Technical Report GL-95-5
May 1995

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# Geophysical Survey at Cluster 6, Westwood Area, U.S. Army Aberdeen Proving Ground

*by Janet E. Simms, Danny W. Harrelson, Michael K. Sharp*

WES



Prepared for U.S. Army Aberdeen Proving Ground

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U.S. Army Corps of Engineers
Waterways Experiment Station
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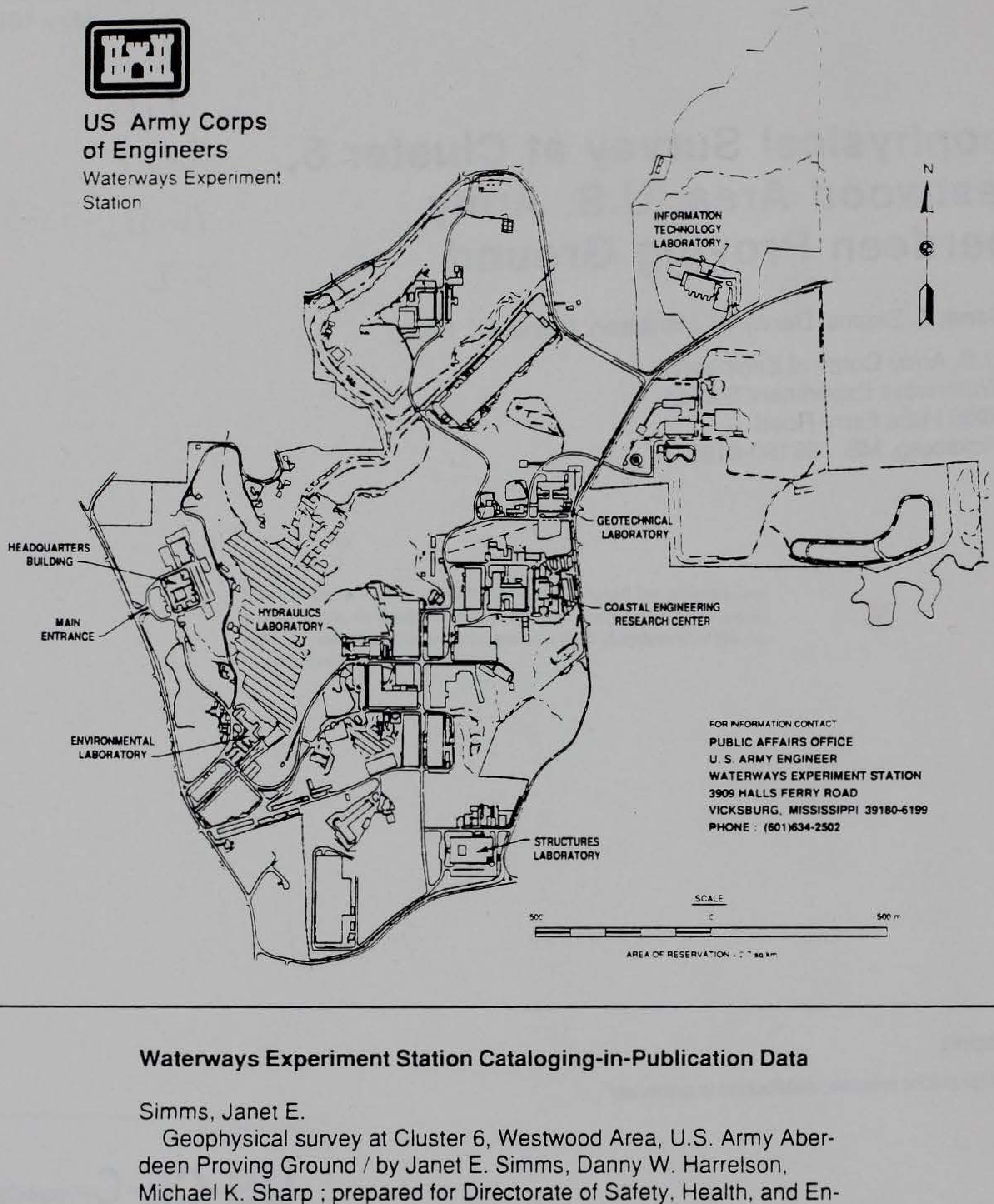
Final Report

Approved for public release; distribution is unlimited



Prepared for Directorate of Safety, Health, and Environment
U.S. Army Aberdeen Proving Ground
Aberdeen, MD 21010-5423

**US Army Corps of Engineers**
Waterways Experiment Station




**Waterways Experiment Station Cataloging-in-Publication Data**

Simms, Janet E.

Geophysical survey at Cluster 6, Westwood Area, U.S. Army Aberdeen Proving Ground / by Janet E. Simms, Danny W. Harrelson, Michael K. Sharp ; prepared for Directorate of Safety, Health, and Environment, U.S. Army Aberdeen Proving Ground.

36 p. : ill. ; 28 cm. -- (Technical report ; GL-95-5)

Includes bibliographic references.

1. Radioactive waste sites -- Aberdeen Proving Ground (Md.) 2. Water -- Pollution -- Aberdeen Proving Ground (Md.) 3. Geophysics -- Surveys -- Aberdeen Proving Ground (Md.) I. Harrelson, Danny W. II. Sharp, Michael K. III. United States. Army. Corps of Engineers. IV. U.S. Army Engineer Waterways Experiment Station. V. Geotechnical Laboratory (U.S. Army Engineer Waterways Experiment Station) VI. Aberdeen Proving Ground (Md.). Directorate of Safety, Health, and Environment. VI. Title. VII. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; GL-95-5.

TA7 W34 no.GL-95-5

# Contents

# Preface

A geophysical investigation was conducted at Cluster 6, Westwood Area, U.S. Army Aberdeen Proving Ground (APG), Aberdeen, Maryland, by personnel of the Geotechnical Laboratory (GL), U.S. Army Engineer Waterways Experiment Station (WES), 1 to 4 June 1994. The investigation was conducted for the Engineering Geology Branch, Earthquake Engineering and Geosciences Division (EEGD), GL, WES as part of the Westwood Area investigation under supervision of the Directorate of Safety, Health, and Environment, APG.

This report was prepared by Dr. Janet E. Simms and Mr. Danny W. Harrelson, EEGD. The work was performed under the direct supervision of Mr. Joseph R. Curro, Jr., Chief, Engineering Geophysics Branch, EEGD. The work was performed under the general supervision of Drs. A. G. Franklin, Chief, EEGD, and William F. Marcuson III, Director, GL. Field work and data analysis were performed by Dr. Janet E. Simms and Mr. Michael K. Sharp, EEGD.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

# Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

| Multiply | By | To Obtain |
|---|---|---|
| acres | 4,046.873 | square meters |
| feet | 0.3048 | meters |
| miles (U.S. statute) | 1.609347 | kilometers |
| gamma | 1.0 | nanotesla |
| millimhos per foot | 3.28 | millimhos per meter |
| millimhos per foot | 3.28 | milliSiemens per meter |

# 1 Introduction

## Background

The area currently referred to as Cluster 6, Site 5 is the former Westwood Area Radioactive Material Disposal Facility (WRMDF). It is located on the Edgewood Area (EA) Aberdeen Proving Ground approximately 0.4 mile southwest of the present EA gate on Magnolia Road (Figure 1). The following information describing the structures at the WRMDF and their use is taken from the U.S. Army Corps of Engineers, Baltimore District 1993 report "Detailed RI Work Plan for Cluster 6."

From the late 1950's through the early 1960's, the WRMDF was used for processing and packaging radioactive waste material prior to disposal. Little information is available on the types of radioactive waste handled, but radium markers were probably the primary waste items processed. There was no actual disposal of radioactive waste material onsite. Radioactive waste research and development work was also performed at the facility for a short time during the early 1960's.

The WRMDF was located within a fenced area approximately 120x200 ft. Structures included Building 3013 and adjacent concrete slabs where the waste handling work was accomplished, a small equipment shed, and a wastewater holding and drain system which included tanks in a concrete tank pit (Figure 2). Discharge of wastewater from the tanks was to Reardon Inlet, located a short distance south of the tank pit. Possible release of radioactive waste to the environment would have been due to either spillage, leakage, or discharge from the wastewater system.

Building 3013 existed prior to its usage for handling radioactive waste. The pipeline running from the western end of the building (Figure 2) was the original wastewater line and discharged into Reardon Inlet Marsh. This system was separate from the wastewater system that handled low-level liquid radioactive wastewater (east pipeline) and it is presumed that radioactive wastewater was not discharged through this line. After radioactive waste handling activities were discontinued at WRMDF, the west pipeline system was upgraded to include a 625 gallon septic tank, a sand filter bed approximately 23 ft long and 10 ft wide, and a chlorine contact chamber. The north end of the septic tank was located 10 ft south of the fence surrounding the Building 3013 area. The chlorine contact chamber was about 40 ft north of the discharge point at the edge of Reardon Inlet Marsh. The sand filter bed was located between the septic tank and the chlorine contact chamber (Figure 2).

The structures associated with the WRMDF were removed during the early 1970's, including the concrete tank pit. The pipe associated with the low-level radioactive wastewater system (eastern pipeline) is visible at the Reardon Inlet discharge point, indicating that it was not completely removed when the other structures were removed. The western wastewater line is also visible at the edge of Reardon Inlet Marsh, suggesting that this pipeline, the septic tank, and sand filter bed still remain in place. It is believed that the chlorine contact chamber was previously removed.

## Objectives

At the request of the Engineering Geology Branch, U.S. Army Engineers Waterways Experiment Station (WES), under the direction of the Directorate of Safety, Health, and Environment, Aberdeen Proving Ground, personnel of the WES conducted a geophysical survey at Cluster 6, Site 5 between 1-4 June 1994. The purpose of the survey was to determine the presence and location of the radioactive wastewater line and the western wastewater system (including location of the septic tank and sand filter bed).

# 2 Westwood Area Geology

Available reports, adjacent stratigraphic borings, surficial features, and geophysical data have been reviewed and the information integrated into an interpretation of the geology underlying Cluster 6. Figure 3 is a cross section based on data derived from four stratigraphic borings (W-1, W-2, W-3, and W-4) drilled in the vicinity of Cluster 6 (see Figure 1 for location of cross section). As can be seen in the cross section, the subsurface geology in the Westwood Area presents a complex situation consisting of interbedded gravels, sands, silts and clays. Two distinct ages of sediments, Pleistocene and Cretaceous, are documented within Edgewood Area. Based upon the lithologies encountered in the stratigraphic borings and analyses of pollen samples found in these sediments, the Pleistocene and Cretaceous sediments are believed to represent the surficial aquifer and the confined aquifer, respectively, in the Westwood Area. Samples taken from the stratigraphic borings were examined for pollen content to determine the ages of these sediments, which have proven critical in the interpretation of the Cluster 6 geology. The Pleistocene - Cretaceous contact is represented by a heavy dashed line on the cross section. The Cretaceous clays and silts outcrop at boring W-1, are encountered within 30 feet of the surface in boring W-2, and at over 100 feet at boring W-3. Published maps indicate a regional strike to the northeast.

A site inspection of the Harford Sands, Inc. pit adjacent to Cluster 6 revealed an unconformable, undulating contact, thought to be the Cretaceous - Pleistocene contact, exposed in the pit wall and floor. Mining appears to have been halted at or near the contact due to the lack of sands and gravels in the upper portion of the Cretaceous sediments at that location. The Pleistocene materials observed in the pit consisted of relatively permeable silts, sands, and basal coarse gravels, with considerable iron staining and iron-cemented concretions (plenthites). The Cretaceous materials were predominately kaolinitic clays with low permeabilities. These findings support data collected in stratigraphic borings in the Westwood area in which the Cretaceous - Pleistocene contact appears to be identifiable by a basal unit consisting of coarse sand and gravel with local lignite and pyrite lying atop thick, hard clays or silty clays, and clayey silts. Data from the stratigraphic borings seem to indicate that this basal sand and gravel deposit thickens eastward. The stratigraphic borings further suggest that the clay deposit thins and becomes discontinuous toward Reardon Inlet.

# 3 Geophysical Test Principles and Field Procedures

## Geophysical Test Principles

Magnetic, electromagnetic, and ground penetrating radar (GPR) surveys were performed at Cluster 6. The magnetic method was chosen because most septic tanks have some ferromagnetic metal associated with the lid or outlet point of the septic tank, and therefore should be detectable with the magnetometer. A previous reconnaissance survey at the site using a magnetometer determined that the terra cotta pipes did not exhibit a magnetic signature, suggesting that they were not fired at a high temperature when formed, and therefore other geophysical methods would be required to locate them. Electromagnetic and GPR techniques were selected to locate the terra cotta pipes, either by detecting the pipes directly or by delineating the trenches in which the pipes were placed.

