Suspected Wells Investigation Report

Potential Conduits Investigation

Volume 2: Appendices

Naval Air Station
Moffett Field, California

K/J/C 866078.03
April 1989

Kennedy/Jenks/Chilton

SUSPECTED WELLS INVESTIGATION REPORT
POTENTIAL CONDUITS INVESTIGATION

DATED 01 APRIL 1989

THIS RECORD CONTAINS MULTIPLE VOLUMES WHICH HAVE BEEN ENTERED SEPARATELY

VOLUME 1 OF 2 IS FILED AS ADMINISTRATIVE RECORD NO. **N00296.000611**

APPENDIX A

GEOPHYSICAL SUBCONSULTANT'S REPORT
DATED OCTOBER 1987

GEOPHYSICAL SEARCH
FOR ABANDONED IRRIGATION WELLS
MOFFETT NAVAL AIR STATION
SUNNYVALE, CALIFORNIA

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Project No. 87-403

October 1987

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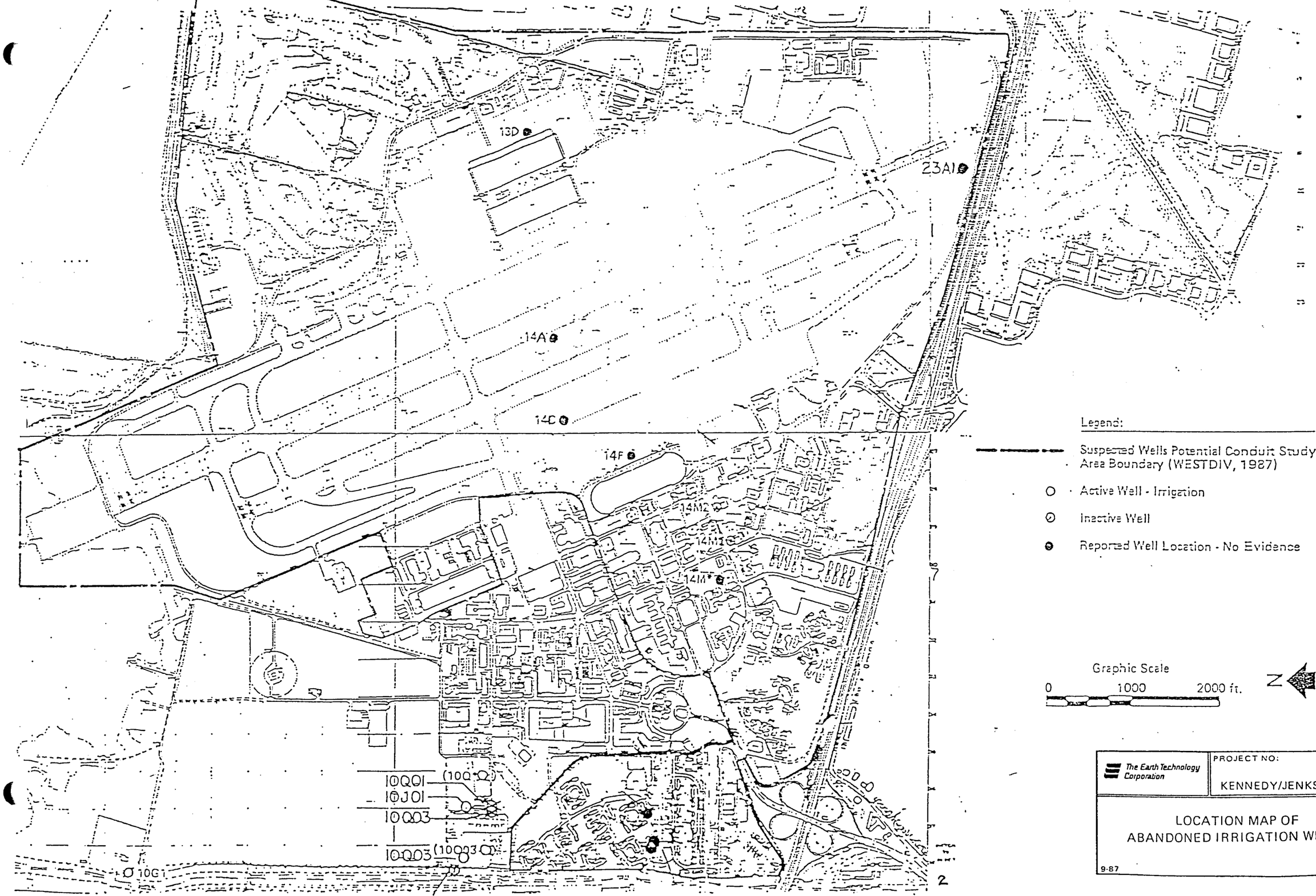
1.0 INTRODUCTION

This report presents the results of a geophysical search for five abandoned irrigation wells at Moffett Naval Air Station near Sunnyvale, California. Generalized well locations based on historical data are shown in Figure 1. The objective of the project was to use surface geophysical methods to search for probable locations of the abandoned wells. The work was authorized by Kennedy/Jenks/Chilton contract number K/J/C 866078.13-G-93. Field work was completed between July 29 and August 15, 1987. Field work was conducted in accordance with the Kennedy/Jenks/Chilton Site Safety Plan and was coordinated by Mr. Bill Bazlen.

Surface geophysical techniques were thought to be useful methods for locating these wells because they were probably cased with steel pipe. Three complementary geophysical profiling methods were used in this study to increase the probability of locating the wells. Profiles were obtained using magnetic, electromagnetic induction (EMI), and ground penetrating radar (GPR) methods. Magnetic surveys measure the earth's magnetic field, which is disturbed by buried ferrous metal. EMI surveys use the principal of electromagnetic induction to measure soil conductivity. Conductivity changes can be caused by variable geologic features (groundwater zones, shallow rock, faults/fracture zones) or buried electrically conductive objects. GPR surveys use high frequency (MHz) electromagnetic waves in a reflection mode to locate subsurface contrasts in dielectric properties. Dielectric changes can also be caused by geologic features or buried conductive objects. Therefore, each of these methods is potentially able to locate buried steel well casing because it represents a magnetic/conductive/dielectric contrast relative to the surrounding soils.



Legend:

- Suspected Wells Potential Conduit Study Area Boundary (WESTDIV, 1987)
- Active Well - Irrigation
- Inactive Well
- Reported Well Location - No Evidence

Graphic Scale

0 1000 2000 ft.

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LOCATION MAP OF
ABANDONED IRRIGATION WELLS

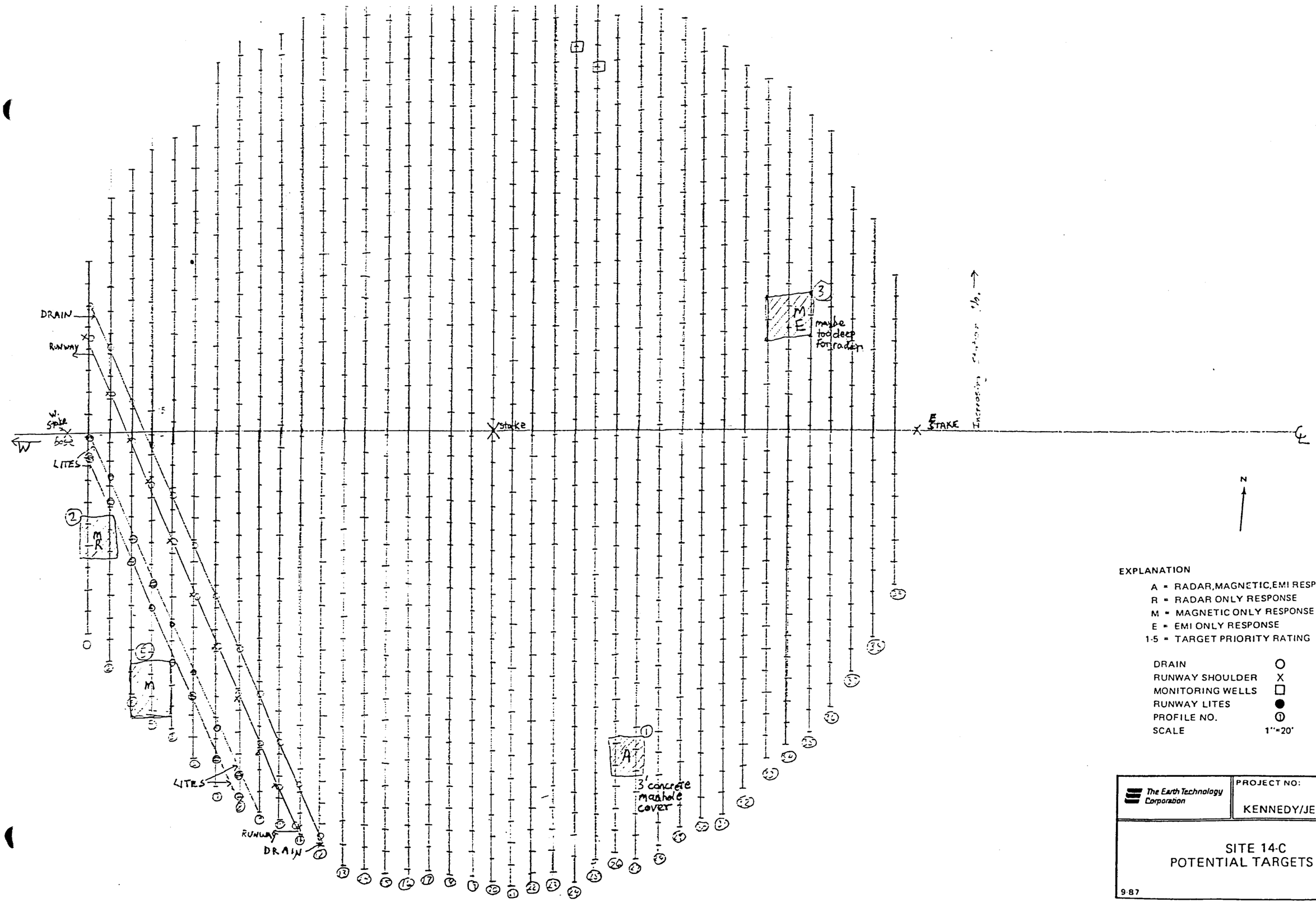
9-87

FIGURE 1

2.0 SUMMARY OF RESULTS

Several geophysical anomalies were located in each of the five sites (Figures 2 through 6) investigated. These anomalies might represent the abandoned irrigation wells. The survey data were processed nightly by the crew and anomalous zones in each data set were highlighted. Coincident geophysical anomalies that were not obviously caused by cultural effects were marked as "Potential Targets" and staked in the field. One of these targets at site 23-A1 was hand excavated and the steel cover plate of a well was found about 4 inches below grade. One of the targets at site 14-C was found to be a buried manhole cover. The discovery of these two buried objects demonstrated that the geophysical techniques are appropriate, and the resolution provided by the sampling interval was adequate, for locating wells. However, it should be noted that any of the three geophysical techniques could fail to detect a buried irrigation well for a number of reasons. The well would certainly not be detected if, as sometimes happens, the well is not within the survey area. It would not be detected if it is buried deeper than the effective range of the instrument or if the physical properties of the well do not differ greatly from the surroundings. The limiting depth for the EMI is about 15 feet and for GPR it is probably 8 to 10 feet here. The penetration of the GPR is highly dependent on the electrical conductivity of the ground (wet clay can render GPR ineffective). Magnetic detection depends on the magnetic strength and depth of the target. If there is no iron in the well casing, it will not be detected in any case. Detection by any of the techniques can be made unreliable by background noise caused especially by things like scrap metal, metal fences, cars, power lines, etc. The use of three complementary techniques greatly improved the prospects of detection.

