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TECHNICAL MEMORANDUM GEOPHYSICS INVESTIGATION OF SOLID WASTE MANAGEMENT UNIT 62 NAS FORT WORTH TX

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TECHNICAL MEMORANDUM NO. 2

Geophysics Investigation of SWMU 62
Naval Air Station Fort Worth, Texas

CTO-103, Contract No. N62467-89-D-0318

For:

The Department of the Navy
Southern Division Naval Facilities Engineering Command
North Charleston, South Carolina

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EXECUTIVE SUMMARY

In support of possible construction of a van pad facility and a liquid oxygen storage facility at NAS Fort Worth, EnSafe/Allen & Hoshall recently conducted a geophysics study near a former landfill at the proposed site of construction, which has been designated SWMU 62. The purpose of the work was to characterize the extent of buried material and to map features of potential environmental concern such as buried drums.

The anomalies were classified according to the likelihood that they might be of environmental concern: Type A anomalies are well-defined features needing further investigation; type B are weaker anomalies; Type C are anomalies not related to buried features.

Twelve Type A anomalies are identified in the data. Followup investigation is needed to see if the anomalies are due to innocuous, minor buried rubble, such as metal construction debris, or if they represent an environmental concern. The geophysics data indicate very specific locations where the followup investigations should be conducted.

The geophysics data show that the eastern part of the property may be better suited for construction than the western part, based on the frequency and intensity of anomalies encountered. However, if followup sampling of western anomalies does not identify any environmental concerns, the western part of the property might also be considered for construction.

1.0 INTRODUCTION

1.1 Purpose of the Study

A RCRA Facility Investigation (RFI) Work Plan for the former Carswell Air Force Base (now known as Naval Air Station, Fort Worth Joint Reserve Base) has been completed and reviewed by the Texas Natural Resources & Conservation Commission. One of the solid waste management units (SWMUs) to be investigated is SWMU 62 (Landfill 6), known as LF-06 in the base's Installation Restoration Program.

EnSafe/Allen & Hoshall has been retained under the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract to determine whether two portions of SWMU 62 are suitable for future construction. The land east of former Landfill 6 is the site for the proposed van pad facility. Another portion west of former Landfill 6 has been proposed as a liquid oxygen storage facility. The suitability of these sites for construction will depend on whether it appears that landfilling has occurred in these areas.

A geophysical study was performed at SWMU 62 to evaluate it as a potential construction site. The study was not intended to map the edges of the landfill or to obtain closure for this SWMU.

The first technical memorandum on geophysics at this site was issued 20 April 1995. Subsequently additional work was done on another portion further east of Landfill 6 and a reinterpretation was performed on the full data set. The current technical memorandum includes the more recent work and is the final report on the work.

The study used the frequency domain electromagnetics (FDEM) technique to detect buried metals and disturbed soil. FDEM provides rapid and high-density data coverage of conductive features within approximately 6 meters of the surface.

1.2 Setting and Regional Geology

NAS Fort Worth is 6 miles west of downtown Fort Worth. On the southwest part of the base is former Landfill No. 6, around which this geophysical investigation was conducted. Originally, the site was a gravel pit used to support base construction. From 1975 to 1978, the pit was used to dispose of construction rubble, trees, and miscellaneous trash. However, disposal of material of environmental concern could have occurred here. Several drums of hydraulic fluid were reported to have been buried at the site in a centrally located pit used to collect groundwater.

The gravel pit and landfill were located at what is now a fenced-in, unused parking lot, formerly used to store recreational vehicles. The area is immediately west of the liquid oxygen area. Previous site visits have suggested that all the fill material and disposed of debris might not be contained within the fenced area. Thus, identifying the extent of fill material and debris is a key objective of the geophysical investigation.

The SWMU has gently rolling terrain with several artificially constructed drainages (Figure 1). The surface is mostly grassy and weedy; locally several gravel patches, zones of bare soil, and occasional asphalt and cement areas are associated with the few buildings in the area. Soil from petroleum storage tank excavations is piled up in a mound on the northwest part of the study area. A mound in the fenced area contains the former gravel pit, possibly representing a disposal area. Otherwise, no areas of widescale disposal are obvious.

During the geophysical survey, two 20-foot long holes and several patches of stressed vegetation were identified (see Figure 1). Near the fences on the east-central part of the study area, small holes in the ground showed buried construction debris, including concrete bricks, rubble, and loose metal pipes. However, no mounds or other indications of systematic waste disposal were obvious outside the identified landfill area.

SITE FEATURES

SWMU 62 (potential van pad facility), NAS Ft. Worth

EnSafe/Allen & Hoshall - 1995 Geophysics Study

Figure 1

Locally, shallow groundwater flows southeast, roughly following the general topography.

2.0 GEOPHYSICAL APPLICATION

2.1 Description of FDEM

Frequency-domain electromagnetics is a geophysical technique useful for mapping buried drums, tanks, utility lines, old trenches, construction rubble, extent of landfills, etc. Typically the instrument is an EM-31, manufactured by Geonics, Ltd. The EM-31 consists of a 2-meter long boom with a transmitting antenna at one end and a receiving antenna at the other. The transmitting antenna is energized by a current pulse, which propagates into the ground as an electromagnetic field. As it encounters electrically responsive materials in the ground, the signal received at the surface in the receiving antenna is distorted. These distortions can then be interpreted to develop a graphical image of the subsurface.