### Electromagnetic surveys

The electromagnetic (EM) method is used to measure terrain conductivity. The conductivity of a material is dependent on the degree of water saturation, the types of ions in solution, porosity, the chemical constituents of the soil, and the physical nature of the soil. Due to these factors, conductivity values can range over several orders of magnitude.

The EM system consists of a transmitter and receiver coil separated by a fixed distance. An alternating current, generally in the kilohertz range, is passed through the transmitter coil, thus generating a primary time varying magnetic field. This primary field induces eddy currents in the subsurface conductive materials. These currents are the source of a secondary magnetic field which is detected by the receiver coil along with the primary field. Under a fairly wide range of conditions, the measured component that is ninety degrees out of phase (quadrature component) with the primary field is linearly related to the terrain conductivity (Keller and Frischnect 1966, Dobrin 1976, Telford et al. 1976). Conductivity is measured in units of millimho per meter (mmho/m) or, in the SI system, milliSiemen per meter (mS/m).

There are two components of the induced magnetic field measured by the EM equipment. The first is the quadrature phase component, sometimes referred to as the out-of-phase or imaginary component, which gives the ground conductivity measurement. Disturbances in the subsurface due to soil removal and fill activities or buried objects may produce conductivity readings different from that of the background values, thus indicating anomalous areas. The second component is the inphase or real component, which is the ratio of the induced secondary magnetic field to the primary magnetic field. The inphase component is primarily used for calibration purposes, however, it is significantly more sensitive to large metallic objects and therefore very useful when looking for buried metal containers. The inphase component is measured relative to an arbitrarily set level and assigned units of parts per thousand (ppt).

The Geonics EM-38 ground conductivity meter was used for this investigation. The EM-38 has a transmitter-receiver coil seperation of one meter and an effective depth of investigation of approximately five feet. The instrument can be operated in both a horizontal and vertical dipole orientation, each having different depths of investigation. Data were collected with the instrument at ground level and in vertical dipole mode, which provides the greatest depth of investigation (five feet).

### Magnetic surveys

A magnetic survey measures changes in the earth's magnetic field due to variations in the magnetic mineral content of near surface rocks and soils or iron objects. These anomalies are generally local in extent. Magnetic anomalies are due in part to induction by the magnetizing field and to remanent magnetization (Parasnis 1986). Remanent magnetization is permanent magnetization and depends on the thermal and magnetic history of the body; it is independent of the field in which it is measured (Breiner 1973). Induced magnetization is temporary magnetization that disappears if the material is removed from the inducing field. Generally, the induced magnetization is parallel with and proportional to the inducing field (Barrows and Rocchio 1990).

An EG&G Geometrics G-822L cesium magnetometer was used to survey the area. This magnetometer is equipped with one sensor carried at the end of a wand. It can be operated in sweep mode or the survey data can be collected and stored on a peripheral laptop computer. Sweep mode is ideal for reconnaissance operations, allowing the operator to cover a large area in a relatively short period of time. For this survey, data were collected at stations along the survey lines and stored on a field computer for later analysis.

The magnetometer has both a digital display and an audio indicator. The frequency of the audio tone is dependent on the strength of the measured magnetic response; as the magnetic anomaly increases, the frequency increases thus producing a higher pitched tone. The G-822L magnetometer measures the total magnetic field and has a sensitivity of 0.1 nanotesla. The sensor was carried approximately six inches above the ground.

The general operating theory of a magnetometer invloves the generation of an external magnetic field by applying a sinusoidal current to a fluid-filled sensor (either liquid or gas). The applied magnetic field excites the atomic particles (protons or electrons) within the fluid causing them to precess about the axis of the resultant field (between that of the external magnetic field and earth magnetic field). The frequency at which the atomic particles precess is proportional to the strength of the local magnetic field. The sensor on the G-822L magnetometer contains a cesium fluid. A sinusoidal current at the Larmor frequency is applied to the fluid which excites the electrons in the cesium atom to a higher energy level. The local magnetic field strength can be determined from the precession frequency of the electrons. For a more detailed explanation of the operating theory of a cesium magnetometer, refer to Telford et al. (1976).

Any material having a magnetic component will contribute to the total magnetic field measured by the magnetometer. If an object is present such that its magnetization is great enough to perturb the ambient field, then it will appear as an anomaly in the magnetic data. The size, depth of burial, and remanent magnetization of the object affect the ability of the magnetometer to detect the object. For a given remanent magnetization, as the size of the object decreases and the depth of burial increases, the level of detection will decrease. The wastewater systems associated with Building 3013 are relatively shallow, therefore any magnetic material connected with the pipeline should be detected.

### Ground penetrating radar surveys

Ground penetrating radar (GPR) is also an electromagnetic method, however it differs significantly from the EM induction methods described above to warrant a separate discussion. At the lower frequencies (kilohertz range) where EM induction instruments operate, conduction currents (currents which flow via electrons in a metallic matrix or ions in solution) dominate and energy diffuses into the ground. At the higher frequencies (megahertz range) which GPR utilizes, displacement currents (currents associated with charges which are constrained from moving any distance) dominate and energy propagates into the ground as a wave.

Ground penetrating radar is used to image the subsurface. This is achieved by transmitting an electromagnetic pulse, which propagates into the earth where it undergoes refraction, reflection, scattering, and dispersion, and measuring the return signal. The frequencies employed in GPR typically range from 1 to 1000 MHz. Contrast in the dielectric permittivity at layer boundaries causes the EM wave to be reflected and refracted. The dielectric permittivity is the proportionality factor relating the displacement current to energy. Since electromagnetic fields consist of both electric and magnetic fields, any properties of the geologic material which affect either of these fields will also affect the propagation of the EM wave in the subsurface. Generally, the electrical properties of the soil and rock have a greater influence on the EM wave propagation. Soil conductivity is a major factor in determining if GPR can be used successfully at a site. High conductivity soils, such as those with a high clay content, can significantly attenuate the EM signal and render GPR virtually useless.

A Sensors & Software, Inc. pulseEKKO IV system employing a 200 MHz antenna was used to collect the GPR data. The survey was performed in reflection mode where the transmitter and receiver antennas are kept a fixed distance apart and both antennas are simultaneously moved along the survey line. The time required for the EM wave to travel through the subsurface and return to the receiver was recorded at each sample station. The received signal is plotted against two-way travel time at each sample station along the survey line. Figure 4 illustrates the reflection mode and the corresponding GPR response for the anomaly shown.

## Field Methods

Two grids, one which encompassed the west and east terra cotta pipes, were flagged at five foot intervals. The east grid was 20 ft wide and extended approximately 130 ft north from the exposed end of the pipe. The west grid was 40 ft wide at the widest point and extended about 125 ft north from the exposed pipe end to the furthest point north. Magnetometer and EM-38 measurements were collected at 2.5 ft intervals. GPR data were collected along survey lines perpendicular to the suspected orientation of the pipes at selected locations.

# 4 Geophysical Results

A map of the site showing the probable location of former structures (denoted by dashed line) and the possible location of present wastewater lines and related structures (solid line) is given in Figure 2. Both pipes are visible at the outlet to Reardon Inlet Marsh. The east terra cotta pipe is at ground surface at the concrete outfall junction near the outlet and is exposed for five feet due north of the junction, where it is believed to continue underground (Figure 5). South of the concrete outfall junction is an exposed section of iron pipe. A washout gully runs along the same general line and direction as the terra cotta pipe, and it is suspected that the pipe either underlies or parallels the gully.

The west pipe is known to extend 12 ft due north of the exposed end at the outlet to Reardon Inlet Marsh. Beyond that point it is not sure if the pipe continues in the same direction or makes a turn, as indicated in Figure 2. A strong magnetic anomaly detected due north of the exposed pipe end during the reconnaissance survey, indicating the possible location of the septic tank, suggests that the pipe probably does not angle off in another direction, but extends due north to the anomaly. Figure 5 shows the known locations of both pipes and the survey grids.

## West Pipe

The west pipe area was surveyed to determine the location of the terra cotta pipe and associated septic tank and sand filter bed. Figure 6 depicts the survey grid with surface and cultural features noted. The magnetic and EM-38 inphase surveys were performed over a portion of the grid extending from (0E-20E, 40S-20N). The primary purpose of these surveys was to locate the septic tank. The EM-38 conductivity data were initially collected over the same area, however the grid was extended (to 40E, 80S) to encompass an anomalous region.

The magnetic total field data are presented in Figure 7. The large high anomaly centered at (10E, 15N) and at an estimated depth of 3.5 ft is the suspected location of the septic tank. The high extending from the anomaly to 20E is probably due to a cable which terminates about one foot above the base of the telephone pole located at (20E, 14N). The magnetic high also exhibits a southward trend, suggesting the location of a ferrous metallic pipe fitting on the outside of the septic tank. The magnetic high at (0E, 4N) and lows at (0E,40S), (10E, 13S), and (20E, 7S) are due to small, shallow, ferrous objects. It is possible that the anomaly low at (10E, 13S) may be associated with the wastewater system since it is in line with the suspected location of the pipe.

A plot of the EM-38 conductivity data is given in Figure 8. A strong conductivity high is located between (0E-15E, 0N-20E), the same area where the magnetic high is located. There is also a linear conductivity high trending to the southeast toward Reardon Inlet Marsh (5-15E, 2S to 32-40E, 80S). This anomaly may represent a trench filled with a higher conductivity soil than that of the local soil, or it may indicate a drainage path where the soil is more saturated than the surrounding material. It is doubtful that this linear anomaly is related to the terra cotta pipe since the exposed pipe is located 30 ft west of the southeast end of the linear anomaly high. The high at (2E, 72S) is due to a small, shallow object.

The EM-38 inphase data indicate an anomaly high at the suspected location of the septic tank (5E-15E, 10N-20N) (Figure 9). A linear anomaly low that corresponds to the linear conductivity high is also seen, indicating the presence of a material which differs from that of the sourrounding soil.

Preliminary GPR tests performed on a section of exposed pipe indicated that the terra cotta pipe does not possess strong reflective properties. If the location of the pipe could be determined, it would probably be through the detection of the trench in which the pipe was placed rather than detection of the pipe directly. Figures 10-13 are GPR profile data collected along traverses perpendicular to the suspected location of the terra cotta pipe, which is at 10E on each profile line. The location of each line is denoted in Figure 6. The radar data are not conclusive, but there appear to be some anomalies which may indicate the location of the pipe. An anomaly is located at 12E at a depth of 2.3 ft on profile line 69S in Figure 10. This GPR line is only 13 ft north of the exposed pipe end and it is questionable if the pipe is over two feet deep at this point. The anomaly seen on GPR line 59S (Figure 11) is at 16E (depth 2.7 ft), and therefore probably not associated with the pipe. No anomalies are evident on line 46S (Figure 12). Two anomalies are apparent in Figure 13; line 13S; one is located at 0E and the other at 11E. The anomaly at 11E is at a depth of 1.6 ft and may correspond to the pipe. Figure 14 is a GPR profile collected along line 15N, where the magnetic high is located. Two anomalies are evident, a broad hyperbola at 11E and a sharper hyperbola at 21E. Both anomalies are about 2.2ft deep. The anomaly at 11E corresponds to the suspected location of the septic tank. The other anomaly may be a cable associated with the powerline pole.

Figure 15 shows the location of the major anomalies detected on the west grid by the various geophysical methods.

## East Pipe

A map of the east grid showing surface features is given in Figure 16. The location of the terra cotta pipe was the only objective for the east pipe wastewater line, therefore conductivity and GPR data were the only data sets collected. GPR data were collected along just one profile line because the location of the gully and how it would appear on the GPR record would inhibit the identification of the pipe in the data, if it was present. Also, because of the thick underbrush and questionable results obtained with the radar on the west pipe grid, it was decided that a point north of the wood line would be best for running a profile line.

The EM-38 conductivity data are presented in Figure 17. The data do not exhibit any linear trends which would suggest the location of the pipe. A very small anomaly high due to an unknown shallow object is located at (15E, 112N).

A plot of the GPR profile data is given in Figure 18. There are no obvious anomalies in this data. One point (7.5E, depth 1.8ft) is suspicious, but it may be where the 1.3 ft deep subsurface layer is splitting into two layers.

# 5 Conclusions and Recommendations

A geophysical investigation was conducted at Cluster 6, Site 5 of the Westwood Area, Aberdeen Proving Ground. The purpose of the investigation was to determine the presence and location of two buried wastewater lines, and to determine the location of a septic tank and sand filter bed associated with one of the water lines.

The magnetic and conductivity surveys identified a large high associated with the western pipe system which is thought to be due to the septic tank. The center of the high is located 97 feet due north of the exposed end of the pipe at an estimated depth of 2-3.5 ft. Neither data set gave any indication of the location of the terra cotta pipe. Of the four GPR lines which traversed the suspected location of the western pipe, two showed anomalies at locations where the pipe is believed to be buried. No method utilized was able to determine the location of the sand filter bed. A southeast trending linear conductivity high which extends from the suspected septic tank to Reardon Inlet Marsh was detected. The anomaly may represent a trench filled with a higher conductivity material, or it may indicate a drainage path where the soil has a higher degree of saturation than that of the surrounding soil. Further investigation of this anomaly is warranted.