The survey data for each technique are shown in site maps in Apppendices A through E. The "Potential Targets" shown in Figures 2 through 6 are discussed in Section 7.0.



EXPLANATION

A = RADAR, MAGNETIC, EMI RESPONSE
R = RADAR ONLY RESPONSE
M = MAGNETIC ONLY RESPONSE
E = EMI ONLY RESPONSE
1-5 = TARGET PRIORITY RATING

DRAIN	O
RUNWAY SHOULDER	X
MONITORING WELLS	□
RUNWAY LITES	●
PROFILE NO.	①
SCALE	1"=20'

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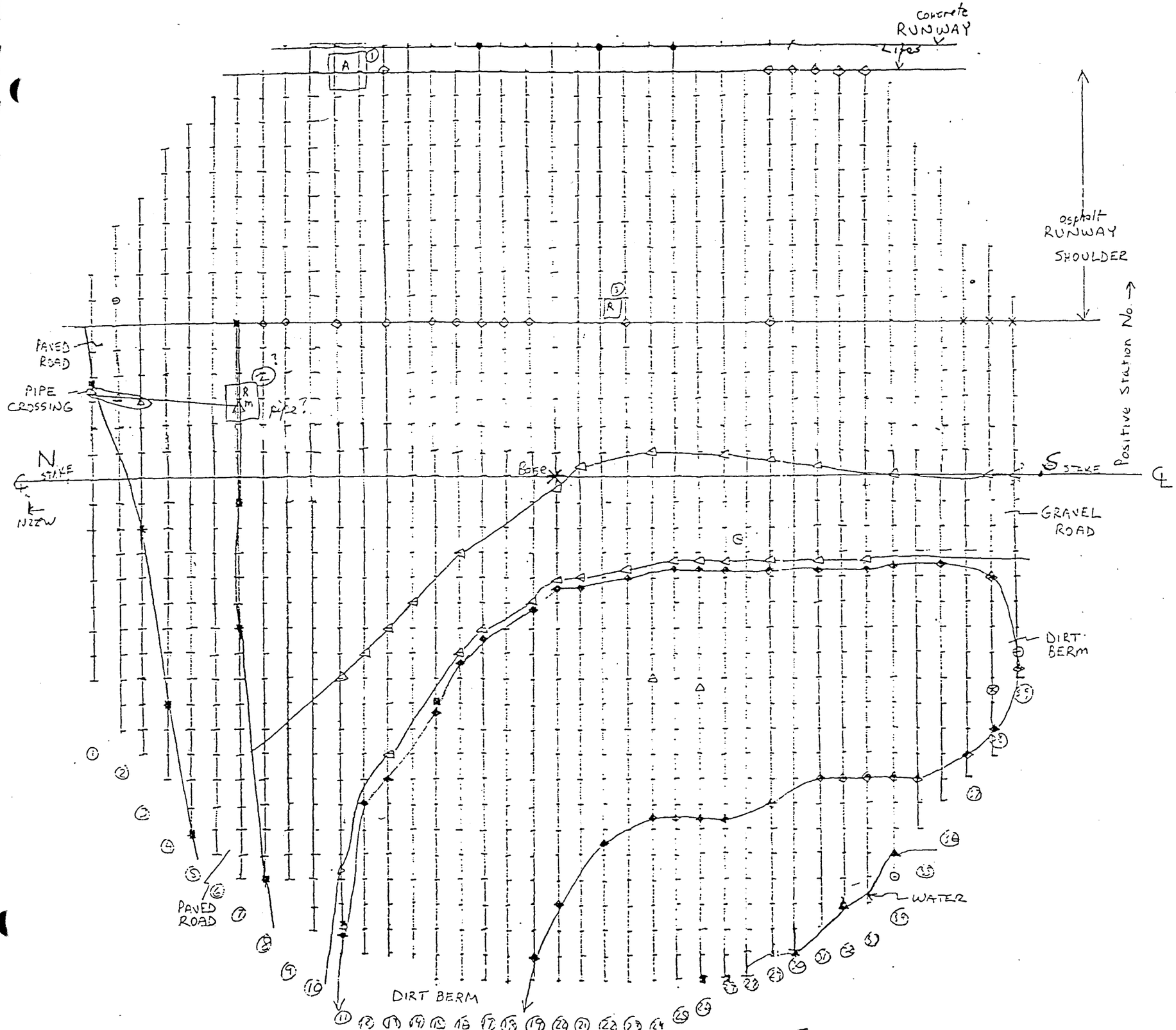
SITE 14-C
POTENTIAL TARGETS MAP

9-87

FIGURE 2



EXPLANATION

A = RADAR,MAGNETIC,EMI RESPONSE
R = RADAR ONLY RESPONSE
M = MAGNETIC ONLY RESPONSE
E = EMI ONLY RESPONSE
1-5 = TARGET PRIORITY RATING

DRAIN	○
RUNWAY SHOULDER	X
RUNWAY EDGE	●
RUNWAY LITES	◇
MONITORING WELLS	□
BERM	◆
PIPE CROSSING	△
PAVED ROAD EDGE	■
WATER	▲
GRAVEL ROAD EDGE	◁
LARGE METAL PLATE	⊗
PROFILE NO.	ⓘ
SCALE	1"=20'

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SITE 14-A
POTENTIAL TARGETS MAP

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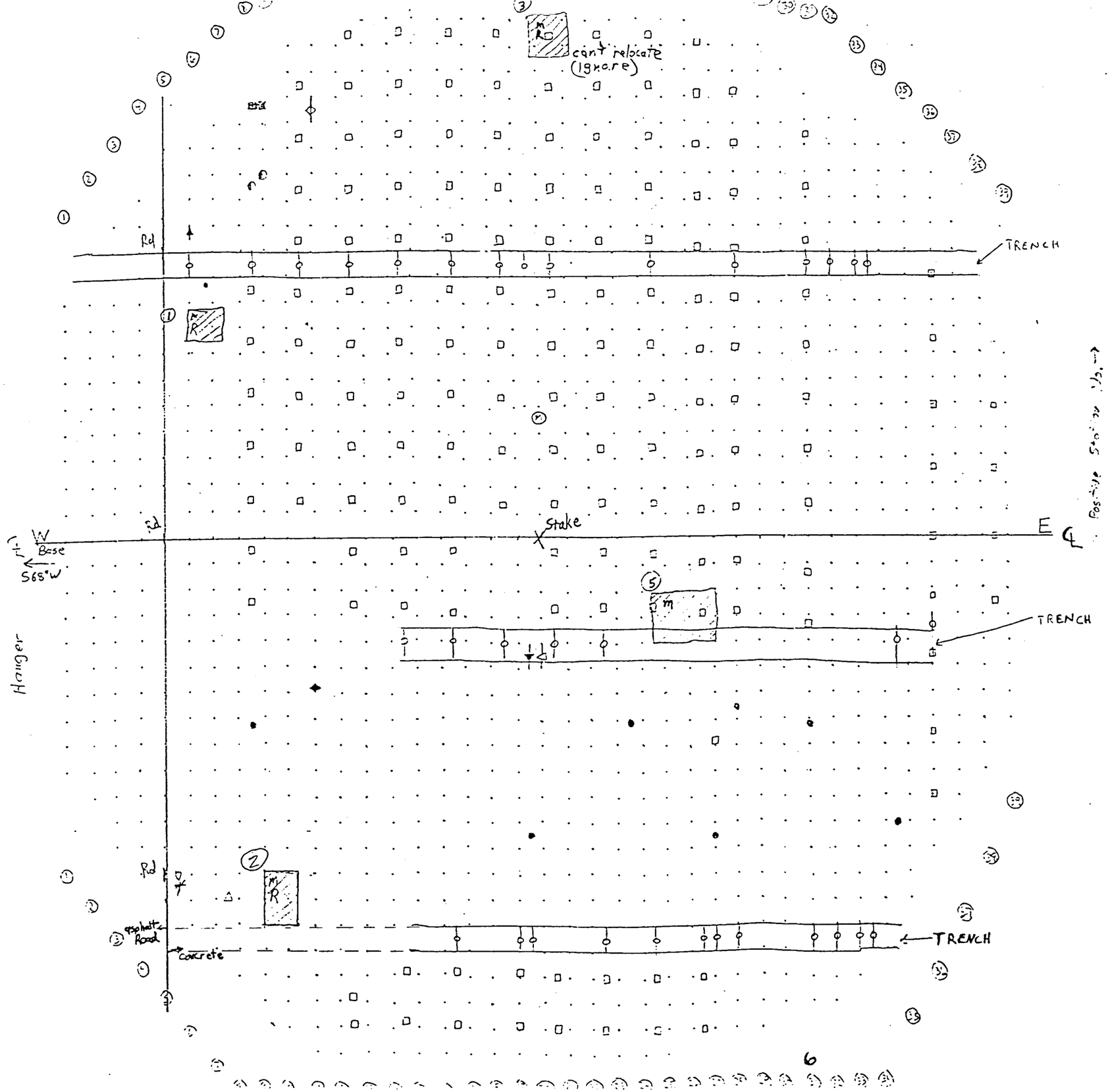
FIGURE 3