The signal can penetrate to 6 meters below ground surface. FDEM is primarily a profiling method and does not yield detailed vertical resolution, although it can perform some limited sounding capability by varying the instrument height and dipole orientation. Resolution in plan view is often to within a meter or so. Signals are sensed by the instrument's electronics and the data are sent to a field data recorder, whose contents are downloaded to a separate computer for processing and plotting.

Two parameters are measured: conductivity and in-phase. Conductivity is a measurement of how well the earth conducts electrical current. Dry materials yield low conductivities, while wet materials yield high conductivities. Saturated clays are particularly conductive. When present, buried metals may also increase the effective conductivity. Conductivity data have units of milliSiemens per meter (mS/m).

The in-phase component is a ratio of the secondary to primary field strengths (the primary field is the generated signal and the secondary is the ground's response). The in-phase component is primarily sensitive to metals, not soil moisture, and can go negative or positive over metallic objects, depending on the relative geometries of the conductor and instrument. In-phase has units of parts per thousand of the secondary field strength (ppt).

FDEM was used on this project to detect disturbed soil and buried metals related to landfill activities, and to find potential buried drums. Landfill burials are characterized by disturbed soil which is less compacted and might have a higher moisture than surrounding, undisturbed soil, making the landfill show up as a conductive feature. However, in some cases the landfill material displaces conductive indigenous clayey soil, and thus might show up as a resistor. When landfill debris contains scrap metals and steel-reinforced concrete, it may produce a conductive and a high in-phase anomaly. Buried drums produce local anomalies with specific characteristics depending on the relative geometries of the instrument antennas and the buried feature. Positive and negative anomalies can be expected.

2.2 Field Implementation

Before the geophysical work, a 100 x 100-foot grid was surveyed, referencing existing benchmarks north of Hobby Shop Road and placing grid nodes at evenly numbered state plane increments. Baselines were put in by transit, and the rest of the nodes were located by transit and chain. The maximum location error was less than 0.5 foot, and errors were not cumulative. Work done starting at line 8070E and continuing eastward used a grid extrapolated from the previous grid; these positions are subject to larger errors, although the internal precision within this extrapolated grid section is within 1 foot.

Wood stakes were placed every 10 feet along key east-west grid lines. Data were collected along north-south lines by careful pacing, using the wood laths to maintain the proper east-west alignment. Positions at which data points were obtained are accurate to ± 1 foot, which is more than sufficient for this investigation.

Easting and northing coordinates are abbreviated throughout this report by dropping the first three digits. To obtain the full state-plane coordinates, add 2,290,000 to eastings and 6,960,000 to northings. For example, "7700E/3000N" in this report is actually state plane 2297700E/6963000N.

Data were obtained along north-south lines, walking north on "even" lines (e.g., 7100, 7120, 7140,...) and south on "odd" lines (7110, 7130, 7150,...). The receiver antenna was pointed north on even lines and south on odd lines. Conductivity and in-phase data were obtained using a vertical dipole configuration at an elevation of 1 m above ground surface (using the shoulder sling supplied with the instrument).

Because of logistical obstructions such as fences, data were obtained in sections and later assembled into a complete database. Care was taken to avoid offsets in instrument response between sections.

The field work was completed in two sessions. Session 1 (April 1995) covered the majority of the area as far east as 8060E. It was decided after this work to extend coverage to the east. Session 2 (June 1995) extended coverage to line 8470E.

3.0 QUALITY ASSURANCE PROCEDURES

Equipment was calibrated according to the manufacturer's instructions every morning before data acquisition.

The two items of chief concern in any data set are precision and biasing: both can influence the interpretability of a data set. A standard set of tests was used to investigate both types of effects. Results are outlined below.

3.1 Data Precision

A base station is normally established in a background area to determine short-term and long-term measurement precision. Periodically during data acquisition, the instrument is returned to the base station and a burst of 10 to 20 successive measurements is made. At NAS Fort Worth, four base stations were required for logistical efficiency: Base 1 (7200E/2900N), Base 2 (7960E/3100N), Base 3 (7800E/2500N), and Base 4 (8200E/3030N). Base 1 to 3 were used in Session 1, and Base 4 in Session 2.

Short-term precision shows how closely a measurement can be repeated in a short range of time, and thus is a function of inherent instrument noise. Short-term precision is estimated by a statistical analysis of the base station burst measurements. The results are as follows:

	Conductivity (mS/m)	In-Phase (ppt)
RESULTS		
Short-Term Precision, Base 1 to 3	±0.098	±0.028
Short-Term Precision, Base 4	±0.170	±0.084
BENCHMARKS		
Desired Minimum Resolution	±1.	±0.5
Subtle Landfill Anomaly	±2.	±1.
Typical Buried Drum Anomaly	±5.	±5.

The precision is acceptable, judged by benchmarks set by the survey objectives, and hence does not influence the interpretability of this data set. The precision level is better than average for EM-31 surveys for base stations 1 to 3, but only average for base 4, possibly due to a change in instruments.

Long-term precision is primarily controlled by instrument drift, which occurs because of slight response changes in the instrument's electronics. Figure 2 shows the instrument drift during occupation of the three base stations used in Session 1. The minimum and maximum vertical scales are adjusted to represent $\pm 10\%$ of the conductivity value and ± 1 ppt of in-phase, considered to be "high drift" bounds which, when exceeded, suggest that drift corrections may need to be considered. The drift is smaller than usual for EM-31 measurements and does not exceed the desired minimum resolution benchmarks defined previously. No drift correction is required for the magnitude of drift observed on this project.

