Equipment Failure:**
Reset GEM settings, collected data was not useable.

hydroGEOPHYSICS

# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** | **Start Time:** | **End Time:** |
| 10/09/2007 | 8:00 a.m. | 3:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ RTK ☒ DGPS ☒ WAAS

**Model:** AG-132 **Out Data Frequency:** 1 HZ

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM-2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
warm, sunny, clear

**Survey Area Notes** (Infrastructure Location, etc.):
Areas east of main road, south of previously surveyed area

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
Bottoms sensor will loose signal after about 1 hour of surveying in the morning and 25 minutes in the afternoon.

**Resolution of Equipment Failure:**
Once bottom sensor gets bad, stop collection, download and QC data.

# HGI G.O. CART FIELD FORM

## GENERAL

| **Job Number:** | **Project Site:** | **Field Operator(s):** |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** 10/10/2007 | **Start Time:** 8:00 a.m. | **End Time:** 3:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ **RTK** ☒ **DGPS** ☒ **WAAS**

**Model:** AG-132 **Out Data Frequency:** 1Hz

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM-2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
raining in the morning, better in afternoon

**Survey Area Notes** (Infrastructure Location, etc.):
Areas east of main road, south of previously surveyed area

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
None

**Resolution of Equipment Failure:**
None

hydroGEOPHYSICS

# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** | **Start Time:** | **End Time:** |
| 10/11/2007 | 8:00 a.m. | 3:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ RTK ☒ DGPS ☒ WAAS

**Model:** AG-132 **Out Data Frequency:** 1 Hz

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
clear, sunny in afternoon

**Survey Area Notes** (Infrastructure Location, etc.):
Areas east of main road, south of previously surveyed area

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
None.

**Resolution of Equipment Failure:**
None

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# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** | **Start Time:** | **End Time:** |
| 10/12/2007 | 8:00 a.m. | 4:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ **RTK** ☒ **DGPS** ☒ **WAAS**

**Model:** AG-132 **Out Data Frequency:** 1 Hz

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM-2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
clear, sunny in afternoon

**Survey Area Notes** (Infrastructure Location, etc.):
Areas east of main road, south of previously surveyed area

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
None

**Resolution of Equipment Failure:**
None

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# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** | **Start Time:** | **End Time:** |
| 10/13/2007 | 8:00 a.m. | 3:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ **RTK** ☒ **DGPS** ☒ **WAAS**

**Model:** AG-132 **Out Data Frequency:** 1 HZ

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM-2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
clear, sunny in afternoon

**Survey Area Notes** (Infrastructure Location, etc.):
Areas east of main road, south of previously surveyed area

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
Sensors lose signal when in northeast survey area (near cathodic protection)

**Resolution of Equipment Failure:**
When signal is lost, survey is stopped, data is QA'd, area was returned to to try to finish survey.

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# HGI G.O. CART FIELD FORM

| GENERAL | | |
|---|---|---|
| **Job Number:**<br>2007-036 | **Project Site:**<br>TxTy | **Field Operator(s):**<br>Andrew Genco |
| **Date:**<br>10/15/2007 | **Start Time:**<br>8:00 a.m. | **End Time:**<br>1:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ **RTK** ☒ **DGPS** ☒ **WAAS**

**Model:** AG-132 **Out Data Frequency:** 1 Hz

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
clear, sunny in afternoon

**Survey Area Notes** (Infrastructure Location, etc.):
Area north of TxTy

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
Boom on GoCart broke after ATV was flipped

**Resolution of Equipment Failure:**
ATV was checked out (okay), and all survey equipment was checked to make sure it still worked properly (it did). Boom was fixed by Andrew, Brian, and Craig. Due to crash collection on GoCart was suspended for the reaminder of the day. Additionally it was determined that prior to the survey of an area, the GoCart operator and a Hanford operator must first go through the intended survey area to locate any hazards.

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# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** 10/16/2007 | **Start Time:** 8:00 a.m. | **End Time:** 4:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ RTK ☒ DGPS ☒ WAAS

**Model:** AG-132 **Out Data Frequency:** 1 Hz

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
clear, sunny in afternoon

**Survey Area Notes** (Infrastructure Location, etc.):
Area south of TxTy

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
None

**Resolution of Equipment Failure:**
None

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# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** | **Start Time:** | **End Time:** |
| 10/17/2007 | 8:00 a.m. | 4:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ **RTK** ☒ **DGPS** ☒ **WAAS**

**Model:** AG-132 **Out Data Frequency:** 1 Hz

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM-2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
cold in the morning, clear, sunny in afternoon, windy all day

**Survey Area Notes** (Infrastructure Location, etc.):
Area west of TxTy

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
In the afternoon, the display on the ATV said that it was too hot.

**Resolution of Equipment Failure:**
After inspection it was determined that the radiator was clogged from all of the dust being collected over the course of the survey. Kraig cleaned the radiator at the end of the day.