EXPLANATION

A = RADAR, MAGNETIC, EMI RESPONSE
R = RADAR ONLY RESPONSE
M = MAGNETIC ONLY RESPONSE
E = EMI ONLY RESPONSE
1-5 = TARGET PRIORITY RATING

TRENCH	○
TIE DOWNS	□
MANHOLE COVER	■
FIRE HYDRANT	*
STEEL CAP	●
CONCRETE-FILLED HOLE	◇
VERTICAL STEEL PIPE	◆
MANHOLE	◁
ASPHALT/CONCRETE	◐
WATER MAIN CAP	△
METAL PLATE	▲
STEEL POST	▽
MANHOLE GRATE	▼
PROFILE NO.	⊖
SCALE	1"=20'

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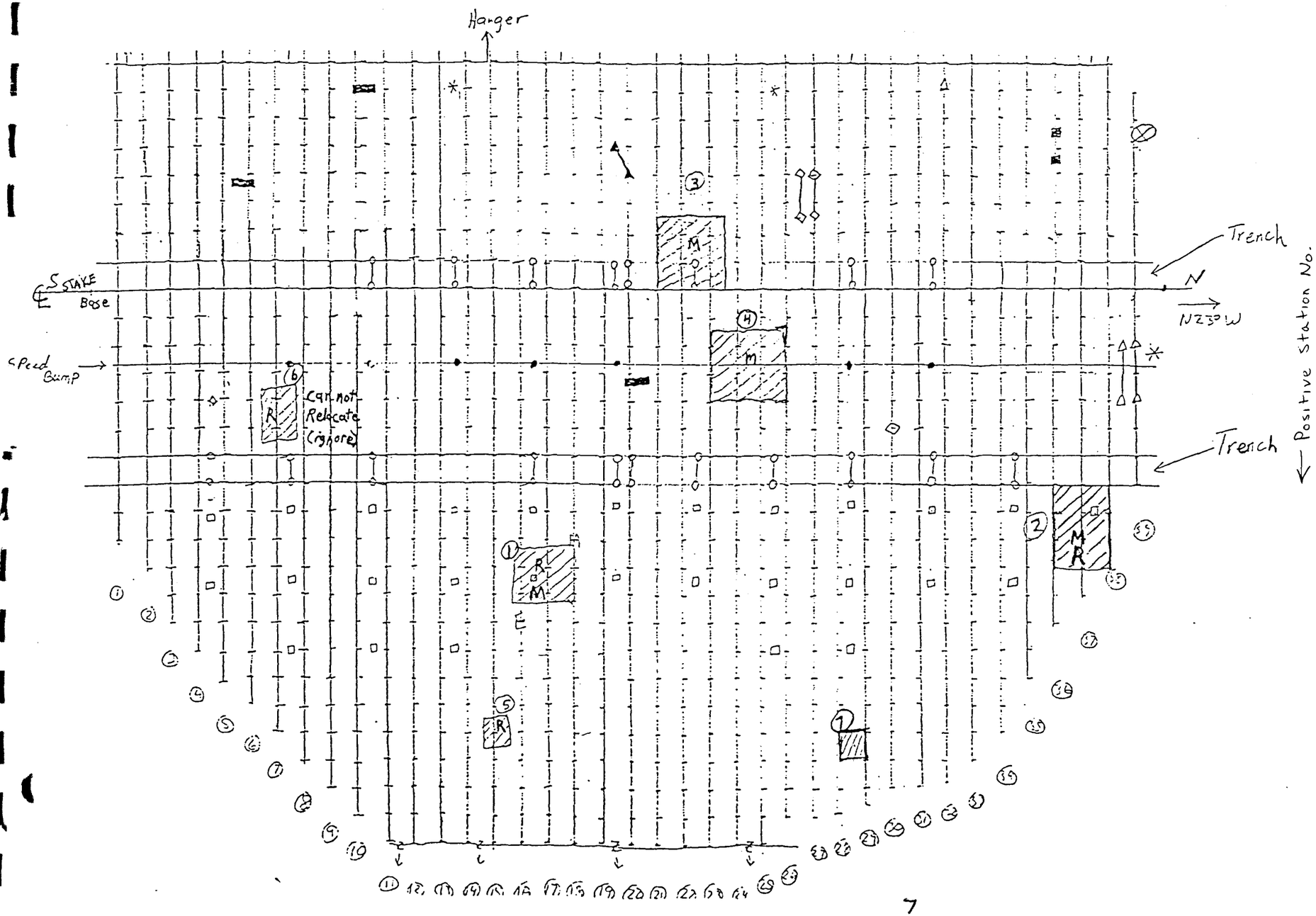
SITE 14-F
POTENTIAL TARGETS MAP

9 87

FIGURE 4



EXPLANATION

A = RADAR,MAGNETIC,EMI RESPONSE
R = RADAR ONLY RESPONSE
M = MAGNETIC ONLY RESPONSE
E = EMI ONLY RESPONSE
1-5 = TARGET PRIORITY RATING

TRENCH	○
SPEED BUMP	●
TAXIWAY	X
TDITIE DOWNS)	□
STEEL PIPES	△
LARGE STEEL PLATE	⊗
MANHOLE COVER	■
ELECTRICAL TRANSFORMER	▲
FIRE HYDRANT	*
PAVEMENT COLLAPSE	◇
CONCRETE APRON	≷
SCALE	1"=20'

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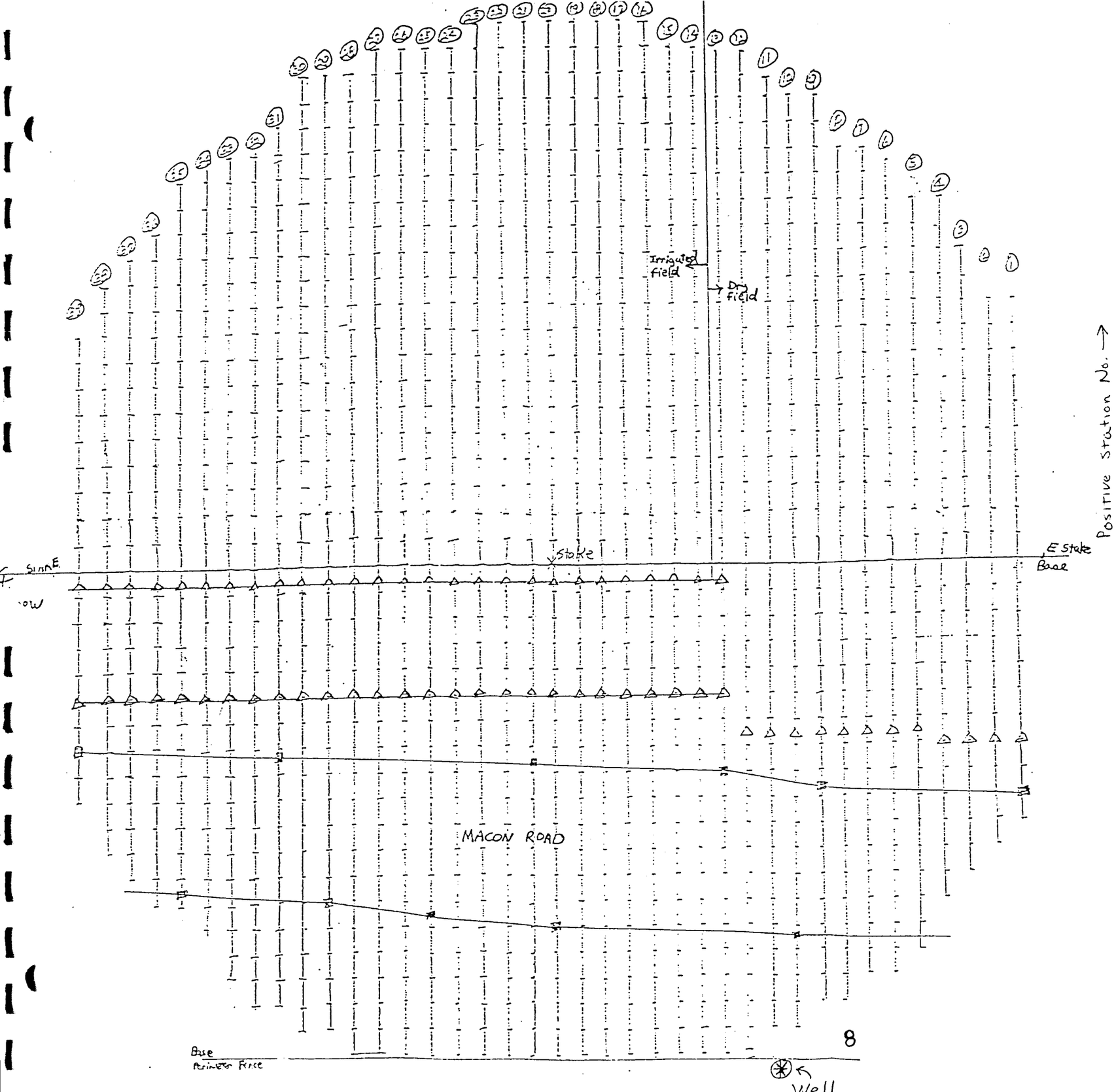
SITE 13-D
POTENTIAL TARGETS MAP

9 87

FIGURE 5



EXPLANATION

A = RADAR, MAGNETIC, EMI RESPONSE
R = RADAR ONLY RESPONSE
M = MAGNETIC ONLY RESPONSE
E = EMI ONLY RESPONSE
1-5 = TARGET PRIORITY RATING

PROFILE NO.	①
RUNWAY SHOULDER	X
PAVED ROAD EDGE	■
IRRIGATION PIPELINE	△
ABANDONED IRRIGATION WELL	⊛
SCALE	1"=20'

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SITE 23-A1
POTENTIAL TARGETS MAP

9-87

FIGURE 6

3.0 SURVEY GRID DESIGN

Probable locations (Figure 1) of the irrigation wells were determined from a historic record search conducted by previous consultants to the Navy. These locations were staked and a circle with a 100 ft radius (centered on the stake) was marked on the ground by Kennedy/Jenks/Chilton before the geophysical search began. A center line was drawn through the circle and was marked at five ft intervals with pin flags or spray paint. These marks were used to space the lines along which data were collected. Two additional reference lines, parallel to the center line, were constructed just outside of the circle. These three lines were used to align the profiles. Construction of the profiles consisted of laying a rope between the appropriate marks on the reference lines. Measurements were taken at five ft interval marks on the rope.