Figure 3 shows the drift for base 4 in Session 2. The drift is very strong, especially in conductivity, where a change exceeding 10 percent of the initial value is recorded. This effect was noted in the field; checks on instrument indicated no malfunction. The instrument used in Session 2 was an older, analog-meter type, which had shown higher than average drift on a preceding survey. The maximum drift rate indicated by these data is about 0.046 mS/m. Given that survey lines took an average of 3 minutes each, the maximum inter-line drift is roughly 0.15 mS/m — still below the internal precision of the instrument. Since anomaly-pattern recognition is primarily determined by short-term drift between successive lines, it appears that any significant anomaly would not be missed because of this high drift. Therefore, the time-consuming task of drift correction was not undertaken.

3.2 Data Biasing Effects

Spatial aliasing — Aliasing is an undersampling effect when searching for small, subtle targets, such as deeply buried single drums. The key to a successful survey is to optimize the grid spacing or data density to the smallest target being investigated. In this case, a single buried drum is the smallest object sought. Past experience has shown that a 10x10-foot grid is a good compromise between effectiveness of detection and survey speed in drum detection. Most drums within the penetration range of the instrument will be detected in a 10x10-foot data grid, since the anomaly width is about 20 feet.

Figure 2
EM-31 Instrument Drift, March 1995

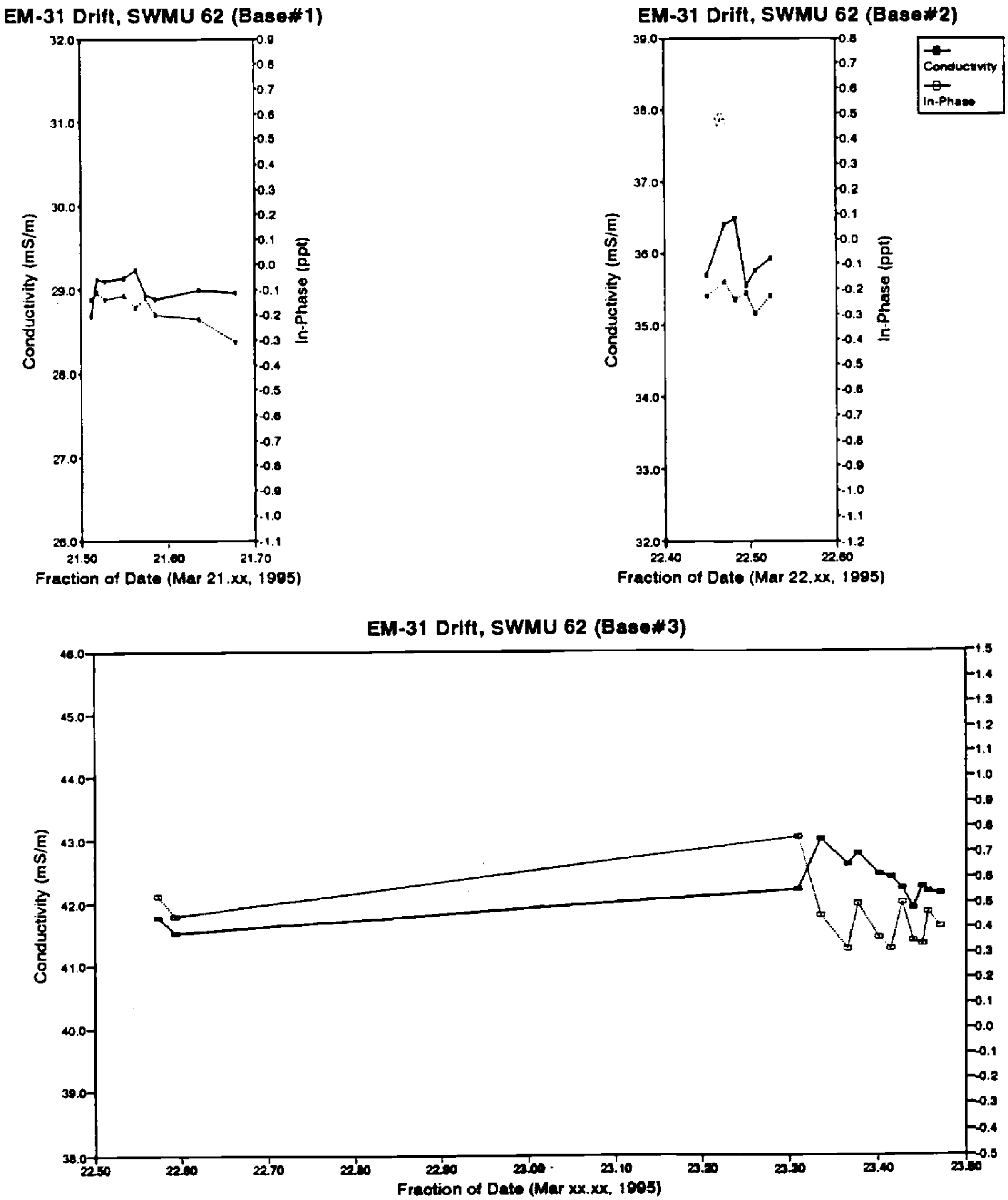
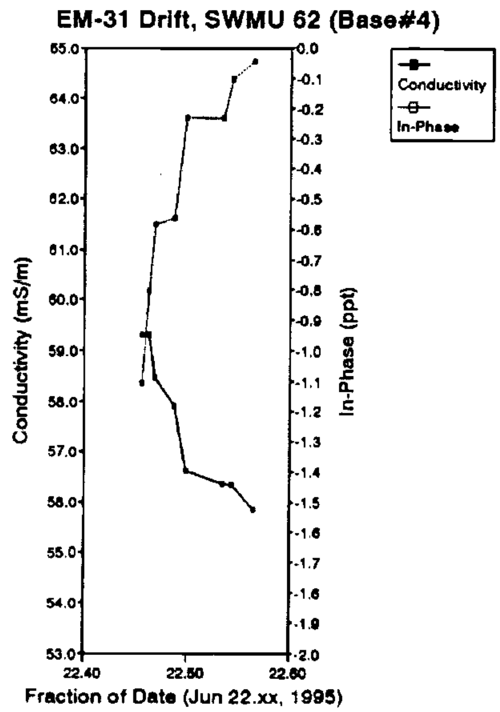