The eastern terra cotta pipe could not be detected by either the conductivity or GPR survey methods.

Since the location of the terra cotta pipes could not be positively determined, it is recommended that a metal rod, approximately 3 to 4 ft long, be used to probe the subsurface to determine the exact location of the pipes.

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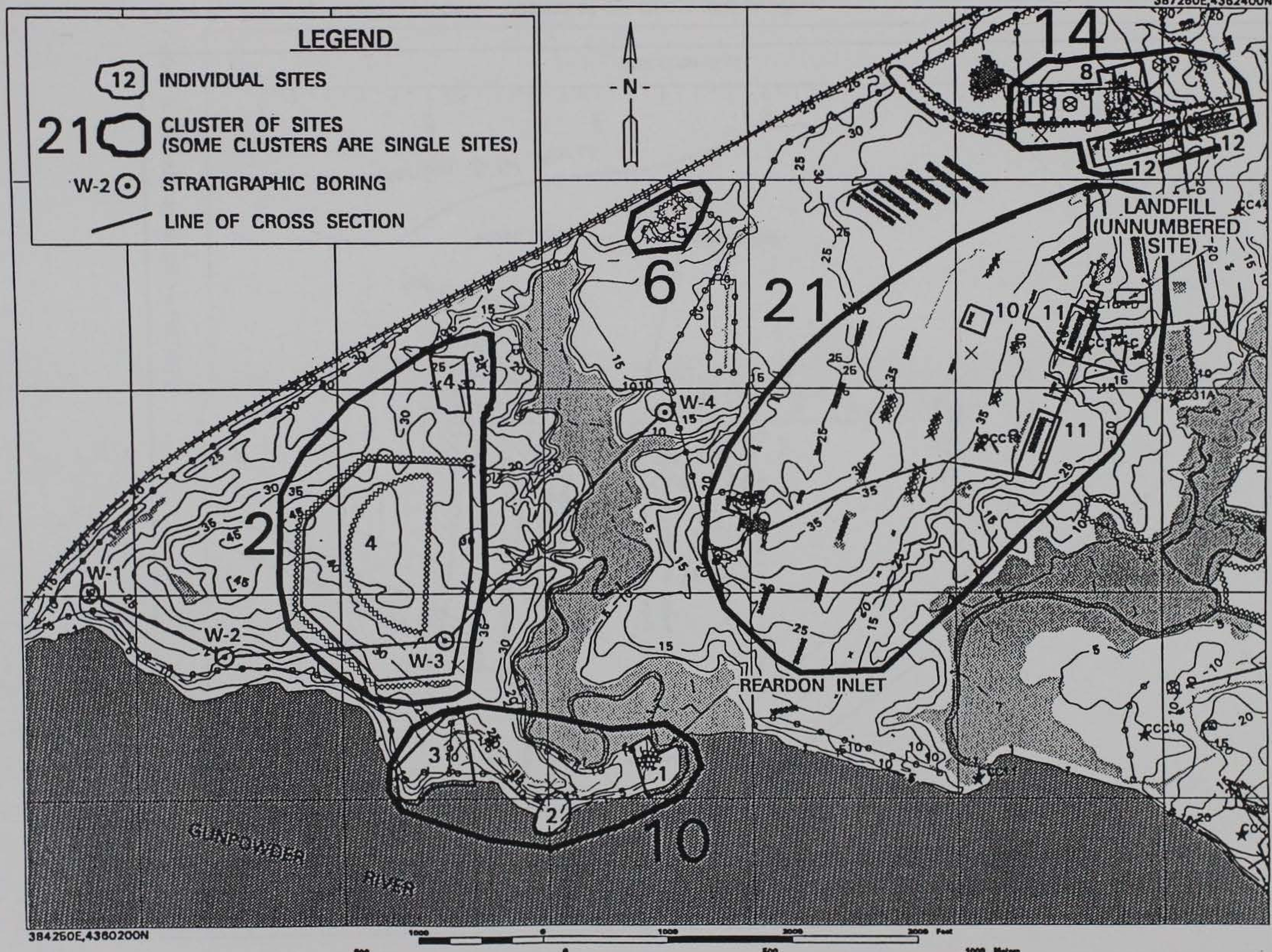



Figure 1. General location of Cluster 6

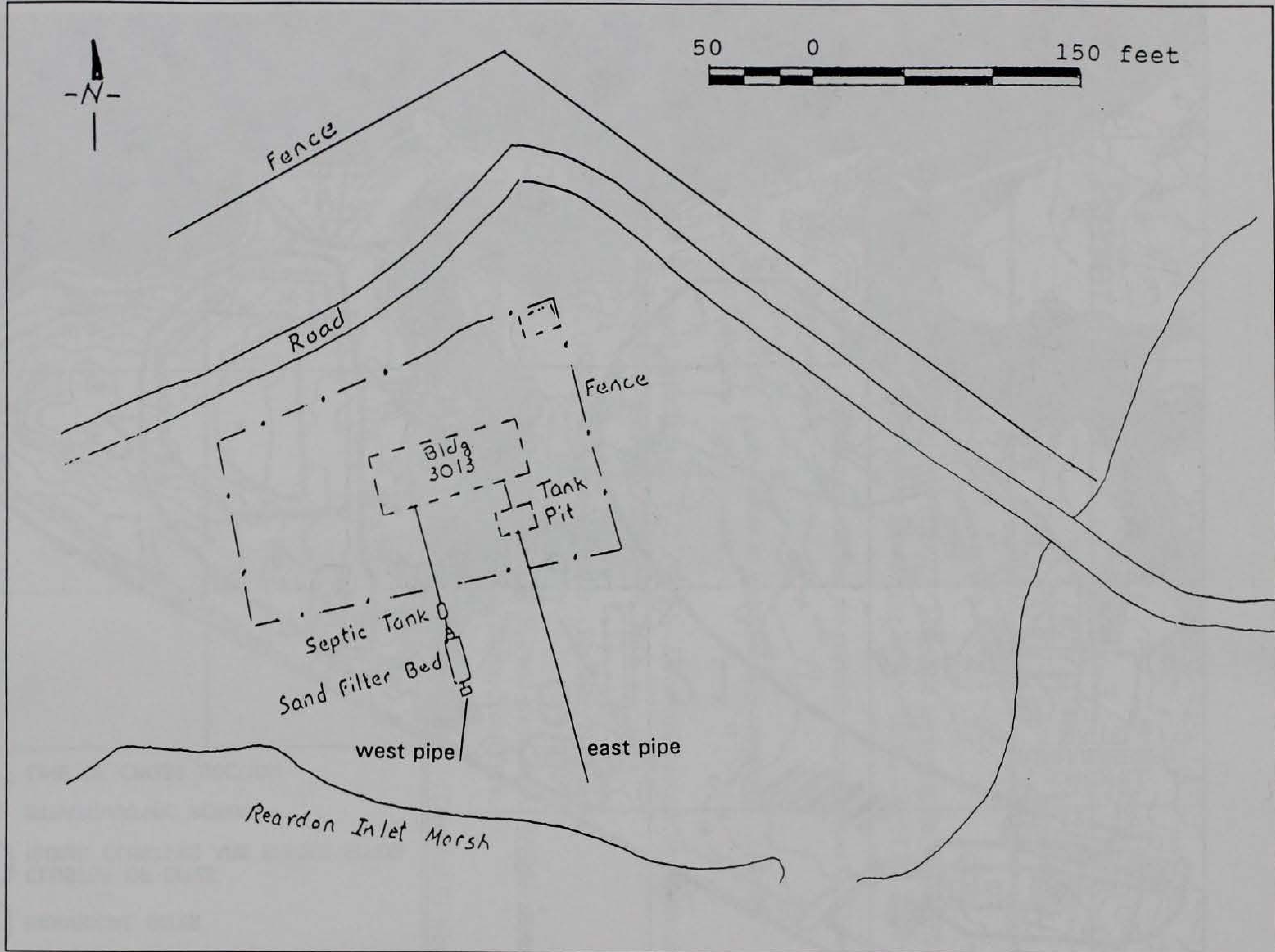
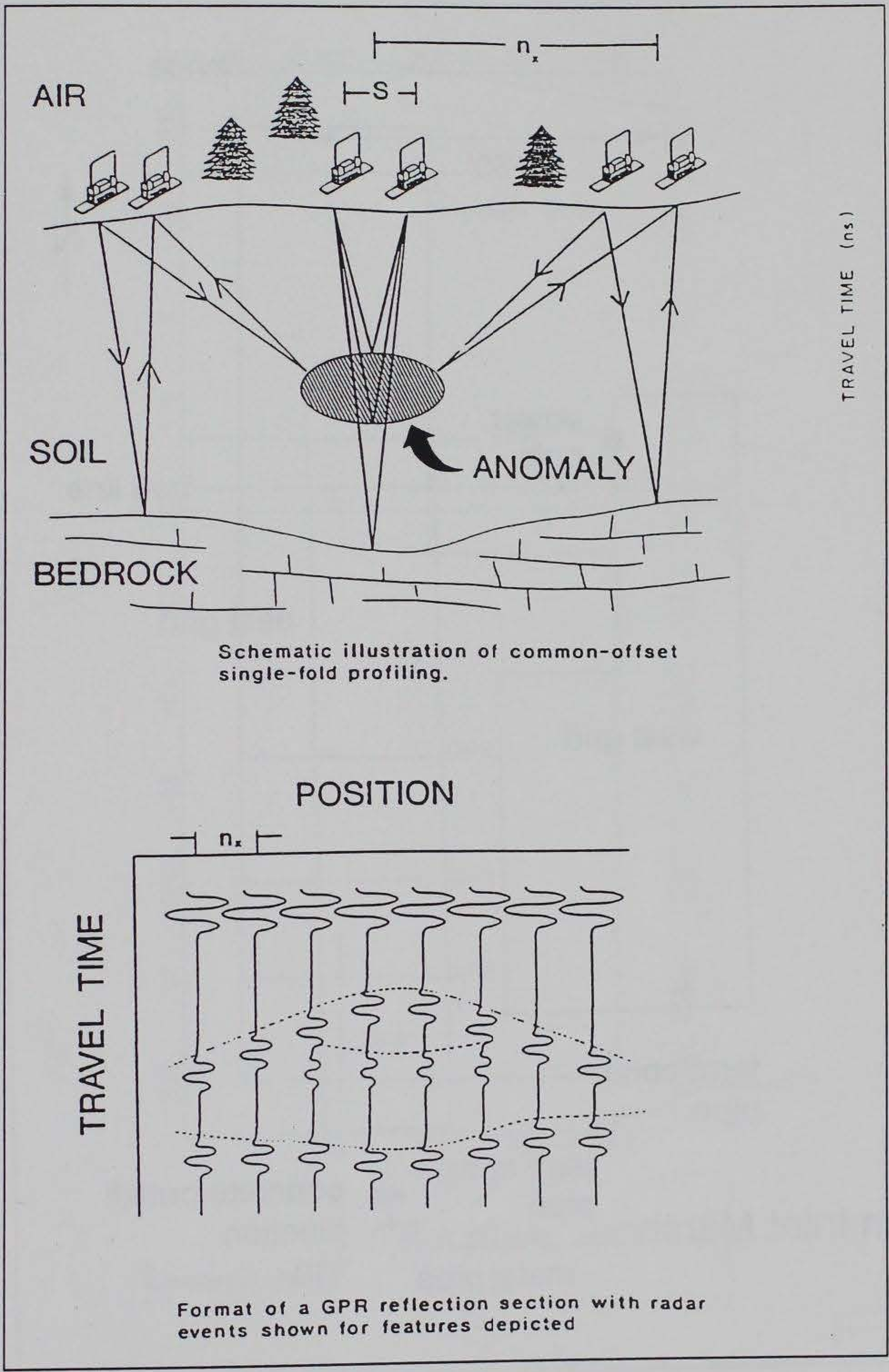



Figure 2. Site map showing probable location of structures and pipelines


Figure 3. Stratigraphic cross section of Westwood Area




Schematic illustration of common-offset single-fold profiling.