The lines were labelled from 1 to 39 and the stations were numbered with 0 at the center line and positive numbers going one direction and negative numbers going in the reverse direction. This station numbering scheme was not used at the first site, 14-C. Instead a rather cumbersome method of always starting each profile with station 1 was used. This method proved ineffective while making the first base map for the site.

A base map for each site is included in the Appendices. The base maps show the original stake location, profile and station locations and identifications, and the surrounding cultural features (runways, powerlines, underground pipelines, etc). The magnetic and EMI survey data were posted on the base maps and contoured to provide the basis for anomaly identification. The anomalies caused by nearby cultural features were identified and eliminated as possible "Potential Targets". A summary of the geophysical surveys at each site is shown in Table 1.

TABLE 1. SUMMARY OF GEOPHYSICAL SURVEY ACTIVITIES

Site ID	No. of Mag Stations	Mag Coverage (linear ft)	No. of EMI Stations	EMI Coverage (linear ft)	GPR Coverage (linear ft)
14-C	1,359	6,575	1,353	6,575	13,085
14-A	1,274	6,190	1,279	6,190	12,305
14-F	1,175	6,200	633	3,070*	12,620
13-D	926	4,435	707	2,285*	8,935
23-A1	1,402	6,375	1,295	6,375	11,760
Totals	6,136	29,775	4,567	24,495	58,705

* Note: The difference between the magnetic and EMI surveys coverage is explained in Section 7.0

4.0 MAGNETIC SURVEY

4.1 INSTRUMENTATION

The magnetic data were measured with an EDA proton precession magnetometer/gradiometer, model PPM-500. This type of instrument measures the earth's magnetic field with a two step process. First, an external coil surrounding the sensor full of a proton-rich fluid (kerosene) produces a magnetic field normal to the earth's field. This external field polarizes the protons and forces them into alignment. When the external field is removed, the protons precess about the earth's field at the Larmor frequency, which is measured by the instrument. This frequency is directly proportional to the strength of the earth's magnetic field. The meters sensitivity is $\pm$ 1 gamma.

The PPM-500 consists of two sensors, a connecting staff, and the measuring unit. The instrument can measure the earth's total magnetic field and the vertical gradient between the sensors and store this information along with profile/station data and the time in solid state memory. The data can then be automatically transferred to a portable computer for processing and display.

4.2 DATA ACQUISITION

The magnetic data were obtained at every station possible along the 39 profiles laid out at each site. Several precautions must be taken when collecting magnetic data. All metallic objects were removed from the operator, and metallic cultural features (scrap iron, cars, etc) were removed from the survey area (when possible). While taking the readings, the sensors were always oriented toward magnetic north so the external magnetic field in the sensor is normal to the earth's field. The operator always stood about the same distance and in the same direction away from the sensor while reading data. Only one operator read the data within a base loop.

A noise study was conducted at the first site (14-C) prior to conducting the survey. The purpose of this study was to determine the optimum height of the sensors. The closer the sensor is to the target the larger the

magnitude of the magnetic reading. As the distance (d) between the sensor and target increases, the magnitude of the reading will decrease as a function of d^{-3}. If the sensor is too close to the ground, surface metal debris (wire, metal hardware, rebar) will dramatically influence the readings and sometimes mask the magnetic anomaly associated with the desired target.

Magnetic data along a diagonal profile across the first site were collected with the top sensor at 6, 8, and 10 ft above the ground. Only the 10 ft sensor height produced a magnetic profile that was not completely dominated by high amplitude, high frequency noise. A sample profile was then completed across two exposed, metal well covers with the sensor height at 10 ft to make sure that a known target would yield a recognizeable anomaly at this sensor height.

A base station was established at each site in a location relatively free from nearby cultural features. Repeated readings were made at the base station every 1½ to 2 hours during the magnetic survey to determine the rate of instrument and diurnal drift. (Diurnal drift of the earth's field is primarily due to tidal motion of the ionosphere). If not removed, the drift can distort magnetic anomalies of interest.

4.3 DATA PROCESSING

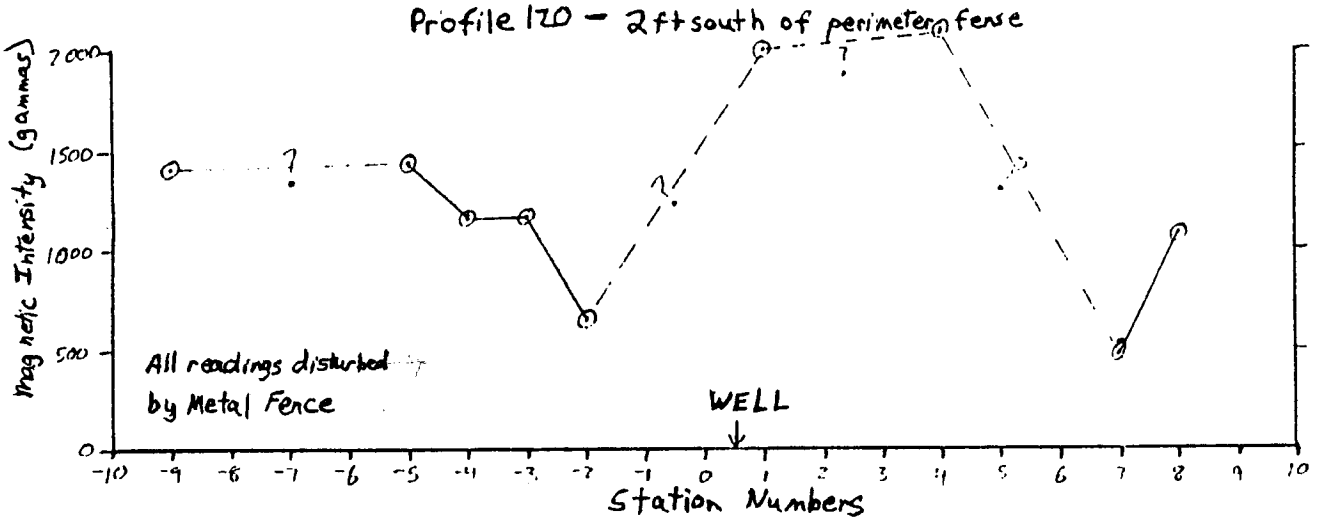
Processing total field magnetic survey data consists of two steps. The drift rate within a base loop is determined from successive base readings. The drift to be removed from each measurement made between the base readings is calculated by linear interpolation versus time. The average drift rate during this survey was 11 gammas per hour which is relatively high. Secondly, an arbritary constant value (48,000 or 50,000 gammas) was subtracted from all the drift corrected readings to reduce the values from five to only three digits. The adjusted data were then posted on a base map showing the relative locations of the cultural features (Appendices A through E). The data were contoured and important anomalies highlighted. Anomalies thought to be caused by cultural features were labelled. Anomalies that might represent "Potential Targets" were ranked according to how they compared with the theoretical magnetic field for a vertical pipe (Breiner, 1973).

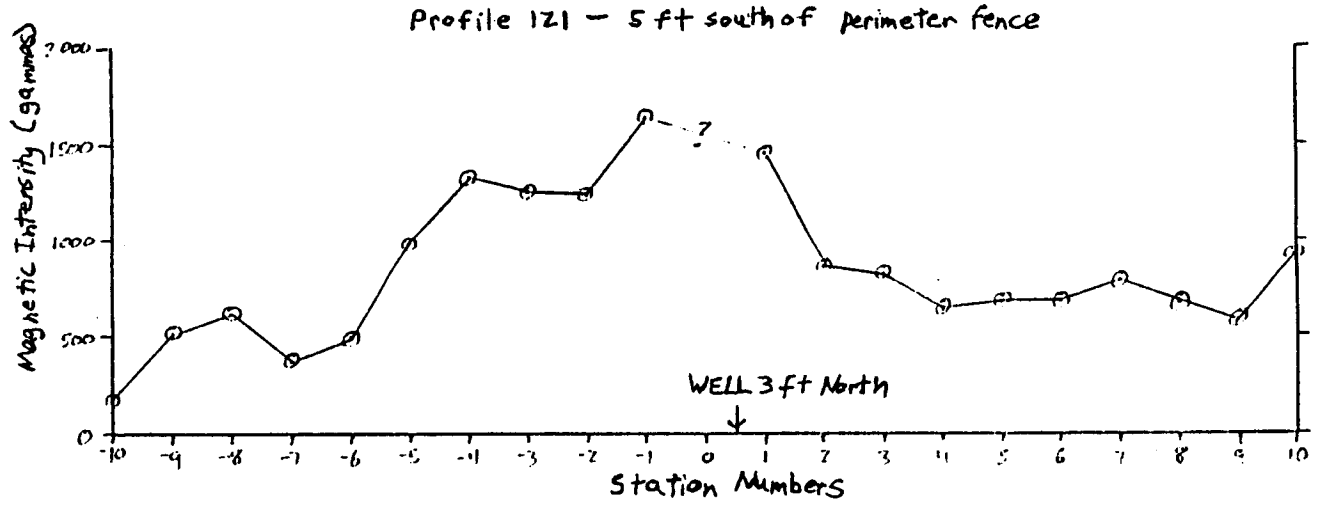
Vertical gradient magnetic data were taken at the first site only. These data were dominated by high amplitude, high frequency noise probably related to very near surface features. An anomaly caused by a buried well easily could be masked by this noise. Therefore, the gradient data were not taken at the other four sites.