Figure 3
EM-31 Instrument Drift, June 1995



An aliasing test was performed over one of the smallest anomalies found on this survey. Detail data were taken at 2.5-foot intervals, four times the nominal density of 10 feet. The conductivity results are shown in profile form in Figure 4. The entire set of boxes represents the dense data set; data at 10-foot intervals are indicated by black boxes. While the 10-foot data do not show every nuance of the response, they still indicate an anomaly. One can shift the 10-foot sampling nodes back and forth and still observe a low-conductivity anomaly.

The aliasing test supports previous experience that the 10x10-foot spacing does not alias the data to a point of compromising detectability of small, drum-sized features.

Instrument response time/nonreciprocity effects — On large-scale surveys, the instrument is usually advanced at a rapid rate along prescribed lines, which reverse direction on each line. This procedure produces a wavy pattern at the edges of high-amplitude anomalies due to a finite instrument response time and due to non-reciprocity when the receiver and transmitter antennas reverse positions. Effects of this nature are observed in this data set, as noted in the following discussion, but they do not compromise the data interpretability.

Summary — The data have an adequate degree of precision for the stated objectives, and confidence can be placed in the data quality.

4.0 DATA INTERPRETATION

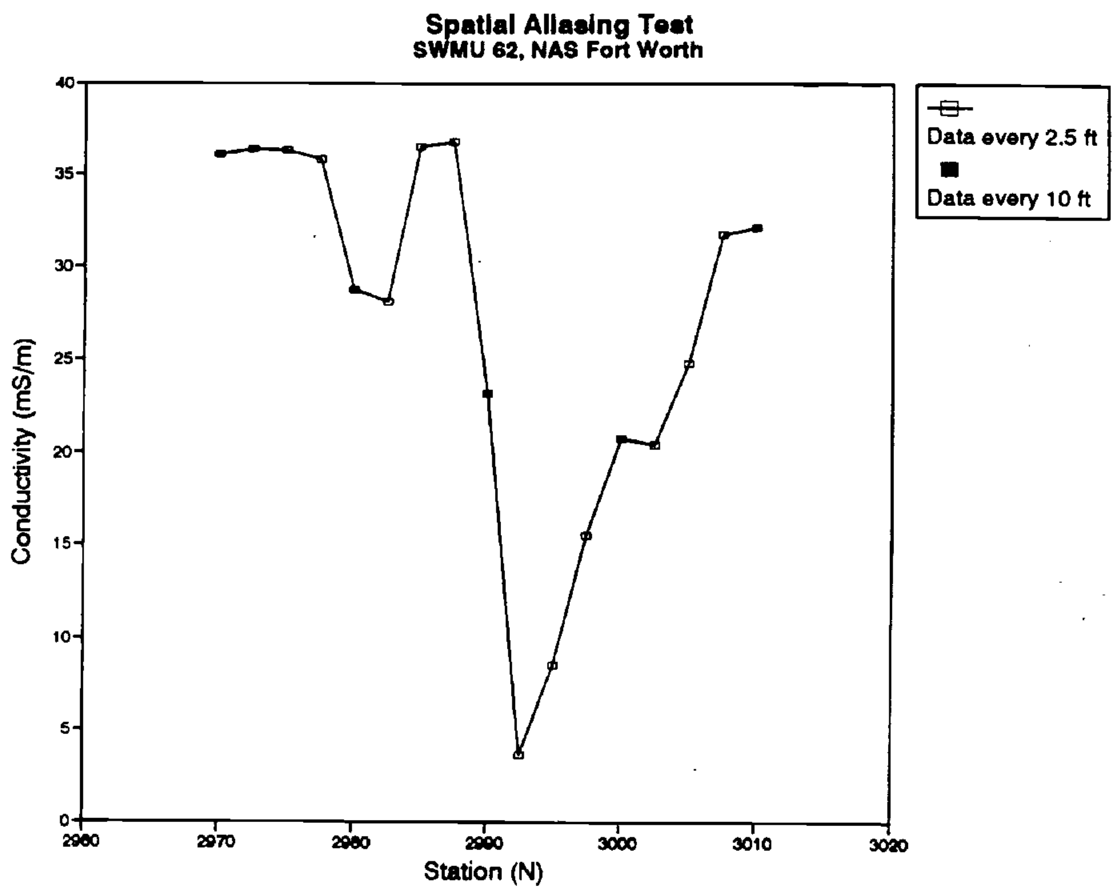
4.1 Data Description

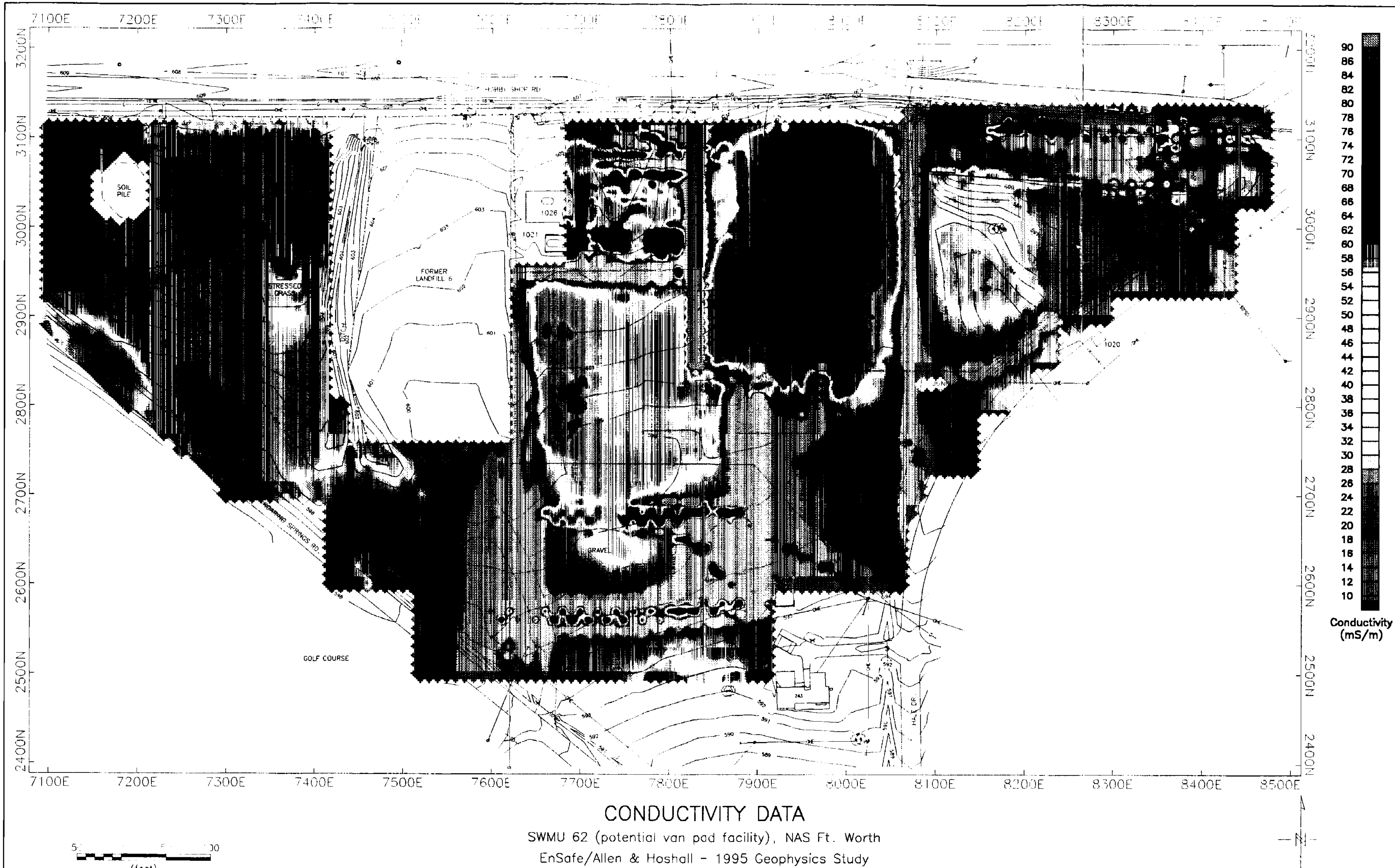
Figures 5 and 6 show the plan-view field data, consisting of conductivity and in-phase. Site features are superposed to aid the interpretation.

Figure 5 shows the conductivity data, which are sensitive to soil moisture changes. The data are depicted in color according to the color bar to the right side of the map. Both large and small conductivity values (compared to background) may be significant, although they do not