Format of a GPR reflection section with radar events shown for features depicted

Figure 4. Illustration of reflection mode GPR and corresponding radar section for anomaly shown

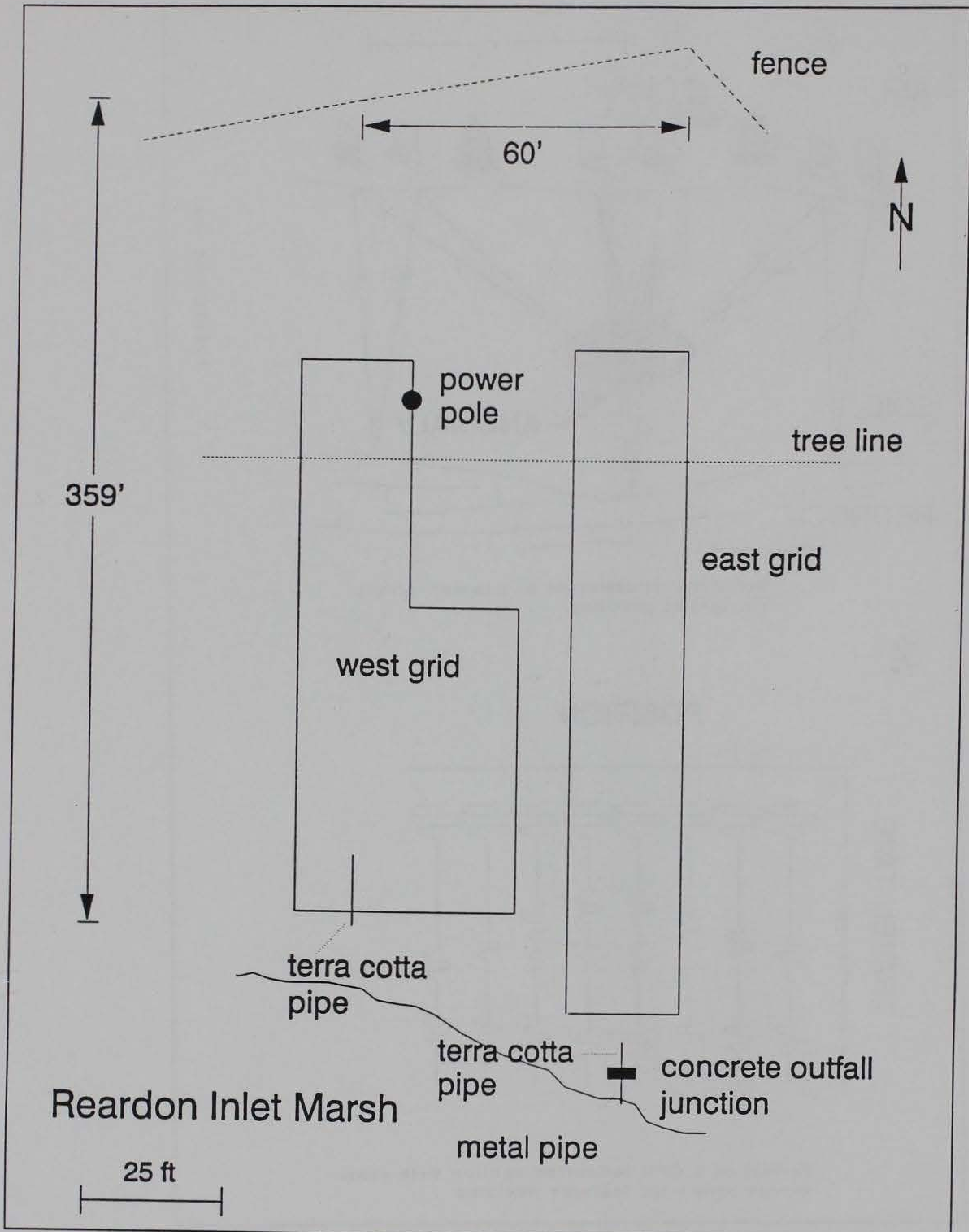



Figure 5. Drawing showing the known location of the two pipes and survey grids

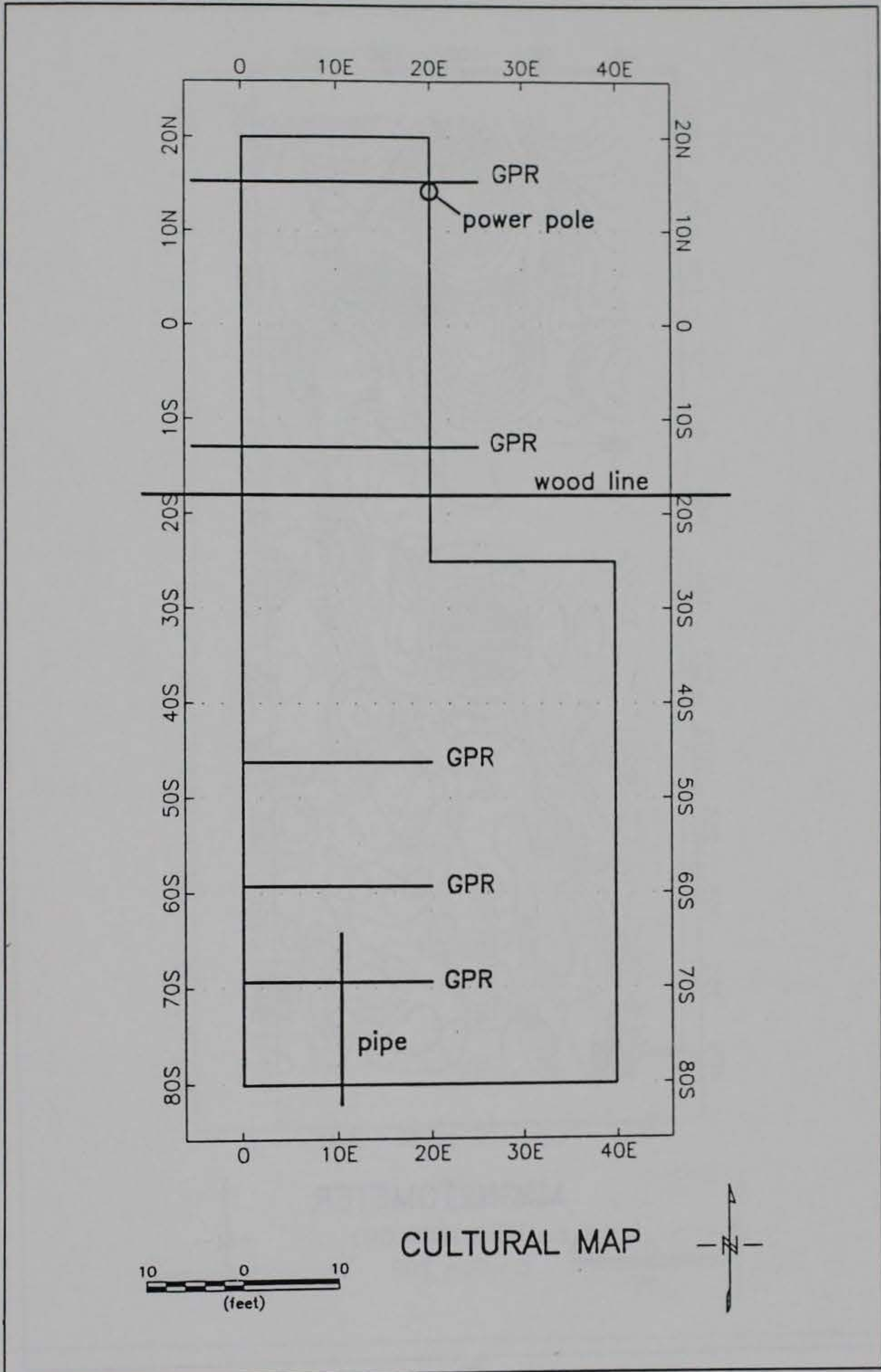



Figure 6. Cultural map of west survey grid

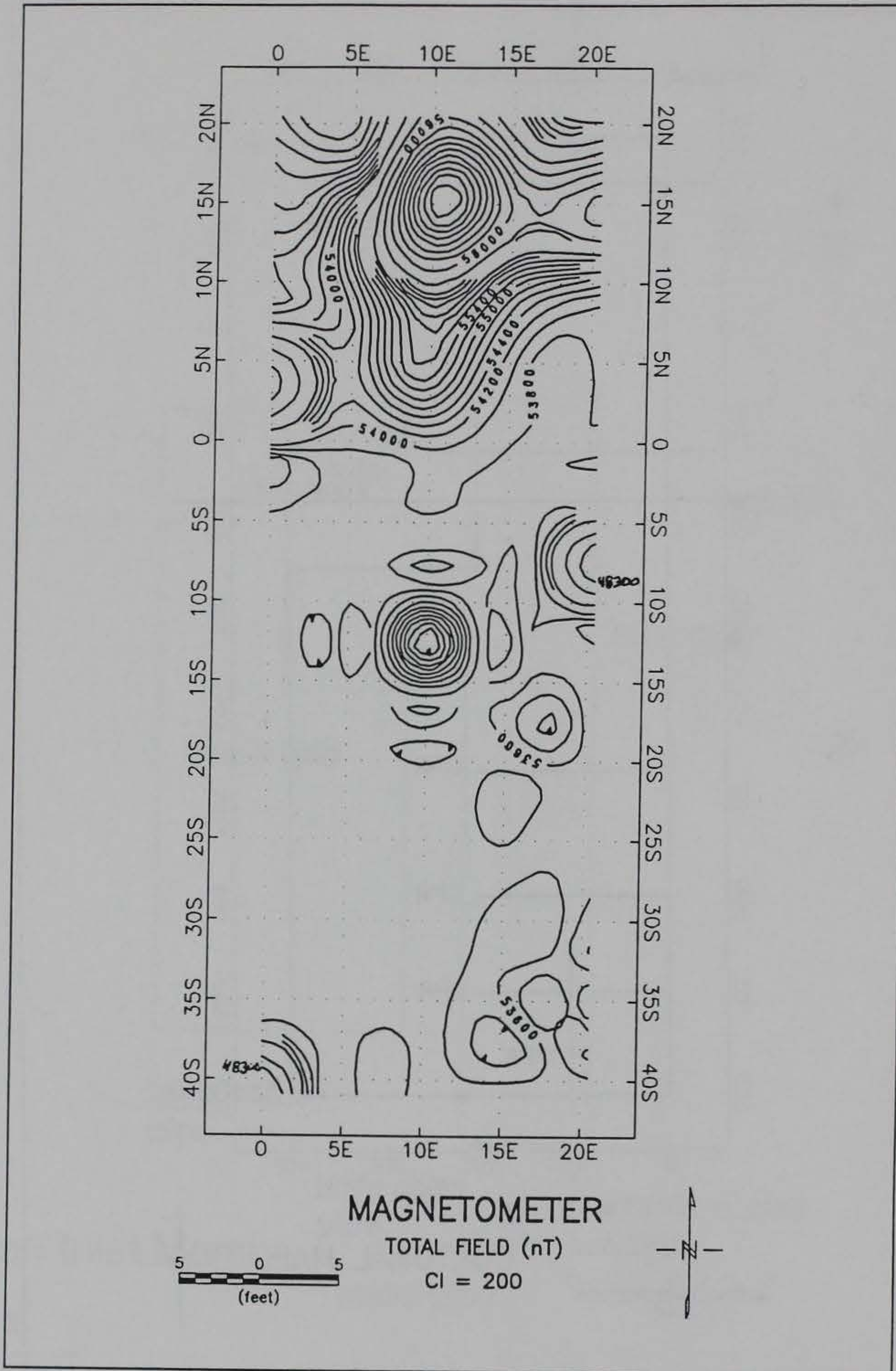



Figure 7. Contour map of magnetic total field data for a section of the west survey grid