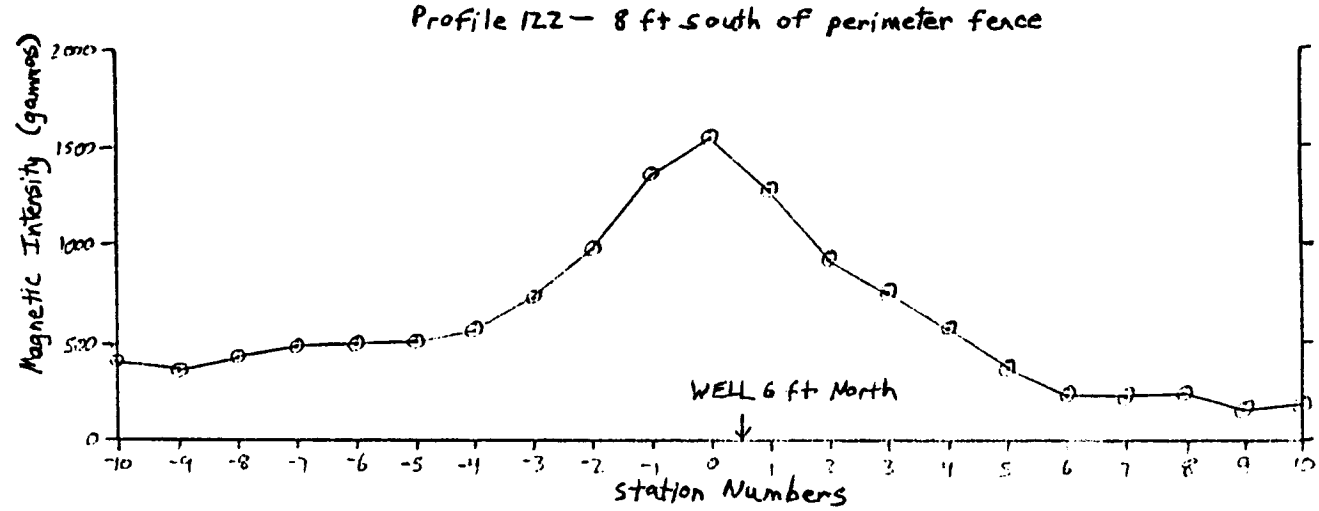
An experiment was conducted with the magnetometer after the well at site 23-A1 was discovered. Magnetic data were taken along three GPR profiles running parallel to the perimeter fence and near the well to see the response. GPR profile 120 was directly over the well and profiles 121 and 122 were 3 and 6 ft south of the well, respectively.

The results of this test are shown in Figure 7. The magnetic data along profile 120 is badly distorted due to the chain link fence which is only 2 ft away. These data clearly show the care that must be taken when interpreting magnetic anomalies in the presence of cultural features. Profile 121 is also heavily influenced by the fence, but the basic shape of the curve is characteristic of the buried well. Profile 122 is far enough away from the fence and does not appear to be distorted. This profile is a good example of the magnetic anomaly over a well. The magnetic anomaly reaches a maximum near the well and then falls off rapidly on either side as the sensor is moved away from the well. This relationship also can be seen on the other two profiles, even though there is distortion by noise from the fence.

ESE







Note: Station Spacing = 5 ft.

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SITE 23-A1
MAGNETIC SURVEY TEST OVER WELL

9-87

FIGURE 7

5.0 ELECTROMAGNETIC INDUCTION SURVEY

5.1 INSTRUMENTATION

Soil conductivity measurements were made with a Geonics EM-31 terrain conductivity meter. The instrument has separate transmitting and receiving coils that act as magnetic dipoles. Small-amplitude eddy currents are induced in the ground when alternating current is applied to the transmitter coil. The resultant, secondary magnetic fields caused by the eddy currents, are detected with the receiver coil. The instrument is designed so that the ratio of the received signal to the transmitted primary field is proportional to the soil conductivity. Field measurements are rapid because no direct connection with the ground is required.

The EM-31 consists of a 12-ft long boom containing both the transmitter and receiver coils and is operated by one person. Because of its short coil separation, the EM-31 gathers data predominantly from near-surface materials. The effective penetration depth, in the normal operating mode (vertical dipoles), is about 15 ft. The meter's sensitivity is $\pm$ mmhos/m.

5.2 DATA ACQUISITION

The EMI data were obtained at every station possible along the 39 profiles laid out at each site (except at sites 14-F and 13-D, See Section 7.0). Precautions similar to those described for the magnetic survey were also taken when collecting the EMI data. While taking the readings, the sensor was held level with both ends of the boom about three feet above the ground. Measurements were made with the boom inline with the profile and always pointing in the same direction regardless of which way the profile was traversed. At every fifth station along the profile, and at obviously anomalous readings, the boom was positioned perpendicular to the profile and the reading noted. This technique can determine the long axis of a narrow conductor, such as a buried pipeline. Only one operator read the data within a base loop.

The magnetic base station established at each site was also used during the EMI survey to determine instrument drift. Repeated readings were made at the base every 1 1/2 to 2 hours.

5.3 DATA PROCESSING

Processing EMI data is similar to the method described for magnetic data. The drift rate is determined from the multiple base readings and is removed from the data. The average drift rate during the survey was 1.5 mmhos/m per hour which is relatively low. The adjusted data were posted on the base map (Appendices A through E) and contoured. Anomalies were highlighted. The anomalies caused by cultural features were labelled and the ones thought to represent "Potential Targets" were ranked.

6.0 GROUND PENETRATING RADAR SURVEY

6.1 INSTRUMENTATION

GPR data were taken with a Geophysical Survey System, Inc., SIR System 8 ground penetrating radar. Impulse radar radiates repetitive, short-time duration, electromagnetic pulses into the earth from a broad bandwidth antenna placed very close to the ground surface. The equipment functions as an echo sounding system using radar pulses of only a few nanoseconds to detect and measure location and depth of reflecting discontinuities in the subsurface. Continuous profiles are generated by towing the antenna along a line and displaying the reflected signals on a graphic recorder. A 120 MHz antenna was used for this survey to obtain maximum penetration. The effective penetration depth at these sites is estimated to be between 8 and 10 ft. The penetration was limited by a shallow water table and clay in the subsurface.

6.2 DATA ACQUISITION

The GPR data were collected continuously along 77 lines at each site, comprising the 39 lines used for magnetic and EMI data and lines halfway between. With this spacing, the swaths covered by the antenna housing overlapped on adjacent profiles, thus increasing the probability of detecting a small diameter well.

As the antenna center passed by the station marks on the profiles, a mark was electronically placed on the GPR records. These marks were labelled with profile and station numbers and formed the basis for posting locations of radar targets on the base map.

No noise or resolution test were conducted with the GPR because obtaining maximum penetration depth was the most important factor. The effective penetration depth was not determined quantitatively because a target (pipeline, storage tank) at a known depth was not available.

6.3 DATA PROCESSING

The GPR data is shown in real time in a graphic format that does not require any drift or other corrections. Anomalies were highlighted on the records and categorized as being small, large, very large, or deep metal targets. Geologic features such as trenches or dipping strata were ignored. The appropriate category symbol for each anomaly was then posted on the site's base map (Appendices A through E). The anomalies caused by known cultural features were labelled. Anomalies with similar shape were connected if they formed linear features and were labelled as a probable buried cultural feature. Anomalies thought to represent "Potential Targets" were ranked.

7.0 CONCLUSIONS

The interpretation process consisted of the following steps:

- Anomalies were identified in each of the three geophysical data sets (i.e., GPR, magnetics, and EMI)
- Anomalies associated with obvious cultural features were labelled and then removed from consideration
- Geophysical data sets were compared to find coincident anomalies
- Coincident anomalies were selected as being "Potential Targets" and were ranked at each site.

For the purpose of ranking the "Potential Targets," the magnetic data are considered to be the most diagnostic for these sites. The magnetic survey can respond to targets deeper than the estimated maximum penetration depth (10 feet) of the GPR survey. Also, the magnetometer, unlike the GPR, can detect a target without passing directly over it. (Twice as many GPR profiles were obtained at each site to minimize the possibility of missing a well because it was located between profiles.) At several sites, the usefulness of the EMI data was limited by interference from cultural features.

Once "Potential Targets" were identified and marked on the map, their locations were also staked in the field. Several marginally suitable anomalies were staked for convenience and were discarded as "Potential Targets" later during data review. Many targets were relocated with the GPR and then flagged.

The targets with the highest probability of being the abandoned irrigation wells are listed below.

Site ID	Most Probable Targets
14-C	2, 5
14-A	1
14-F	1, 5
13-D	3, 4, 7
23-A1	Well located

Several generalized descriptions are used in the following discussion to explain the various observed geophysical anomalies

MAGNETIC ANOMALIES

All "Potential Targets" are located on large-amplitude magnetic anomalies that are circular in shape. If there is no remanent magnetism involved, the anomalies from dipole sources consist of a high-low pair of contour line closures that are only 5 to 20 feet apart and the pair is oriented with the low toward magnetic north. The location of the source is within the steepest part of the gradient between the high-low pair. This general description represents the ideal magnetic anomaly over a small-diameter, vertical well. Any exception to this general description will be specifically noted for each "Potential Target."

EMI ANOMALIES

The majority of the data primarily respond to nearby cultural features.

GPR ANOMALIES

GPR data collected over a buried metal object indicate very strong reflections as shown at the well found at site 23-A1. Some of the "Potential Targets" did not produce GPR anomalies. This does not preclude the possibility that a well is the source of the magnetic anomaly, because the effective penetration depth of the GPR is no more than 8 to 10 feet and may be much less.

The anomaly identification numbers do not represent a ranking or priority at a site.

"POTENTIAL TARGETS"

Site 14-C: 5 targets
Site Between Runway and Taxiway

Target 1 - This target produced a very characteristic magnetic high-low pair with the low toward magnetic north. There is a coincident EMI low and a deep target found with the GPR survey. This target was hand excavated and a 3-ft diameter, reinforced concrete man hole cover was found. Beneath the cover was a concrete tunnel probably running NW along the very prominent magnetic high.

Targets - 2, 5 These probable targets produce strong magnetic highs and are thought to be independent of the lights along the taxiway edge because the anomalies are circular in shape and small in areal extent, which is not typical of an anomaly caused by a linear feature (such as the runway lights). The GPR shows a localized large target at No. 2 but not at No. 5. The taxiway lights dominated the EMI data, which were of no use at these targets.

Target 3 - This target produced a weak magnetic high-low anomaly. Comparison with the EMI and GPR data indicates that this target is probably associated with a buried storm drain

traveling across the infield perpendicular to the taxiway and runway. The target produces a prominent EMI anomaly, so it must contain conductive material, but the weak magnetic anomaly indicates that the conductive material is probably non-ferrous. The GPR also shows a continuous, linear feature coincident with these anomalies.