Figure 4

Spatial Aliasing Over a Small Anomaly





CONDUCTIVITY DATA

SWMU 62 (potential van pad facility), NAS Ft. Worth

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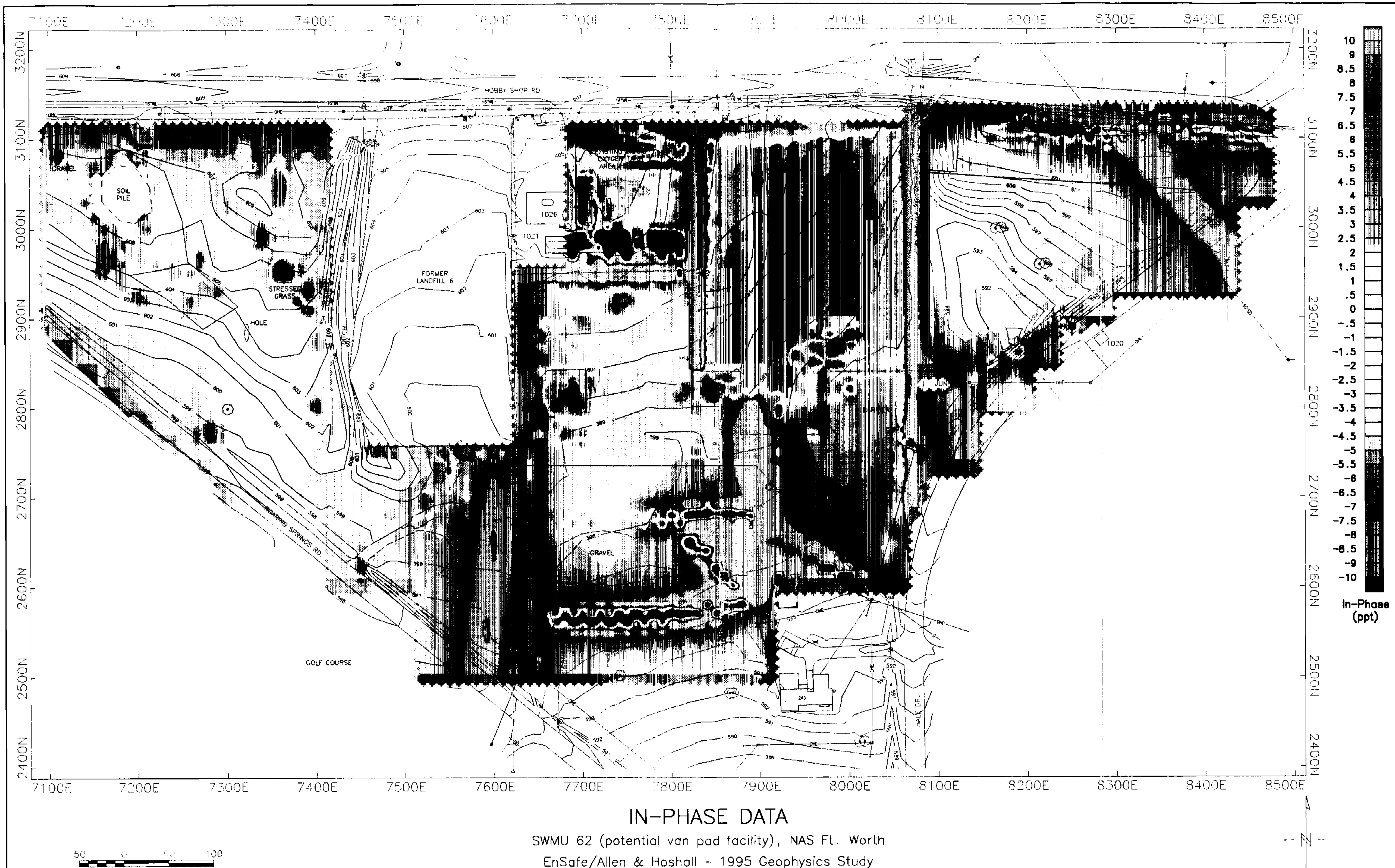
Figure 5



IN-PHASE DATA

SWMU 62 (potential van pad facility), NAS Ft. Worth

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Figure 6

necessarily indicate separate features but may be edge effects from a single feature. Extremely large and small values, sometimes with a distinct linear appearance, are associated with fences and underground utilities. Other anomalies not related to culture are observed, ranging from broad changes over several hundred feet to very small, isolated anomalies.

Figure 6 shows the in-phase data, which can roughly be thought of as a metal indicator. The nominal response in a metal-free area should be nearly zero. Large positive and negative values generally indicate the presence of metal features associated with buried objects or aboveground culture such as fences, buildings, etc. As with conductivity data, in-phase data clearly indicate buried utilities, and also show numerous small, scattered anomalies.

4.2 Anomaly Interpretation

Sixty-three anomalies are identified, and are classified according to their interpreted significance with respect to the project objectives:

TYPE A — Strong, well-defined anomaly characteristic of a buried object, and for which some followup (site walkover, soil boring, trench, etc.) is recommended.

TYPE B — Weaker or more poorly defined anomaly due to a buried object, but less likely to be of environmental concern; followup is deemed less critical, but depends on the investigations of Type A anomalies.

TYPE C — Anomaly not believed to be caused by buried material of environmental concern; examples are anomalies from ditches, culture, metal objects at the surface, etc. Followup is not recommended.