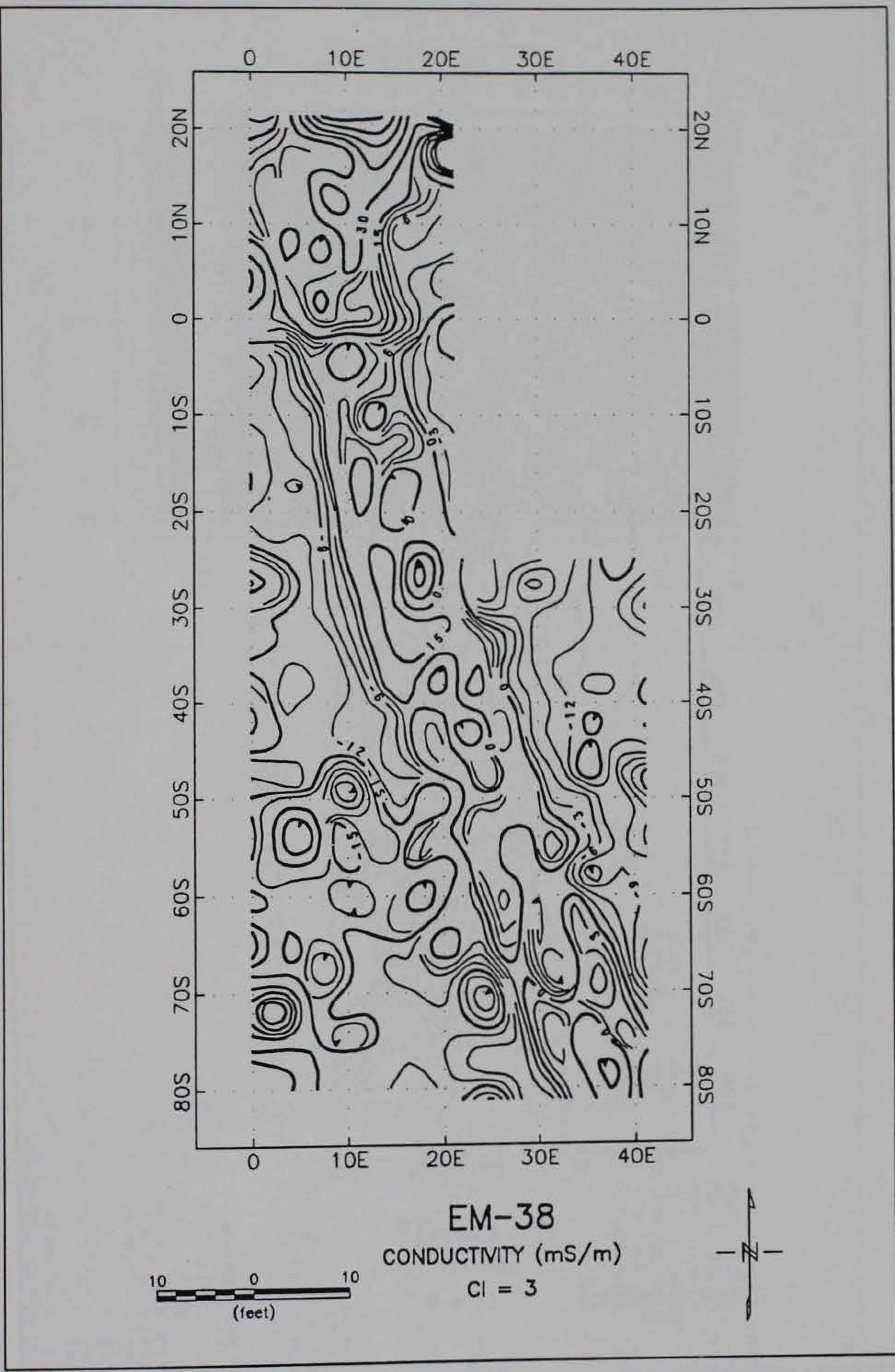



Figure 8. Contour map of conductivity data for the west survey grid

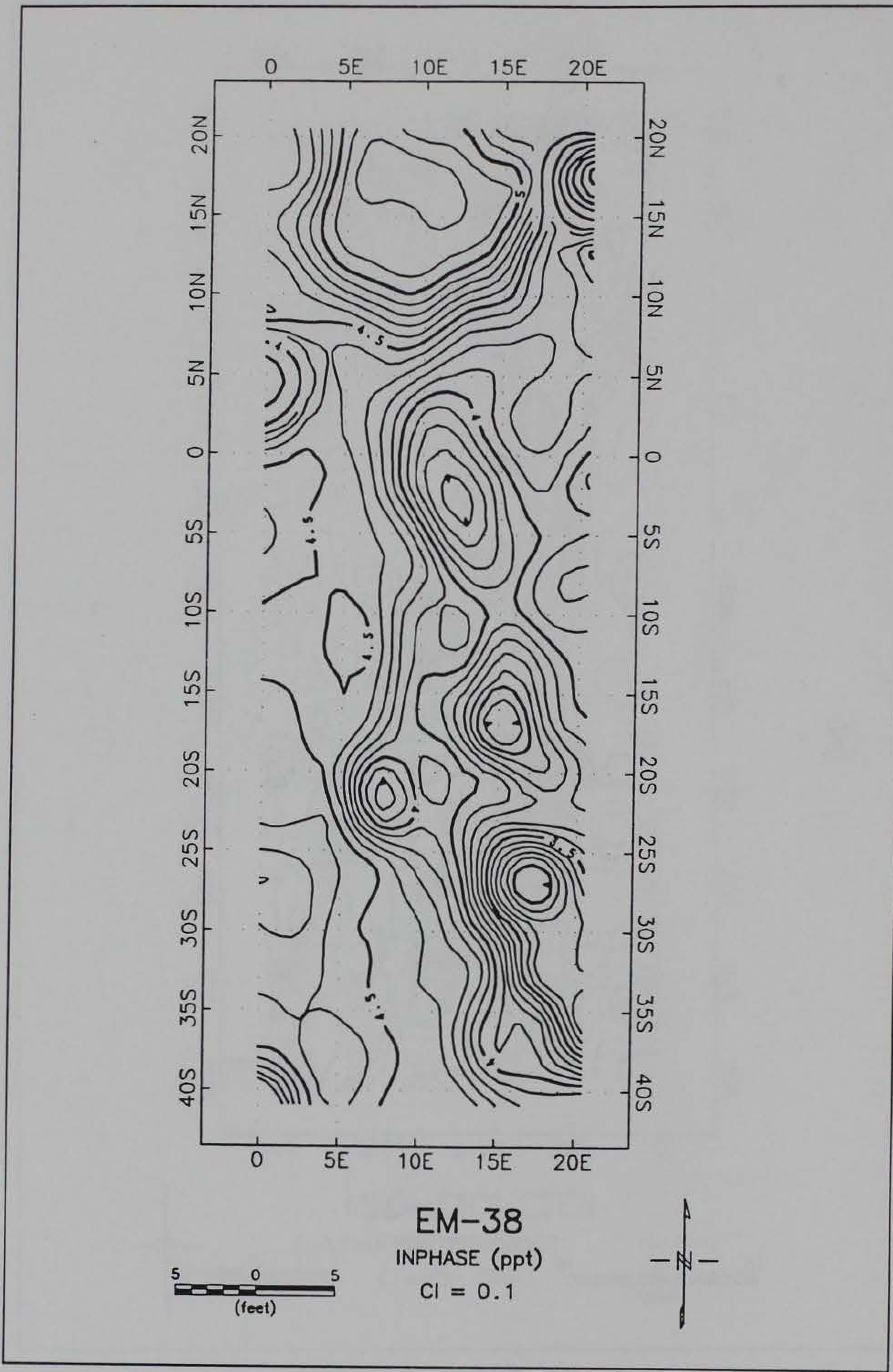



Figure 9. Contour map of inphase data for a section of the west survey grid

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     SURVEY MODE           = Reflection

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                  POINT STACKING: 2
                  TRACE DIFFERENCING: N
     SELECTION    TIME: 0 to 80
                  TRACE: 1 to 41
     GAINS:       GAIN TYPE: SEC
                  MAX GAIN (Manual): 50
                  ATTENUATION: 1.00
                  VELOCITY: 0.0700

PLOT LAYOUT PARAMETERS
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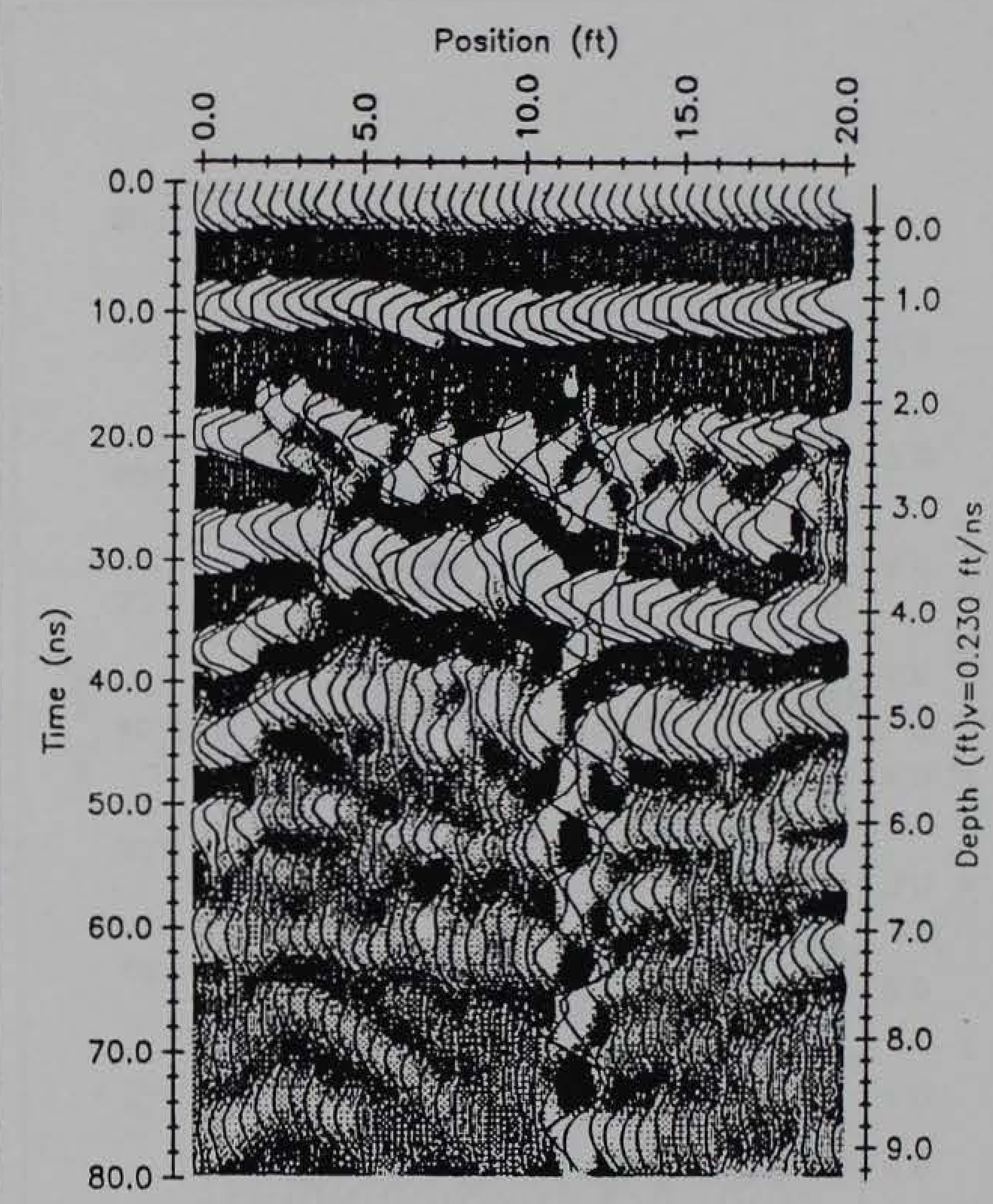


Figure 10. GPR profile line 69S on west survey grid

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     PULSER VOLTAGE        = 400
     NUMBER OF STACKS      = 16
     SURVEY MODE           = Reflection

PROCESSING SELECTED
     FILTERS:     TRACE STACKING: 1
                  POINT STACKING: 2
                  TRACE DIFFERENCING: N
     SELECTION    TIME: 0 to 80
                  TRACE: 1 to 38
     GAINS:       GAIN TYPE: SEC
                  MAX GAIN (Manual): 50
                  ATTENUATION: 1.000
                  VELOCITY: 0.0700