Site 14-A: 3 Targets
Site Between Two Runways

Target 1 - This target produced a high magnetic anomaly within the prominent low magnetic zone probably caused by metal pipes running along the SW edge of the concrete apron. The EMI data also show a coincident high anomaly within a very steep gradient running along the apron edge. The GPR survey shows a localized feature at this target location and shows a long linear feature along the apron edge. This target might be a well, or possibly a structure associated with the apron edge feature.

Target 2 - This target produces a circular high magnetic anomaly, no EMI anomaly, and a small GPR anomaly. During target staking, a small metal drain pipe was found that passes just beneath the paved road. The magnetic anomaly is probably caused by the drain pipe; its large magnitude is likely caused by the proximity of the magnetometer to the surface pipe.

Target 3 - This target produces a very strong GPR reflection, but no coincident magnetic or EMI anomalies. Therefore, the source does not appear to be ferrous metal and is not expected to be a well.

Site 14-F: 5 Targets
Site Just East of Hanger 1

The EMI data at this site are primarily influenced by the surrounding cultural features (airplane tie-downs, cars, trenches containing pipes) and are not used in target identification. This fact was recognized in the field and, therefore, measurements were made only on every other profile. The magnetic data have also been influenced by the cultural features, but not as severely as the EMI data. Originally, the magnetic data were collected only along

every other profile and contoured. To verify the magnetic anomalies, magnetic data were collected on the in-between profiles and tied to the original data by reoccupying the same base station. The data did not significantly change the contour map and are not included in the Appendix C figure.

Target 1 - This probable target is located within a very steep magnetic gradient between high-low anomalies. The steep gradients of this slope suggest a large shallow source such as a well and the GPR shows a deep, isolated feature at this location. There are no obvious nearby cultural features to cause this magnetic anomaly.

Target 2 - This target is located within a steep magnetic gradient just south of a high anomaly covering a large area. There are many surrounding cultural features (water main cap, fire hydrant, and a buried trench with metal pipes). The GPR survey shows many isolated anomalies scattered about this area. This target is not thought to represent the well because there are too many surrounding cultural features that are contributing to the measurements that caused the elongated magnetic anomaly.

Target 3 - This target is associated with a large magnetic low and was originally thought to be a probable target. There are several isolated GPR anomalies in the area. The target could not be relocated during target staking. The magnetic low can probably be attributed to the cars parked immediately to the east and west, and it is considered unlikely to represent a well location.

Target 4 - This GPR target produced no magnetic anomaly and therefore does not represent the well and was removed from the map.

Target 5 - This target produces a relatively small circular magnetic high but no GPR anomaly. The target is located immediately north of a buried trench with pipes (as seen by repeated GPR anomalies). This anomaly is considered a "Potential Target" because there is no general magnetic anomaly associated with this trench (the pipes are probably not ferrous metal).

Site 13-D: 7 targets
Site Just East of Double Hangers

Site 13-D is surrounded by many cultural features, similar to Site 14-F. The EMI data are of no use at this site either and the magnetic data are highly influenced by these features. The EMI and the magnetic data were reevaluated after the first half of the grid was completed and it was decided to read only every other profile during the second half of the survey. Later, magnetic

data were collected along the in-between profiles for completeness. The new data were tied to the original data by reoccupying the base. The new data did not significantly change the contour map and, therefore, are not shown in the Appendix D figure.

Targets 1,2 - These targets are associated with magnetic highs and several GPR anomalies and were originally thought to be "Potential Targets", until data review showed that a magnetic high extends almost continuously north-south across this area. The GPR also shows a wide deep feature coincident with these magnetic highs that run parallel and slightly east of the trench seen at the surface. These anomalies are now thought to be part of this wide feature and are no longer considered to be "Potential Targets".

Targets 3,4 - These probable targets produce small, circular magnetic highs within a surrounding magnetic low zone. These anomalies are near a trench but are thought to be unrelated to it because there is no general magnetic anomaly along the trench. Thus, the anomalies are thought to be caused by some other buried feature. The GPR data do not show an anomaly at No. 3, but there is a wide anomaly at No. 4 and a small feature running SE from the fire hydrant on the north edge of the grid. The small feature may be caused by a non-ferrous pipe to the hydrant. The source is thought to be non-ferrous because the magnetic survey does not show a coincident linear anomaly.

Target 5 - This target has a strong GPR reflection and is associated with a long, narrow magnetic high. The GPR shows repeated wide anomalies that are in-line with this magnetic high. Therefore, this target is now thought to be caused by a trench or storm drain not visible at the surface rather than a well location.

Target 6 - This target produced a strong GPR reflection, but no magnetic anomaly and could not be relocated during target staking and is not thought to represent a well.

Target 7 - This location is characterized by localized, large amplitude anomalies in both the EMI and magnetic data. There is also a deep target on the GPR. This target was not staked in the field, but should be considered as a "Potential Target".

Site A23-A1: Well Located
Site in Irrigated Field Along Perimeter Fence

The GPR survey was initially completed at this site and the results plotted. After the GPR survey on the regular grid was finished, two new areas were surveyed immediately south of the original grid. The first area was located between Macon Road and the base perimeter fence (compare the two GPR data maps

in Appendix E). The second area was in-line with the original grid and south of the perimeter fence (off-base). The well was found on profile 120 by digging at the location of a very strong GPR reflection. The magnetic and EMI data were collected at the original grid, but before they were plotted, the well was located.

REFERENCE
APPENDIX A – GEOPHYSICAL
SUBCONSULTANT'S REPORT DATE OCTOBER
1987

SUSPECTED WELLS INVESTIGATION REPORT,
POTENTIAL CONDUITS INVESTIGATION

THE ABOVE IDENTIFIED SECTION
IS NOT AVAILABLE.

EXTENSIVE RESEARCH WAS PERFORMED BY NAVFAC SOUTHWEST TO LOCATE THIS SECTION. THIS PAGE HAS BEEN INSERTED AS A PLACEHOLDER AND WILL BE REPLACED SHOULD THE MISSING ITEM BE LOCATED.

QUESTIONS MAY BE DIRECTED TO:

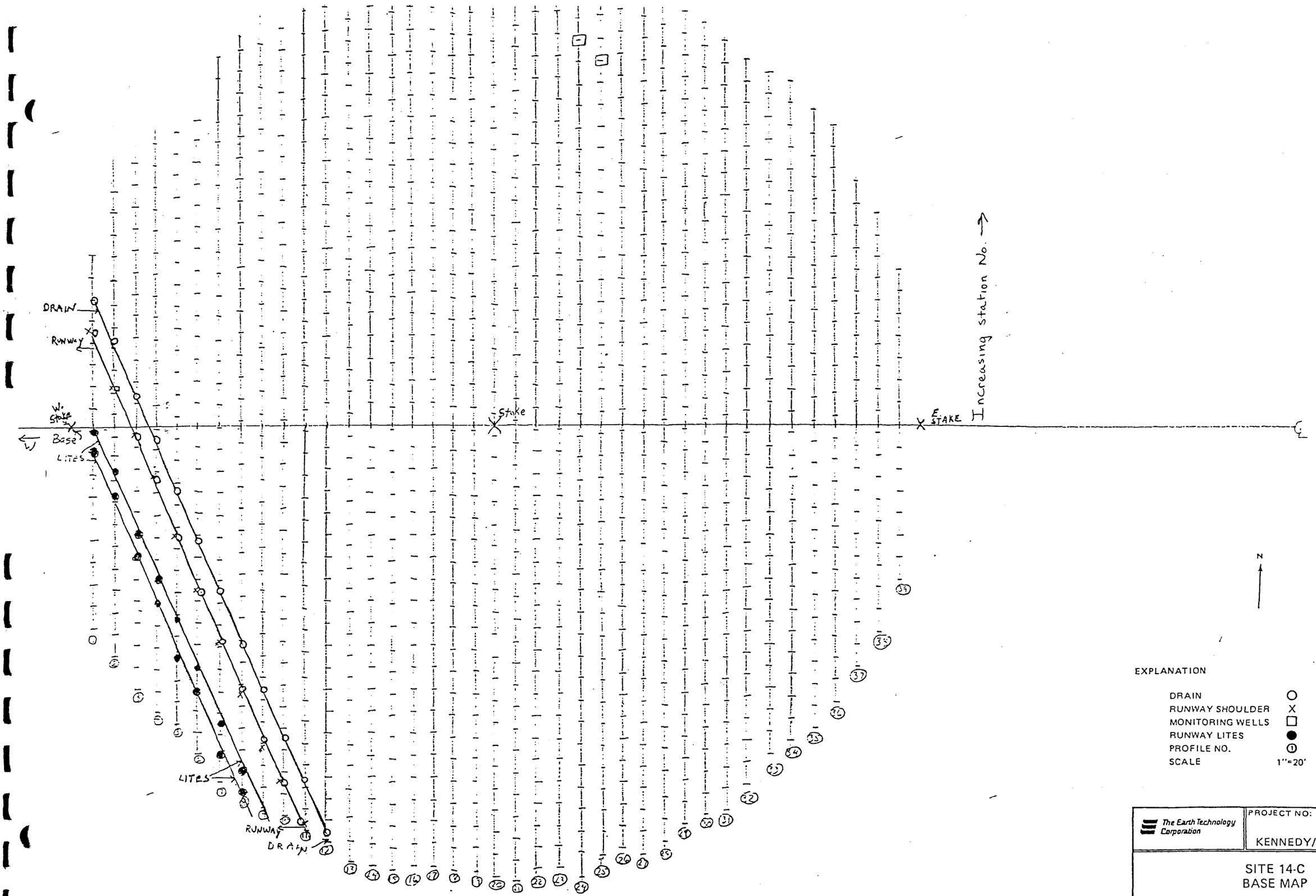
DIANE C. SILVA
RECORDS MANAGEMENT SPECIALIST
NAVAL FACILITIES ENGINEERING COMMAND
SOUTHWEST
1220 PACIFIC HIGHWAY
SAN DIEGO, CA 92132