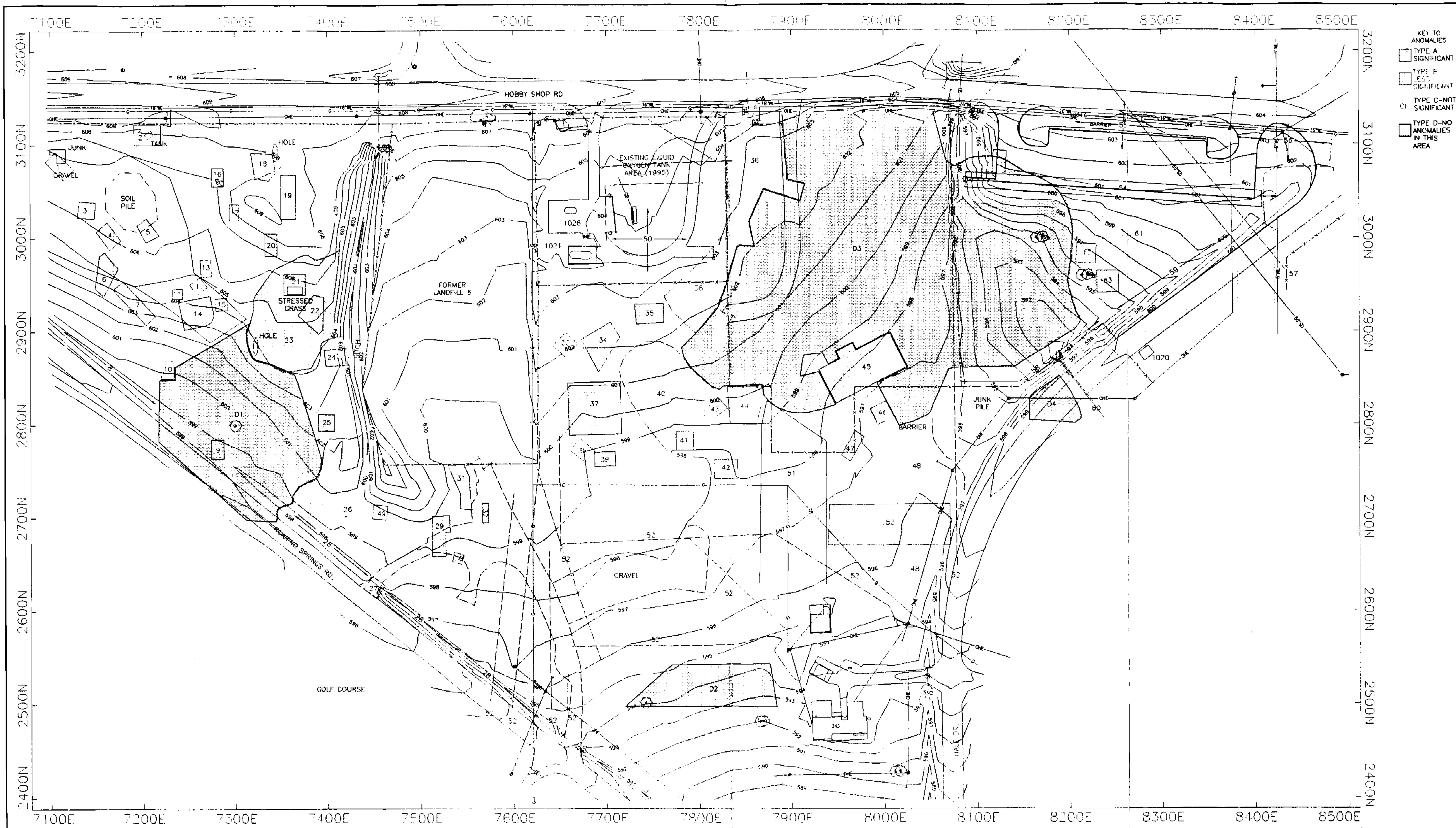
TYPE D — Anomaly-free in light of the stated objectives.

Figure 7 shows the anomalies and their numbers, color coded by type. Table 1 describes the anomalies and lists recommendations for followup. If followup investigation is done, the best spots for doing so are indicated for Type A anomalies in column 2. Note that followup will first be a site walkover to determine if the anomaly is due to some nonenvironmental object such as buried construction debris or topography. Most such explanations were eliminated during the geophysics work but a second site walkover is still recommended. Invasive work may be planned based upon the site walkover.

Anomalies cover a large percentage of the survey area, but a relatively small percentage of the area is classified Type A. Of the 12 Type A anomalies identified, 10 are attributed to buried metal and two suggest higher soil moisture, which could indicate fill material. It should be noted that all fill material may not be landfill-related; in fact, the spatial distribution of interpreted fill suggests that some anomalies may be due to construction material burial unrelated to landfilling. Invasive action will be needed to prove this.

Thirty-five Type B anomalies are identified. These are usually weaker than Type A anomalies and do not require followup work. However, in some cases of clustered, strong anomalies, one anomaly within the cluster is selected as Type A for further investigation and the others are relegated to Type B, assuming that investigation of one will help decide whether the others need to be investigated. Thus, classification as Type B does not eliminate the anomaly from any environmental concern, but merely implies that Type A anomalies should be checked out first.

Type C anomalies, attributed to buried utilities and changes in soil moisture, are prevalent in some areas. Where they are strongest, the anomalies mask the response from the subsurface, preventing a proper interpretation. The most notable example of this problem is the liquid oxygen tank area, where culture obliterates the subsurface response. However, the large majority of the site remains interpretable.



GEOPHYSICAL INTERPRETATION

SWMU 62 (potential van pad facility), NAS Ft. Worth

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Figure 7

About one-fourth of the surveyed area is designated anomaly-free (Type D response). Much of the area is not so designated because of cultural interference or because the data show subtle changes which could indicate some limited soil disturbance in the past. Areas not designated Type D, however, should not be assumed to be areas unsuitable for construction. Suitability is better determined by investigating the cause of Type A and perhaps certain Type B anomalies.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The area east of the present liquid oxygen tank enclosure shows fewer anomalies and larger anomaly-free areas than that to the west, and hence may be the more suitable site for the van pad facility. The geophysics does not suggest an extended landfilling zone extending east of the Landfill 6 enclosure. Instead, the anomalies to the east are most likely related to demolished buildings (foundations, septic systems, demolition debris). Further investigation of several key anomalies, such as 37 and 45, will determine if these features are construction-related or are of more serious environmental concern.

A site walkover, possibly followed by invasive investigation is recommended for Type A anomalies. If a great number of problems are uncovered in this work, it may be wise to reconsider the examination of some Type B anomalies.