PLOT LAYOUT PARAMETERS
     TRACE SPACING AND WIDTH: 0.0800 and 0.3200
     TRACE BOTTOM AND TOP: 1.0000 and 6.0000
     MARGIN LEFT AND RIGHT: -0.5000 and 1.0000
     PAGE WIDTH: 7.0000
     BORDER SIZE: 0.000
     PRINTER NAME: LAS300
     SCALE BAR: Name:grey Type:EA Expansion:0.500 Contour:0
```

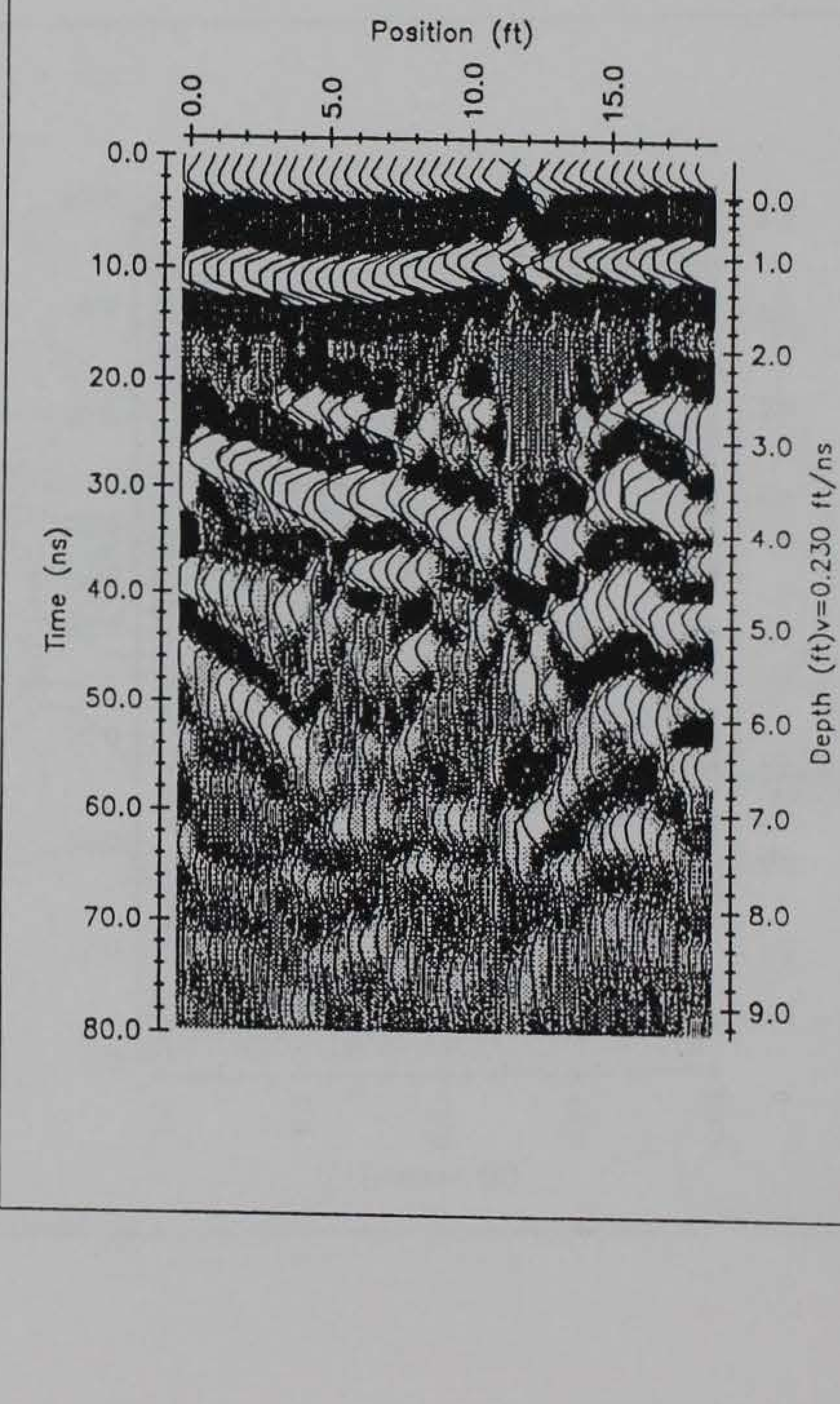


Figure 11. GPR profile line 59S on west survey grid

pulseEKKO HEADER PARAMETERS
FILE = b:\c6l36n
JOB# =
TITLE = c6pipe line 36 n 20ft to 0 ft
TITLE =
DATE = 01/06/94
NUMBER OF TRACES = 41
NUMBER OF PTS/TRC = 187
TIMEZERO AT POINT = 49
TOTAL TIME WINDOW = 150
STARTING POSITION = 20.000
FINAL POSITION = 0.000
STEP SIZE USED = -0.500
POSITION UNITS = feet
NOMINAL FREQUENCY = 200.00
ANTENNA SEPARATION = 1.000
PULSER VOLTAGE = 400
NUMBER OF STACKS = 16
SURVEY MODE = Reflection

PROCESSING SELECTED
FILTERS: TRACE STACKING: 1
POINT STACKING: 2
TRACE DIFFERENCING: N
SELECTION TIME: 0 to 80
TRACE: 1 to 41
GAINS GAIN TYPE: SEC
MAX GAIN (Manual): 50
ATTENUATION: 1.000
VELOCITY: 0.0700

PLOT LAYOUT PARAMETERS
TRACE SPACING AND WIDTH: 0.0800 and 0.3200
TRACE BOTTOM AND TOP: 1.0000 and 6.0000
MARGIN LEFT AND RIGHT: -0.5000 and 1.0000
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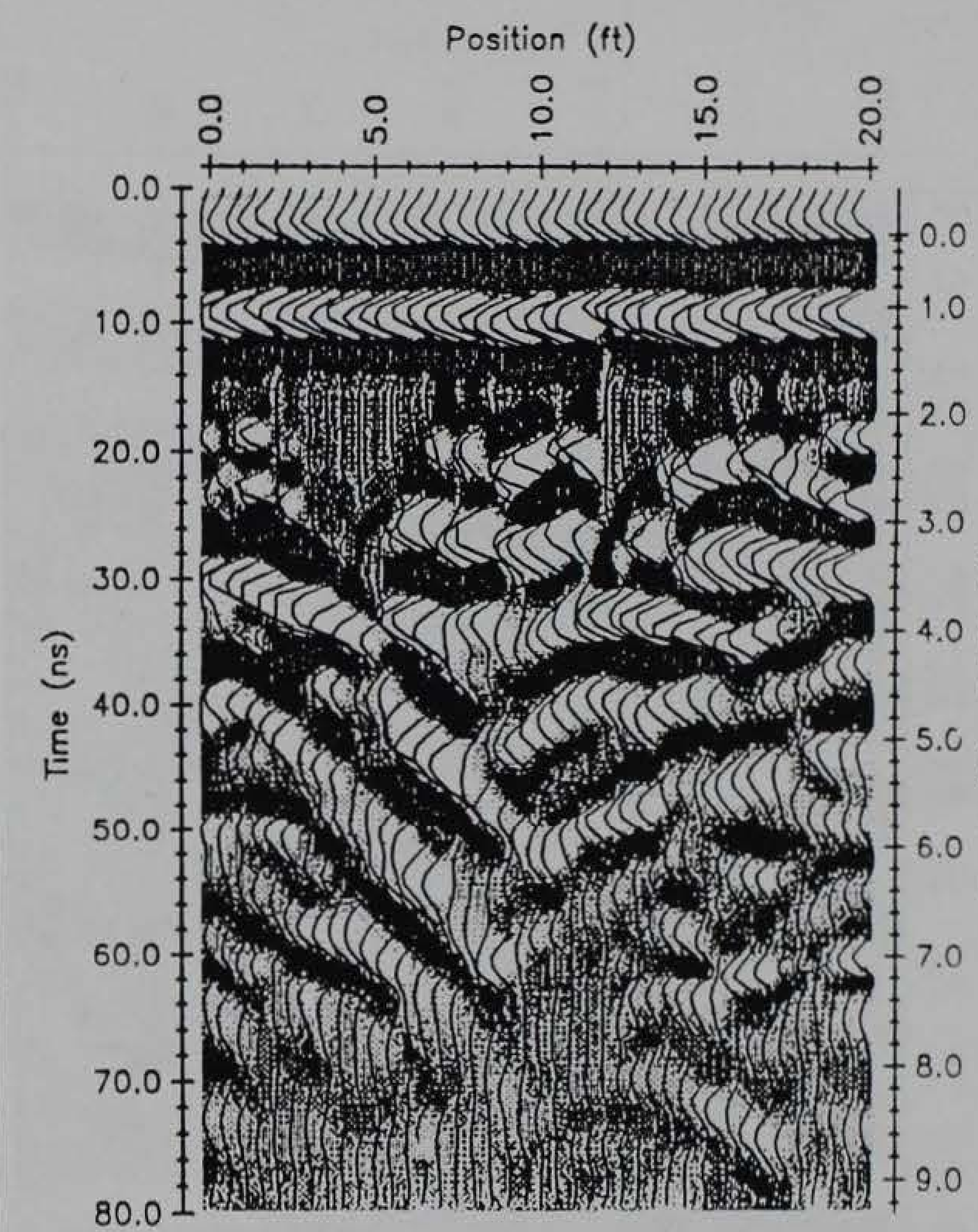


Figure 12. GPR profile line 46S on west survey grid

pulseEKKO HEADER PARAMETERS
FILE = b:\c6wpwl
JOB# =
TITLE = c6pipe line edge of woods 30 to 0ft
TITLE =
DATE = 02/06/94
NUMBER OF TRACES = 63
NUMBER OF PTS/TRC = 125
TIMEZERO AT POINT = 27
TOTAL TIME WINDOW = 100
STARTING POSITION = 25.000
FINAL POSITION = -6.000
STEP SIZE USED = -0.500
POSITION UNITS = feet
NOMINAL FREQUENCY = 200.00
ANTENNA SEPARATION = 1.000
PULSER VOLTAGE = 400
NUMBER OF STACKS = 16
SURVEY MODE = Reflection

PROCESSING SELECTED
FILTERS: TRACE STACKING: 1
POINT STACKING: 2
TRACE DIFFERENCING: N
SELECTION TIME: 0 to 80
TRACE: 1 to 61
GAINS GAIN TYPE: SEC
MAX GAIN (Manual): 50
ATTENUATION: 1.000
VELOCITY: 0.0700

PLOT LAYOUT PARAMETERS
TRACE SPACING AND WIDTH: 0.0800 and 0.3200
TRACE BOTTOM AND TOP: 1.0000 and 6.0000
MARGIN LEFT AND RIGHT: -0.5000 and 1.0000
PAGE WIDTH: 7.0000
BORDER SIZE: 0.000
PRINTER NAME: LAS300
SCALE BAR: Name:grey Type:EA Expansion:0.500 Contour:0

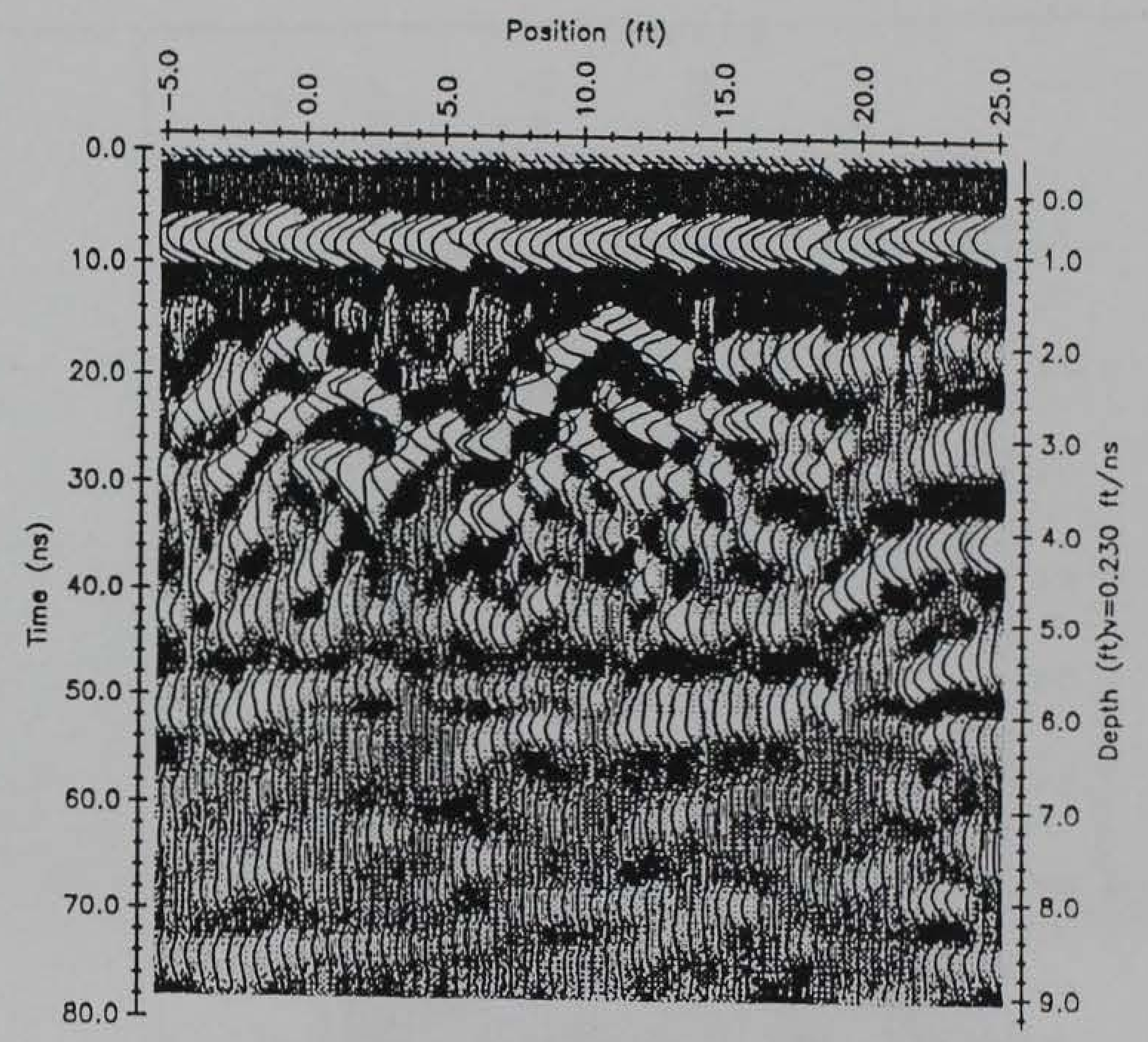


Figure 13. GPR profile line 13S on west survey grid