TELEPHONE: (619) 532-3676

APPENDIX A

SITE 14-C

DATA MAPS



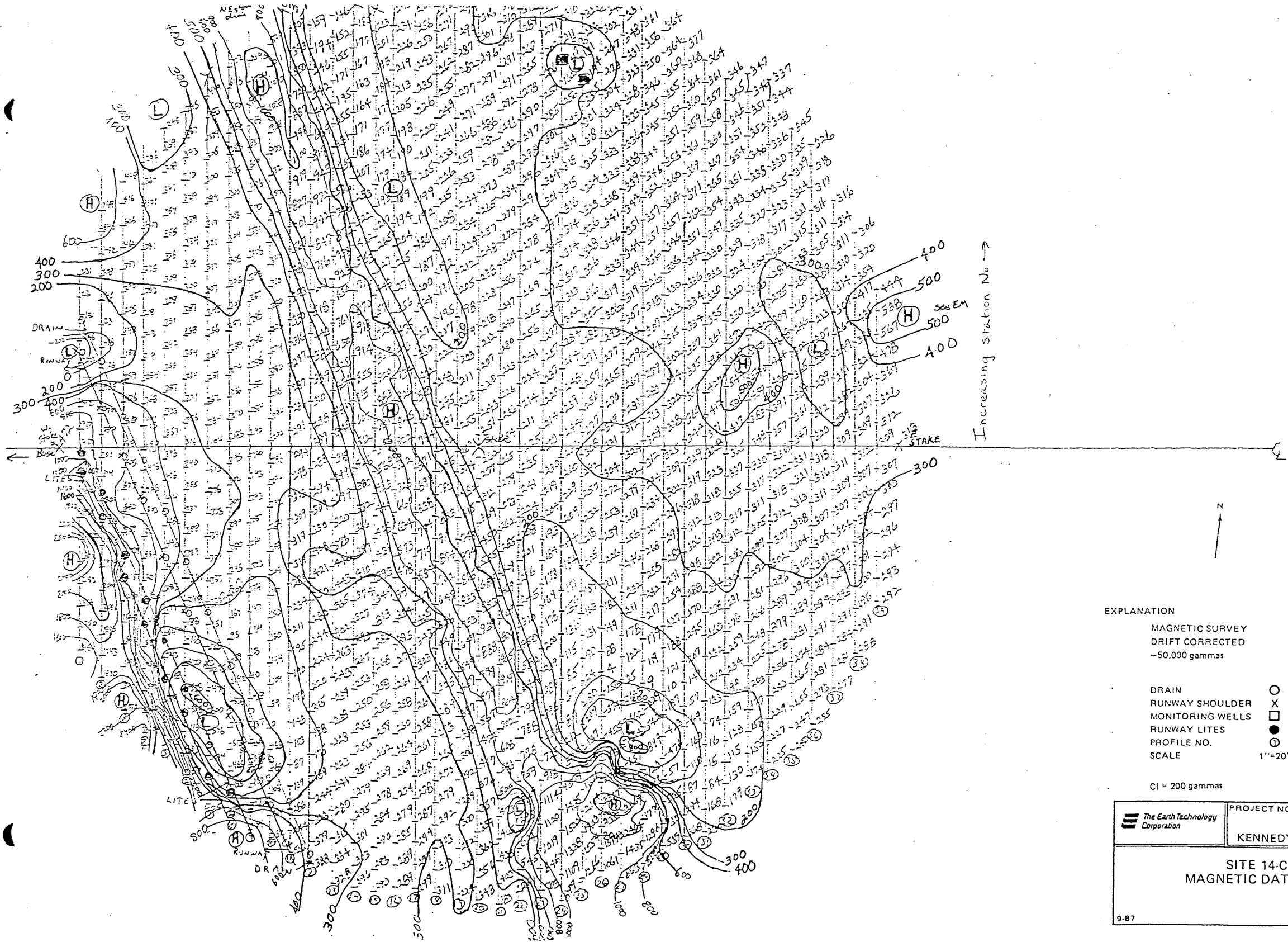
The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

SITE 14-C
BASE MAP

9-87



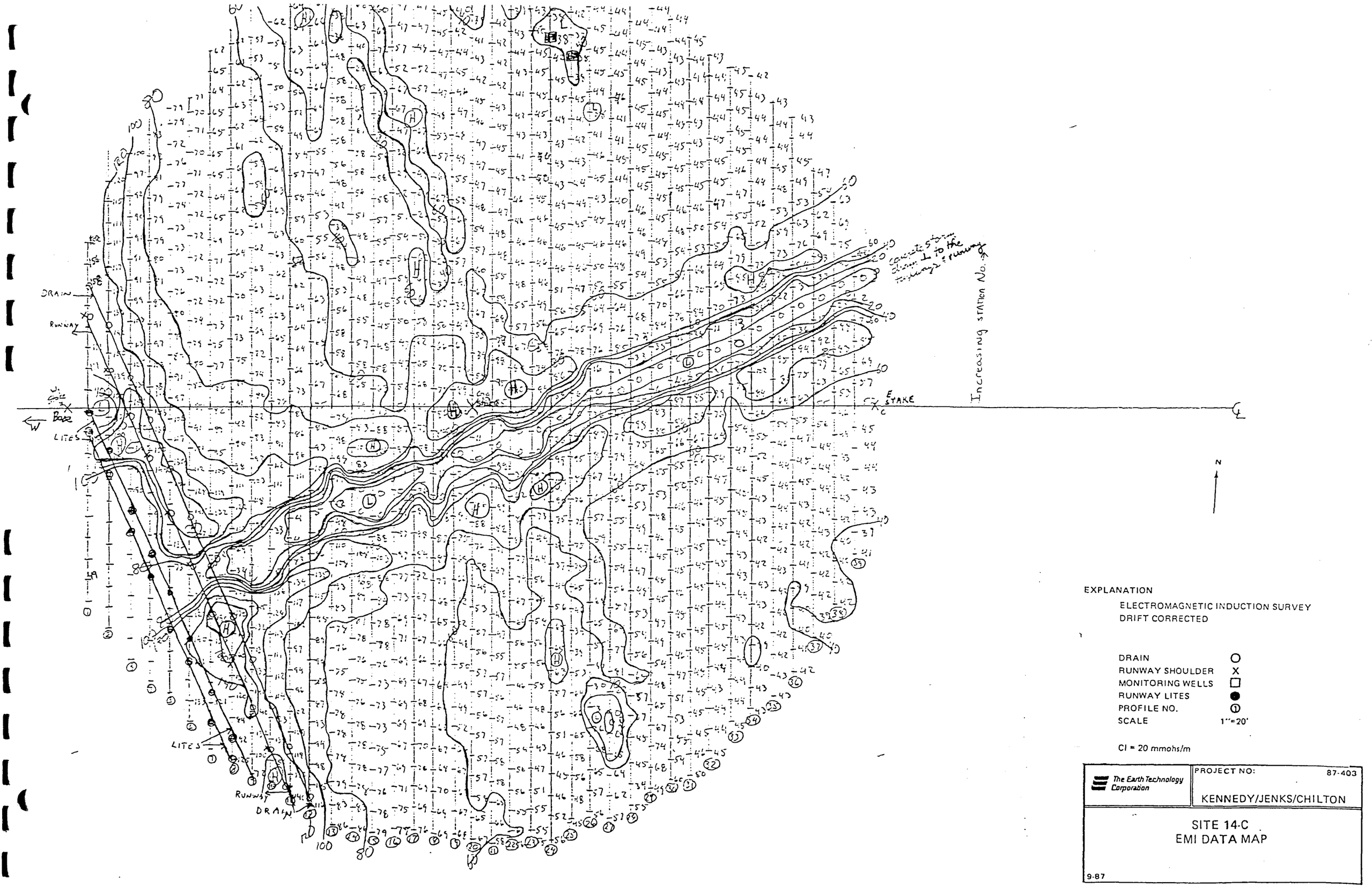
The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

SITE 14-C
MAGNETIC DATA MAP

9-87



EXPLANATION

ELECTROMAGNETIC INDUCTION SURVEY
DRIFT CORRECTED

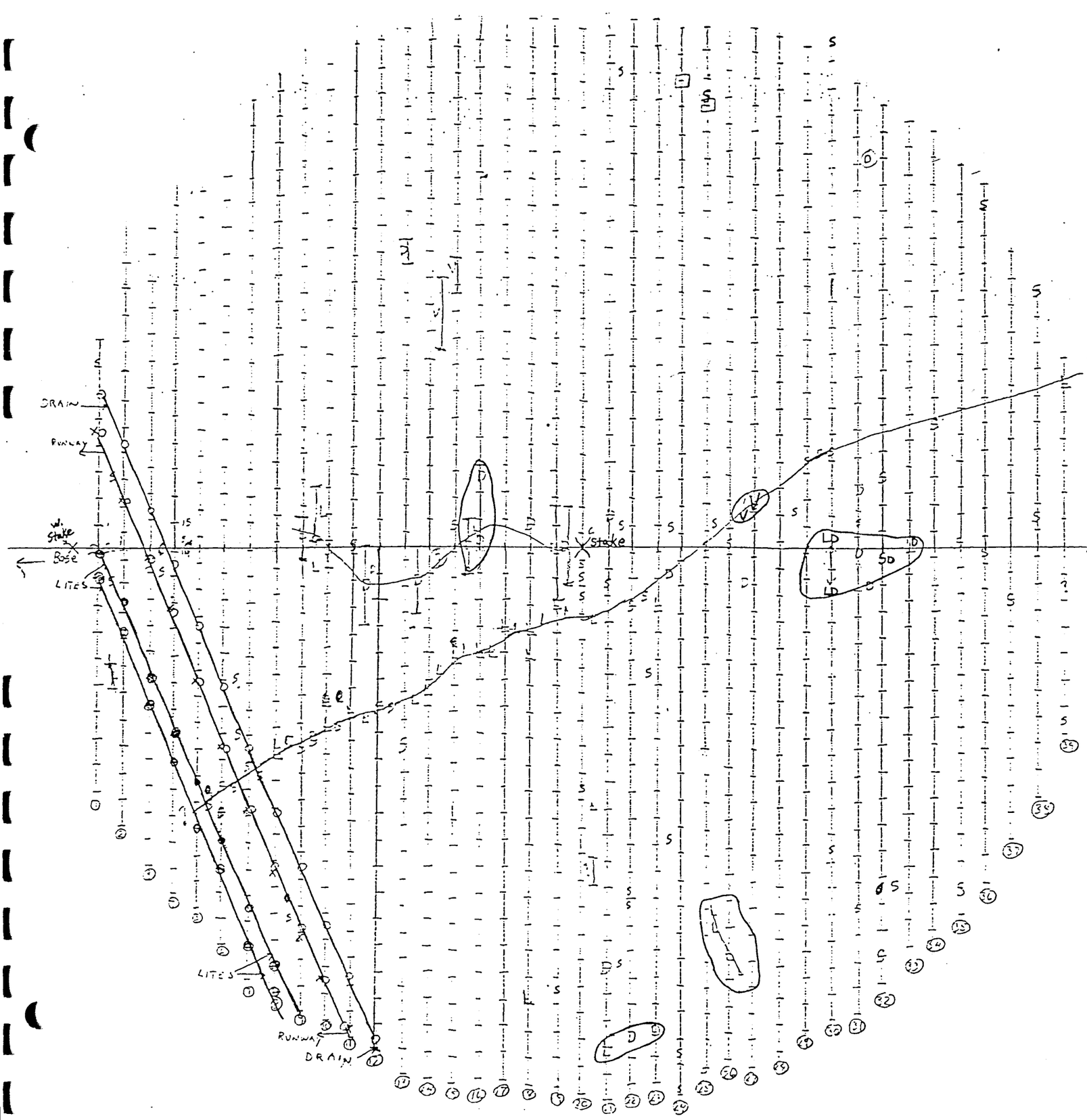
DRAIN	O
RUNWAY SHOULDER	X
MONITORING WELLS	□
RUNWAY LITES	●
PROFILE NO.	①
SCALE	1"=20'