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# HGI G.O. CART FIELD FORM

| GENERAL | | |
|---|---|---|
| **Job Number:** 2007-036 | **Project Site:** TxTy | **Field Operator(s):** Andrew Genco |
| **Date:** 10/18/2007 | **Start Time:** 8:00 a.m. | **End Time:** 4:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ RTK ☒ DGPS ☒ WAAS

**Model:** AG-132 **Out Data Frequency:** 1 Hz

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM 2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
Cold and rainy in the morning, sunny in the afternoon

**Survey Area Notes** (Infrastructure Location, etc.):
Area west of TxTy

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
None

**Resolution of Equipment Failure:**
None

# HGI G.O. CART FIELD FORM

| GENERAL | | |
|---|---|---|
| **Job Number:**<br>2007-036 | **Project Site:**<br>TxTy | **Field Operator(s):**<br>Andrew Genco |
| **Date:**<br>10/22/2007 | **Start Time:**<br>8:00 a.m. | **End Time:**<br>4:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ **RTK** ☒ **DGPS** ☒ **WAAS**

**Model:** AG-132 **Out Data Frequency:** 1 Hz

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM 2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
☒ **Verify Operational Status of GPS System**
☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
☒ **Check Operational Status of EM Instrument**
☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
Clear and sunny

**Survey Area Notes** (Infrastructure Location, etc.):
Area west of TxTy

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
None

**Resolution of Equipment Failure:**
None

# HGI G.O. CART FIELD FORM

## GENERAL

| **Job Number:** 2007-036 | **Project Site:** TxTy | **Field Operator(s):** Andrew Genco |
|---|---|---|
| **Date:** 10/23/2007 | **Start Time:** 8:00 a.m. | **End Time:** 4:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ RTK ☒ DGPS ☒ WAAS

**Model:** AG-132 **Out Data Frequency:** 1 Hz

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
Clear and sunny

**Survey Area Notes** (Infrastructure Location, etc.):
Area west of TxTy in the morning, rose diagram done near the remotes in the morning, and filled in needed gaps in areas north and east of the farm in the afternoon

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
None

**Resolution of Equipment Failure:**
None

# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** | **Start Time:** | **End Time:** |
| 10/24/2007 | 8:00 a.m. | 4:00 p.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ **RTK** ☒ **DGPS** ☒ **WAAS**

**Model:** AG-132 **Out Data Frequency:** 1 Hz

**Manufacturer:** Trimble

**Serial Number:** 132002

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM-2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
Clear, sunny

**Survey Area Notes** (Infrastructure Location, etc.):
Contaminated area east of TxTy, finished area north of TxTy

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
None

**Resolution of Equipment Failure:**
None

# HGI G.O. CART FIELD FORM

## GENERAL

| Job Number: | Project Site: | Field Operator(s): |
|---|---|---|
| 2007-036 | TxTy | Andrew Genco |
| **Date:** | **Start Time:** | **End Time:** |
| 10/25/2007 | 8:00 a.m. | 9:00 a.m. |

## SURVEY INSTRUMENTS

**GPS INSTRUMENT** ☐ RTK ☒ DGPS ☒ WAAS

**Model:** AG-132 **Out Data Frequency:** 1 Hz

**Manufacturer:** Trimble

**Serial Number:** 132003

**MAGNETIC (MAG) INSTRUMENT**

**Base Magnetometer**

**Model:** G-856

**Manufacturer:** Geometrics

**Serial Number:** 27579

**Sample Rate:** 60 seconds

**Rover Magnetometer**

**Model:** G-858

**Manufacturer:** Geometrics

**Serial Number:** 29288

**Sample Rate:** 0.1 seconds

**ELECTROMAGNETIC (EM) INSTRUMENT**

**Model:** GEM-2

**Manufacturer:** Geophex

**Serial Number:** 1600

**Frequencies Used:** 5010, 9990, 20010 Hz

**Sample Rate:** 0.1 seconds

## PRE-OPERATIONAL CHECKLIST

**MAG:**

- ☒ **Check Base Magnetometer Operational Status, Battery Life, and Signal Level**
- ☒ **Install Fresh Battery in Gradiometer and GPS Consoles**
- ☒ **Verify Operational Status of GPS System**
- ☒ **Power Gradiometer (allow coils to energize for a minimum of 5 minutes)**
- ☒ **Verify Battery Level, Memory Space, Operational Status of MAG Instrument**
- ☒ **Perform Visual Inspection of GPS Data String (to ensure an adequate interface between the GPS and gradiometer)**
- ☒ **Synchronize MAG Base and Rover Clocks**

**EM:**

- ☒ **Verify Battery Charge by Viewing Battery Status Indicator on EM Instrument**
- ☒ **Verify GPS Serial Cable is in place and Confirm GPS Communication to EM Instrument**
- ☒ **Check Operational Status of EM Instrument**
- ☒ **Check Memory Space**

## DAILY CALIBRATION CHECKLIST

- ☒ **Drive to calibration site, Park G.O Cart at the same stationary location each day. Record gradiometer data for a minimum of 5 minutes**

## GENERAL NOTES

**Environmental/Weather Conditions:**
Clear, sunny

**Survey Area Notes** (Infrastructure Location, etc.):
Area west of TxTy, where trailers used to be stationed.

## EQUIPMENT FAILURES

**Description of Equipment Failure:**
None

**Resolution of Equipment Failure:**
None