```
pulseEKKO HEADER PARAMETERS
     FILE   = b:\c6wp15n
     JOB#   =
     TITLE  = c6pipe line through grid 0 to 30 ft
     TITLE  =
     DATE   = 02/06/94
     NUMBER OF TRACES      = 63
     NUMBER OF PTS/TRC     = 125
     TIMEZERO AT POINT     = 27
     TOTAL TIME WINDOW     = 100
     STARTING POSITION     = -5.000
     FINAL POSITION        = 26.000
     STEP SIZE USED        = 0.500
     POSITION UNITS        = feet
     NOMINAL FREQUENCY     = 200.00
     ANTENNA SEPARATION    = 1.000
     PULSER VOLTAGE        = 400
     NUMBER OF STACKS      = 16
     SURVEY MODE           = Reflection

PROCESSING SELECTED
     FILTERS:      TRACE STACKING: 1
                   POINT STACKING: 2
                   TRACE DIFFERENCING: N
     SELECTION     TIME: 0 to 80
                   TRACE: 1 to 61
     GAINS:        GAIN TYPE: SEC
                   MAX GAIN (Manual): 50
                   ATTENUATION: 1.000
                   VELOCITY: 0.0700

PLOT LAYOUT PARAMETERS
     TRACE SPACING AND WIDTH: 0.0800 and 0.3200
     TRACE BOTTOM AND TOP: 1.0000 and 6.0000
     MARGIN LEFT AND RIGHT: -0.5000 and 1.0000
     PAGE WIDTH: 7.0000
     BORDER SIZE: 0.000
     PRINTER NAME: LAS300
     SCALE BAR: Name:grey Type:EA Expansion:0.500 Contour:0
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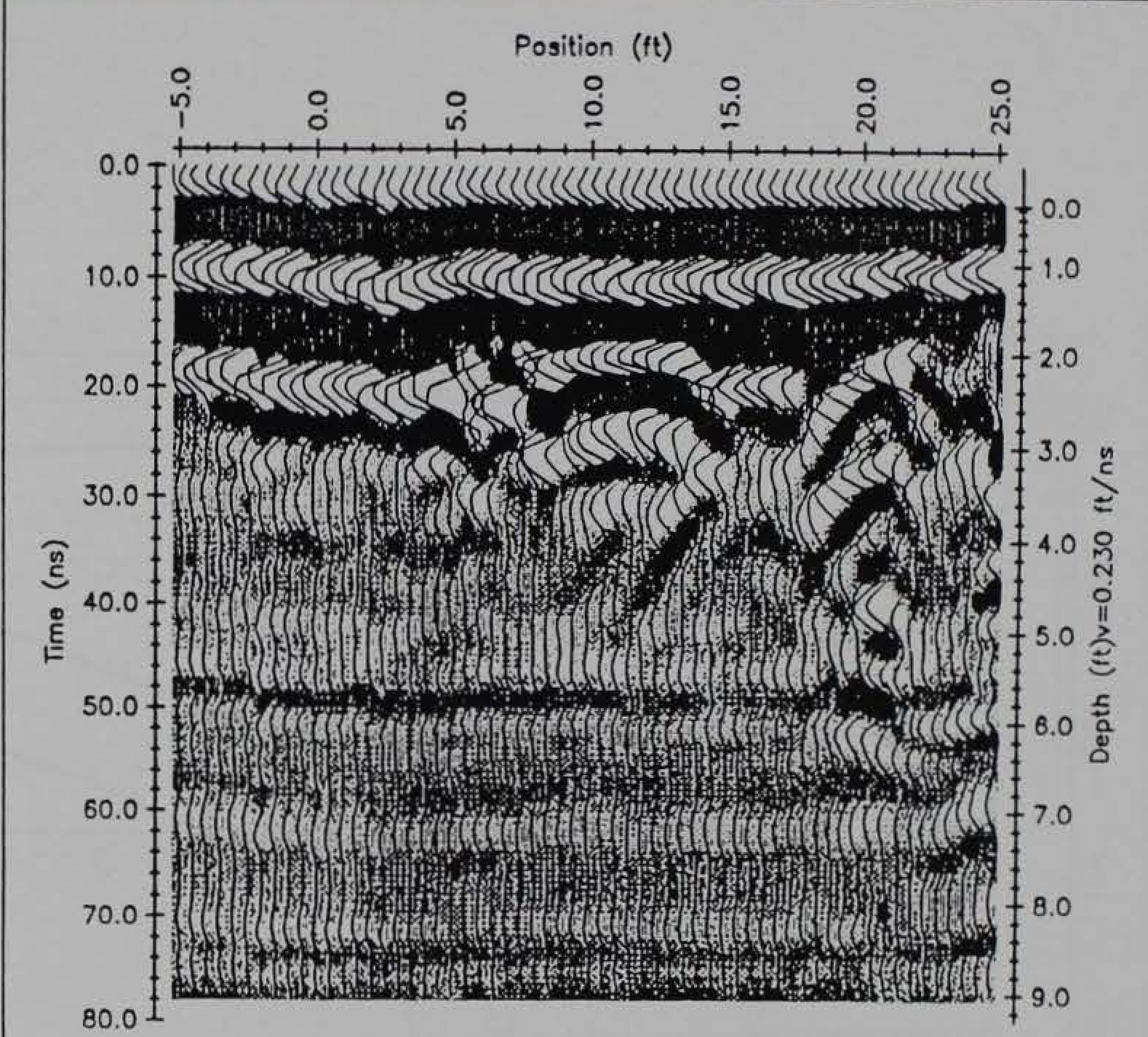