Table 1
Anomaly Interpretations

No.	Best Position to Investigate	Notes
TYPE A ANOMALIES: RECOMMENDED FOR FOLLOWUP		
6	7165E/2965N	Moderate anomaly; buried metal indicated. May be related to anomaly 7.
7	7200E/2925N	Low-amplitude anomaly, but buried metal indicated along a suspiciously linear path.
14	7260E/2920N	Moderate anomaly; representative of several small anomalies in the area.
19	7360E/3040N	Moderate anomaly; buried metal indicated.
20	7340E/2992N	Strong anomaly. A small metallic object is indicated at perhaps 3m deep; one possible cause would be a buried drum. A high priority for followup.
21	7360E/2950N	Strong anomaly; buried metal indicated in an area of slightly stressed vegetation. A high priority for followup.
22	7390E/2920N	Strong anomaly; buried metal indicated. Complex anomaly pattern could indicate several small metal objects. A high priority for followup.
23	see note	Moderately well-defined zone of higher soil moisture and metal content. This could be an extension of the landfill outside the fenced boundary, and should be investigated further, possibly simultaneously with anomalies 21 and 22.
25	7400E/2800N	Minor anomaly; its proximity to the landfill makes followup desirable.
29	7520E/2695N	Metal indicated. Sampling is recommended; sampling just outside the anomaly would also investigate anomaly 26 (Type B).
37	7693E/2800N	Strong anomalous zone; buried metals indicated. Demolition debris was observed buried nearby and this may be due to the same, but the strength and size of the anomaly suggests further investigation. If material of environmental concern is found, other anomalies in the area should be upgraded to Type A status.
45	7990E/2870N	Strong anomaly; buried metal indicated. Demolition debris was observed at this exact location, and a visual inspection with minor soil disturbance may be sufficient to characterize the feature.
TYPE B ANOMALIES: LOWER PRIORITY		
3	—	Minor anomaly near soil pile.
4	—	Moderate anomaly near soil pile.
5	—	Minor anomaly near soil pile.
10	—	Minor anomaly.
11	—	Minor anomaly.
12	—	Minor anomaly.
13	—	Moderate anomaly. Investigation recommended if anomalies 6, 7, or 14 show material of concern.
15	—	Moderate anomaly. Investigation recommended only if anomaly 14 shows material of concern.

Table 1
Anomaly Interpretations

No.	Best Position to Investigate	Notes
16	—	Minor anomaly.
17	—	Minor anomaly.
18	—	Moderate anomaly. Investigation recommended if anomaly 19 shows material of concern.
24	—	Minor anomaly.
26	—	Well-defined zone of higher moisture and metal content. This could be an extension of the landfill, but might be due to topography. Sampling is recommended to confirm; this and anomaly 29 (Type A) can be sampled simultaneously.
30	—	Minor anomaly.
31	—	Moderate anomaly possibly associated with old gravel road.
32	—	Minor anomaly.
33	—	Minor anomaly.
34	—	Moderate anomaly in area of buried rubble.
35	—	Strong anomaly in area of buried rubble. Consider for investigation if anomaly 37 shows material of concern.
36	—	Broad area of higher soil moisture but without significant metal.
38	—	Moderate anomaly.
39	—	Moderate anomaly.
40	—	Broad zone of higher soil moisture.
41	—	Minor anomaly.
42	—	Minor anomaly.
43	—	Minor anomaly.
44	—	Strong anomaly. Followup contingent on results at anomalies 37 and 45.
46	—	Minor anomaly.
48	—	Broad area of anomalies in both parameters. It is unclear if this is due to pervasive culture in the area or it is an area of construction rubble or fill.
49	—	Minor anomaly; metal indicated.
53	—	Stronger response within anomaly 48 may be due to disturbed soil.
61	—	Large area of apparently disturbed soil, possibly the result of construction.
62	—	Small metal object may be buried; minor anomaly.
63	—	Small ground disturbance; minor anomaly.

Table 1
Anomaly Interpretations

No.	Best Position to Investigate	Notes
TYPE C ANOMALIES: NOT RELATED TO SUBSURFACE FEATURES		
1	—	Metal banding in pile of plastic pipes.
2	—	Metal free-standing tank at surface.
8	—	Increased soil moisture along drainage ditch (extension of anomaly 28).
9	—	Metal object in drainage ditch; however, the object is not exposed.
27	—	Metal culvert under gravel road.
28	—	Increased soil moisture along drainage ditch.
47	—	Fence corner.
50	—	Buried utilities and reinforced concrete make all data within the liquid oxygen tank area uninterpretable.
51	—	Broad zone possibly indicating several large metal utilities.
52	—	Numerous buried utilities clearly indicated in the data. The disconnected nature of some of these features is hard to explain; perhaps they have been partly removed. Note that the locations may be at variance with the engineering drawings, which may be schematic rather than literal in regard to utility locations. Note the wavy patterns in the linear features — artifacts of reciprocity effects and response-time effects, which distort the anomaly positions slightly.
54	—	Anomalies along the edge of an asphalt parking lot may be due to reinforced concrete barriers or other artifacts of construction.
55	—	Anomaly due to erosion barrier and street culture.
56	—	Anomaly due to street culture.
57	—	Probably the storm drain indicated on the engineering drawing (the offset may be due to inaccuracy in the drawing).
58	—	Fence plus higher moisture in ditch.
59	—	Higher moisture in ditch.
60	—	Storm drain and culvert.
TYPE D FEATURES: FREE OF ANOMALIES		
D1	—	No landfill or subsurface burial responses.
D2	—	Background responses.
D3	—	Large area clear of obvious burial responses. More conductive zones east and west of it may be related to past construction activity; hence, it is possible that a much larger area than shown is clear of burial.
D4	—	Extension of D3 separated by cultural response along the entry road.

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