Figure 14. GPR profile line 15N on west survey grid

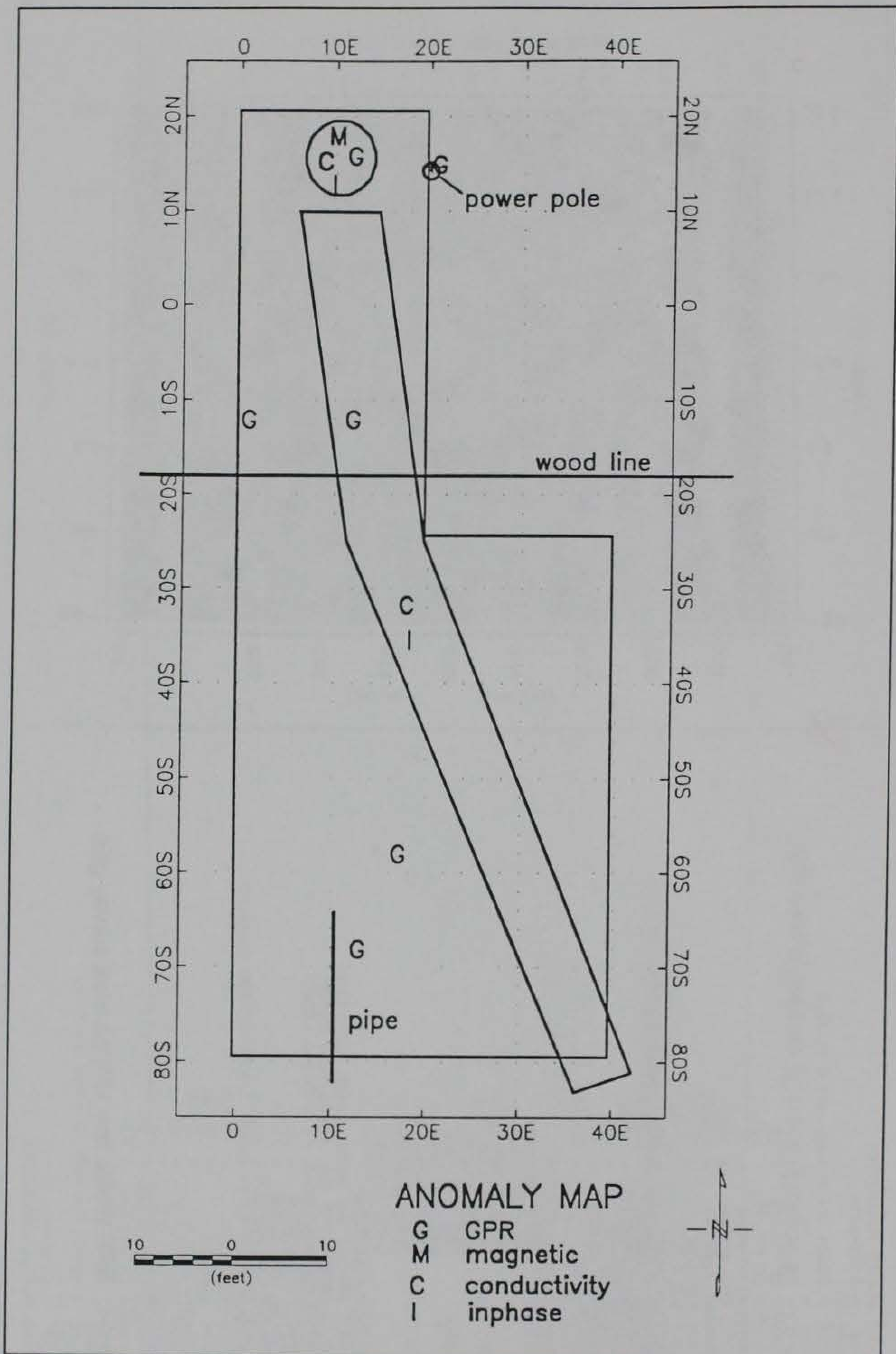


Figure 15. Plot showing location of main anomalies detected on west grid

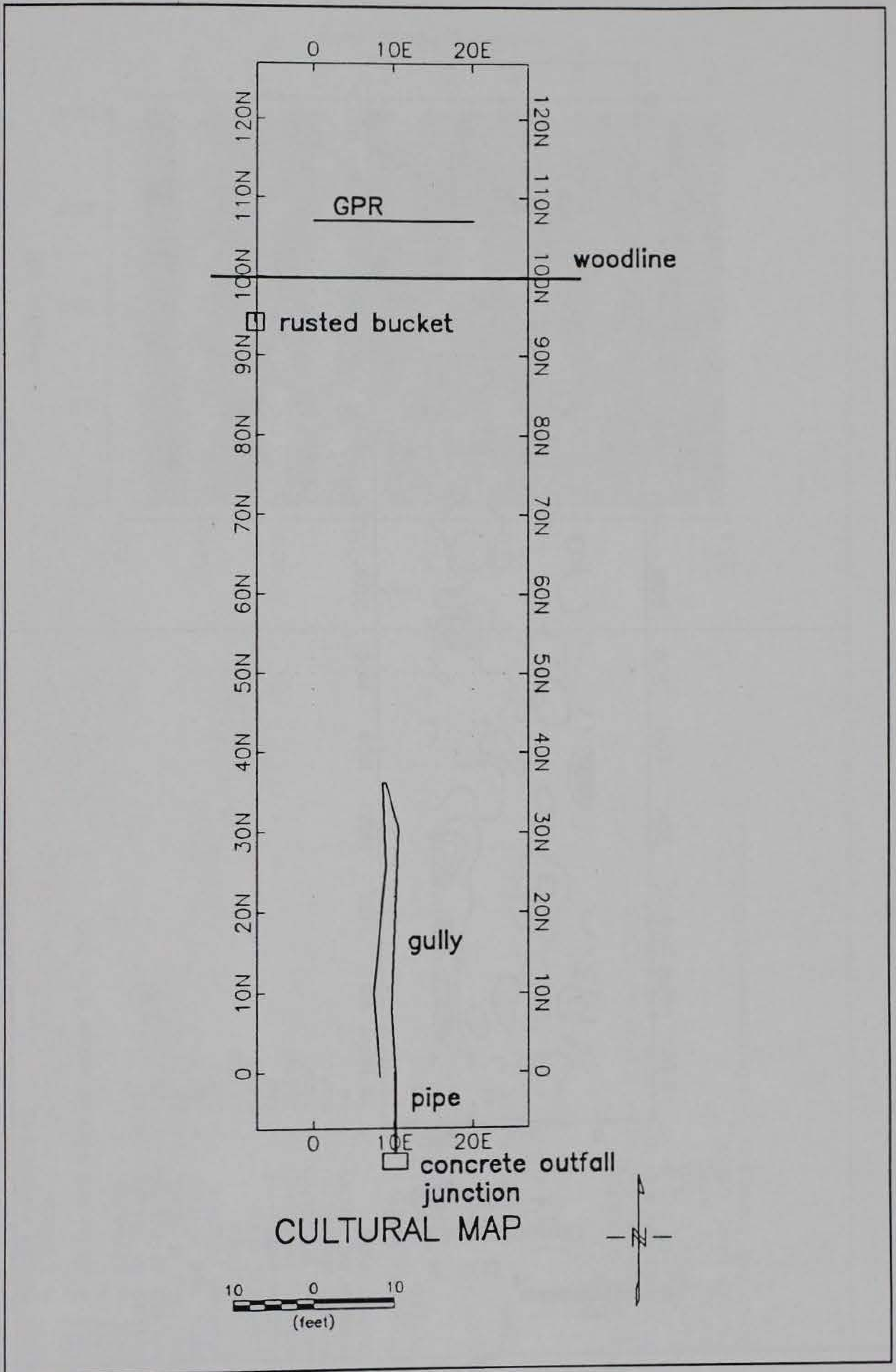


Figure 16. Cultural map of east survey grid

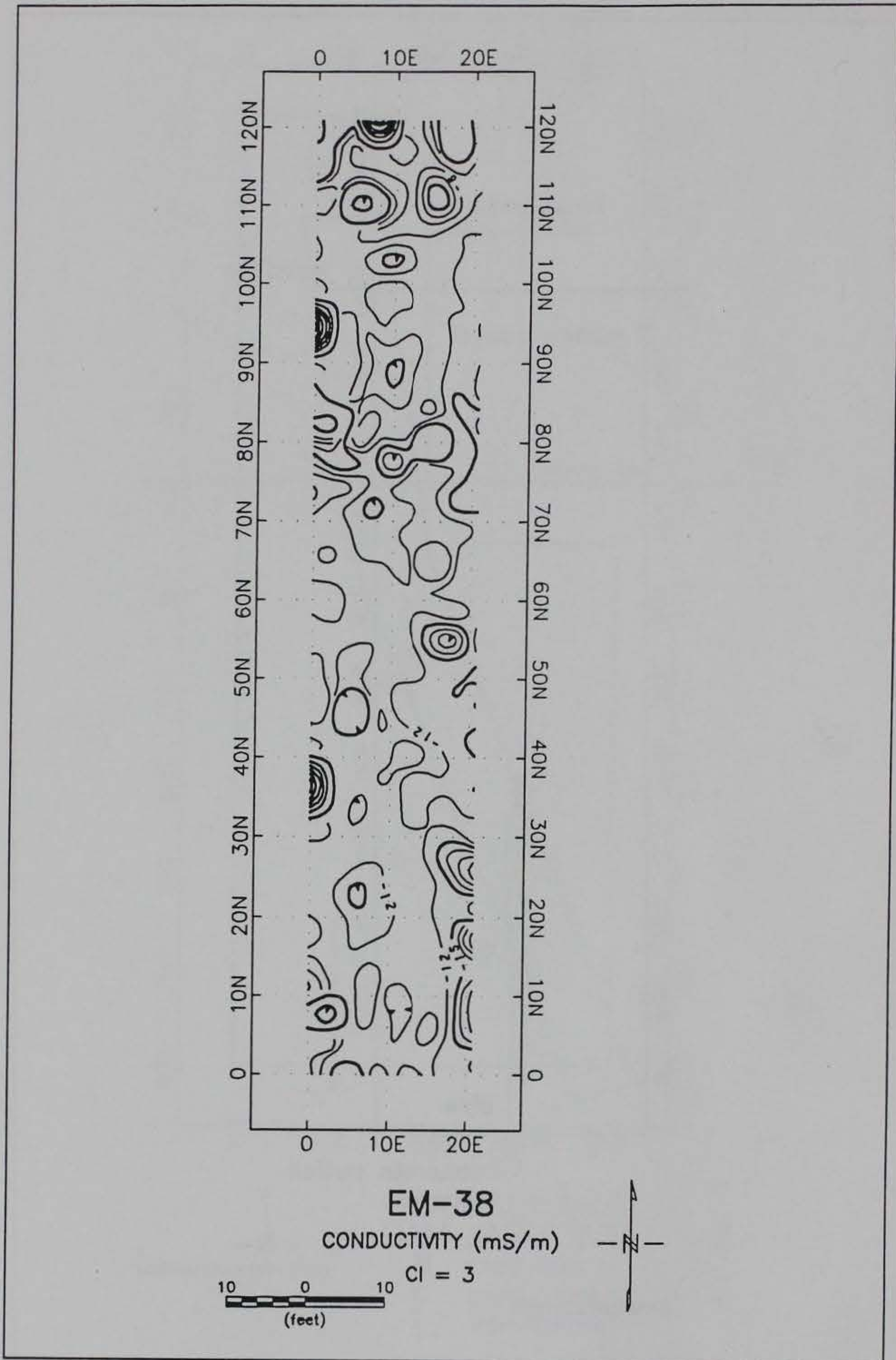


Figure 17. Contour map of conductivity data for east survey grid

```
pulseEKKO HEADER PARAMETERS
     FILE  = b:\c6epwl
     JOB#  =
     TITLE = c6pipe line edge of woods 0 to 20ft
     TITLE =
     DATE  = 02/06/94
     NUMBER OF TRACES      = 43
     NUMBER OF PTS/TRC     = 125
     TIMEZERO AT POINT     = 23
     TOTAL TIME WINDOW     = 100
     STARTING POSITION     = 0.000
     FINAL POSITION        = 21.000
     STEP SIZE USED        = 0.500
     POSITION UNITS        = feet
     NOMINAL FREQUENCY     = 200.00
     ANTENNA SEPARATION    = 1.000
     PULSER VOLTAGE        = 400
     NUMBER OF STACKS      = 16
     SURVEY MODE           = Reflection

PROCESSING SELECTED
     FILTERS:     TRACE STACKING: 1
                  POINT STACKING: 2
                  TRACE DIFFERENCING: N
     SELECTION    TIME: 0 to 80
                  TRACE: 1 to 41
     GAINS:       GAIN TYPE: SEC
                  MAX GAIN (Manual): 50
                  ATTENUATION: 1.000
                  VELOCITY: 0.0700

PLOT LAYOUT PARAMETERS
     TRACE SPACING AND WIDTH: 0.0800 and 0.3200
     TRACE BOTTOM AND TOP: 1.0000 and 6.0000
     MARGIN LEFT AND RIGHT: -0.5000 and 1.0000
     PAGE WIDTH: 7.0000
     BORDER SIZE: 0.000
     PRINTER NAME: LAS300
     SCALE BAR: Name:grey Type:EA Expansion:0.500 Contour:0
```

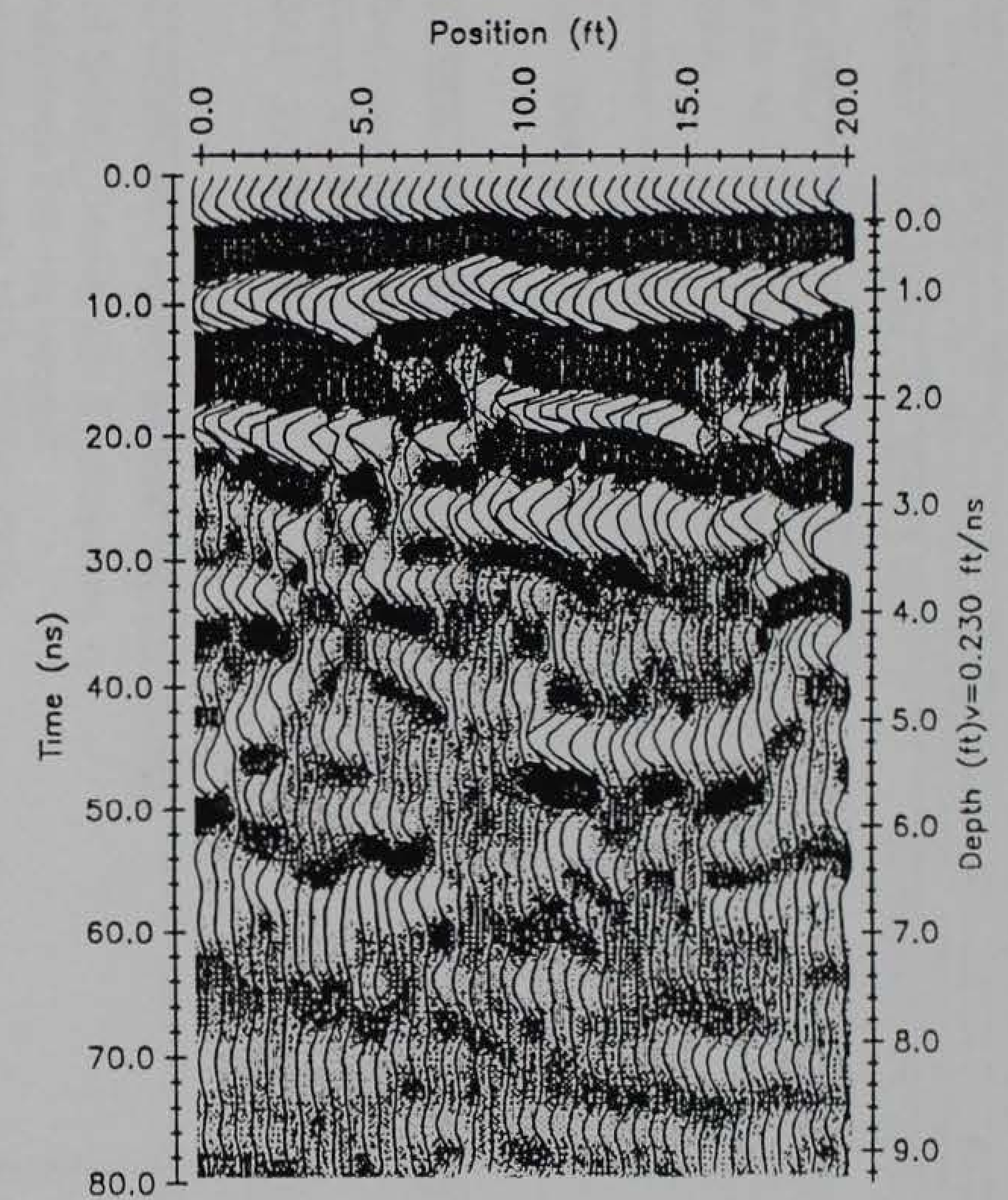


Figure 18. GPR profile line 107N on east survey grid

| REPORT DOCUMENTATION PAGE | | | Form Approved<br>OMB No. 0704-0188 |
|---|---|---|---|



| 1. AGENCY USE ONLY *(Leave blank)* | 2. REPORT DATE | 3. REPORT TYPE AND DATES COVERED |
|---|---|---|
| | May 1995 | Final report |

**4. TITLE AND SUBTITLE**
Geophysical Survey at Cluster 6, Westwood Area, U.S. Army Aberdeen Proving Ground

**5. FUNDING NUMBERS**
MIPR E87940068

**6. AUTHOR(S)**
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**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
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3909 Halls Ferry Road
Vicksburg, MS 39180-6199

**8. PERFORMING ORGANIZATION REPORT NUMBER**
Technical Report
GL-95-5

**9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)**
Directorate of Safety, Health, and Environment
U.S. Army Aberdeen Proving Ground
Aberdeen Proving Ground, MD 21010-5423

**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**

**11. SUPPLEMENTARY NOTES**
Available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

**12a. DISTRIBUTION/AVAILABILITY STATEMENT**
Approved for public release; distribution is unlimited.

**12b. DISTRIBUTION CODE**

**13. ABSTRACT** *(Maximum 200 words)*

A geophysical investigation was conducted at Cluster 6 Site 5, located in Westwood Area of the U.S. Army Aberdeen Proving Ground. This site is the former Westwood Area Radioactive Material Disposal Facility (WRMDF) which was used for processing and packaging radioactive waste material prior to disposal. Original structures at the site included Building 3013 and adjacent concrete slabs where the waste handling work was performed, a small equipment shed, and a wastewater holding and drain system which included tanks in a concrete pit. Discharge of wastewater from the tanks was to Reardon Inlet, located a short distance south of the tank pit. Possible release of radioactive waste to the environment would have been due to either spillage, leakage, or discharge from the wastewater system. Two terra cotta pipelines, one on the western end and one of the eastern end, extended from Building 3013 to Reardon Inlet. The east pipeline handled low-level radioactive wastewater. The west pipeline was the original wastewater line and it is presumed that radioactive wastewater was not discharged through this line. After radioactive waste handling activities were discontinued at WRMDF, the west pipeline system was upgraded to include a septic tank, sand filter bed, and a chlorine contact chamber. The structures associated with the WRMDF were removed during the early 1970's, including the concrete tank pit.

(Continued).

| 14. SUBJECT TERMS | | 15. NUMBER OF PAGES |
|---|---|---|
| Electromagnetics | Ground penetrating radar | 36 |
| Geophysics | Magnetics | 16. PRICE CODE |

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| UNCLASSIFIED | UNCLASSIFIED | | |

13. (Concluded).

Both pipelines are visible near the edge of Reardon Inlet, suggesting that the pipes and related structures have not been removed. Geophysical surveys including magnetics, electromagnetics (EM), and ground penetrating radar, were performed to identify the location of the two terra cotta pipes, septic tank, and sand filter bed. A large anomaly was evident in the magnetic and EM data collected over the western pipe area, and may be due to the septic tank. A linear conductivity anomaly which extended from south of the suspected septic tank location to Reardon Inlet was detected. This anomaly is not believed to correspond to the location of a pipeline since it is directed away from the suspected location of the pipe. None of the methods gave a positive indication of the location of either terra cotta pipeline.