CI = 20 mmohs/m

The Earth Technology Corporation	PROJECT NO: 87-403
	KENNEDY/JENKS/CHILTON

SITE 14-C
EMI DATA MAP

9-87



EXPLANATION

RADAR SURVEY

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

DRAIN	○
RUNWAY SHOULDER	X
MONITORING WELLS	□
RUNWAY LITES	●
PROFILE NO.	①
SCALE	1"=20'

The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

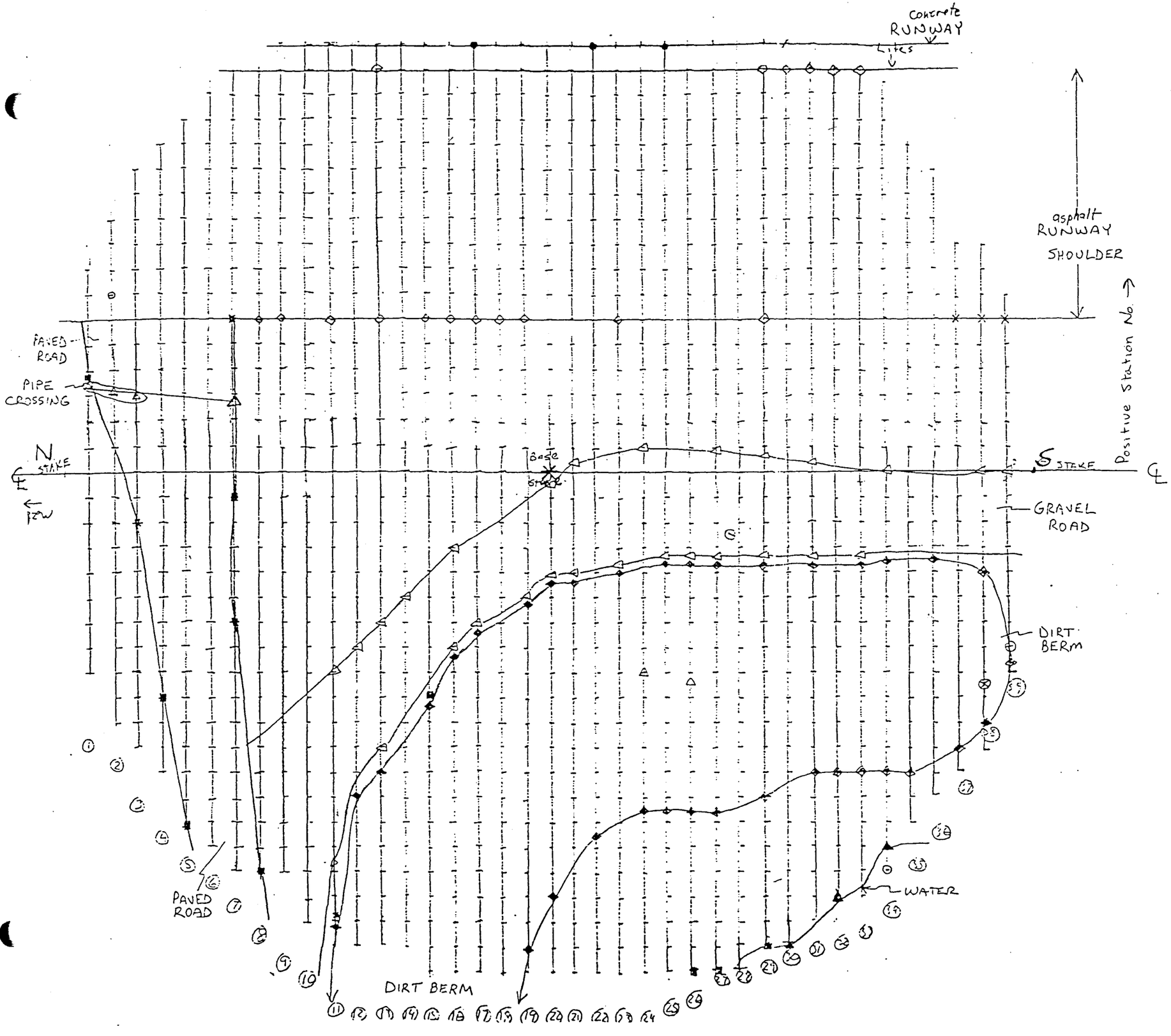
SITE 14-C
GPR DATA MAP

9-87

APPENDIX B

SITE 14-A

DATA MAPS



EXPLANATION

DRAIN	○
RUNWAY SHOULDER	X
RUNWAY EDGE	●
RUNWAY LITES	◇
MONITORING WELLS	□
BERM	◆
PIPE CROSSING	△
PAVED ROAD EDGE	■
WATER	▲
GRAVEL ROAD EDGE	◁
LARGE METAL PLATE	⊗
PROFILE NO.	①
SCALE	1"=20'

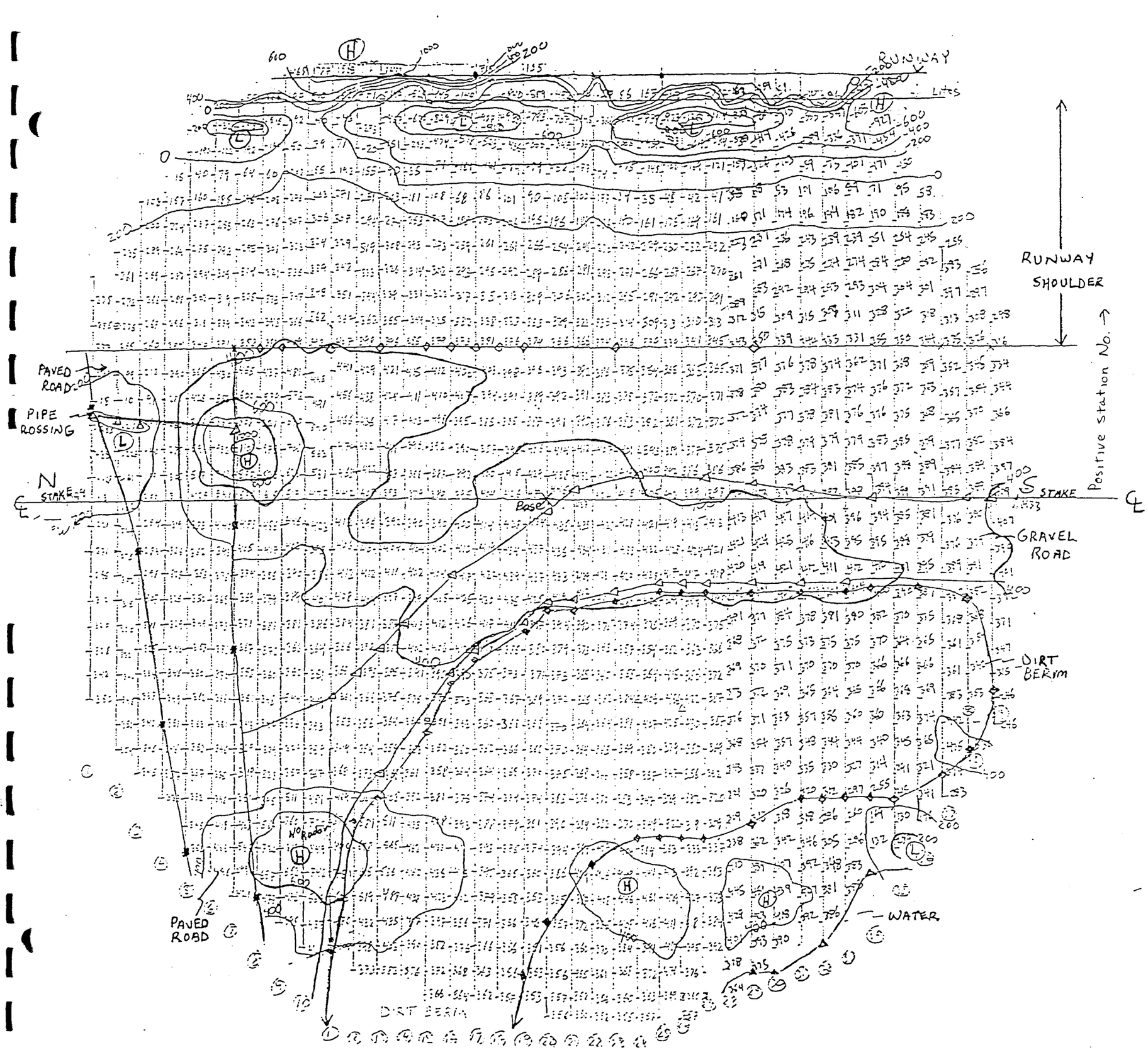
The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

SITE 14-A
BASE MAP

9-87



EXPLANATION

MAGNETIC SURVEY
DRIFT CORRECTED
—50,000 gammas

DRAIN	○
RUNWAY SHOULDER	X
RUNWAY EDGE	●
RUNWAY LITES	◇
MONITORING WELLS	□
BERM	◆
PIPE CROSSING	△
PAVED ROAD EDGE	■
WATER	▲
GRAVEL ROAD EDGE	◁
LARGE METAL PLATE	⊗
PROFILE NO.	⊕
SCALE	1"=20'

CI = 200 gammas

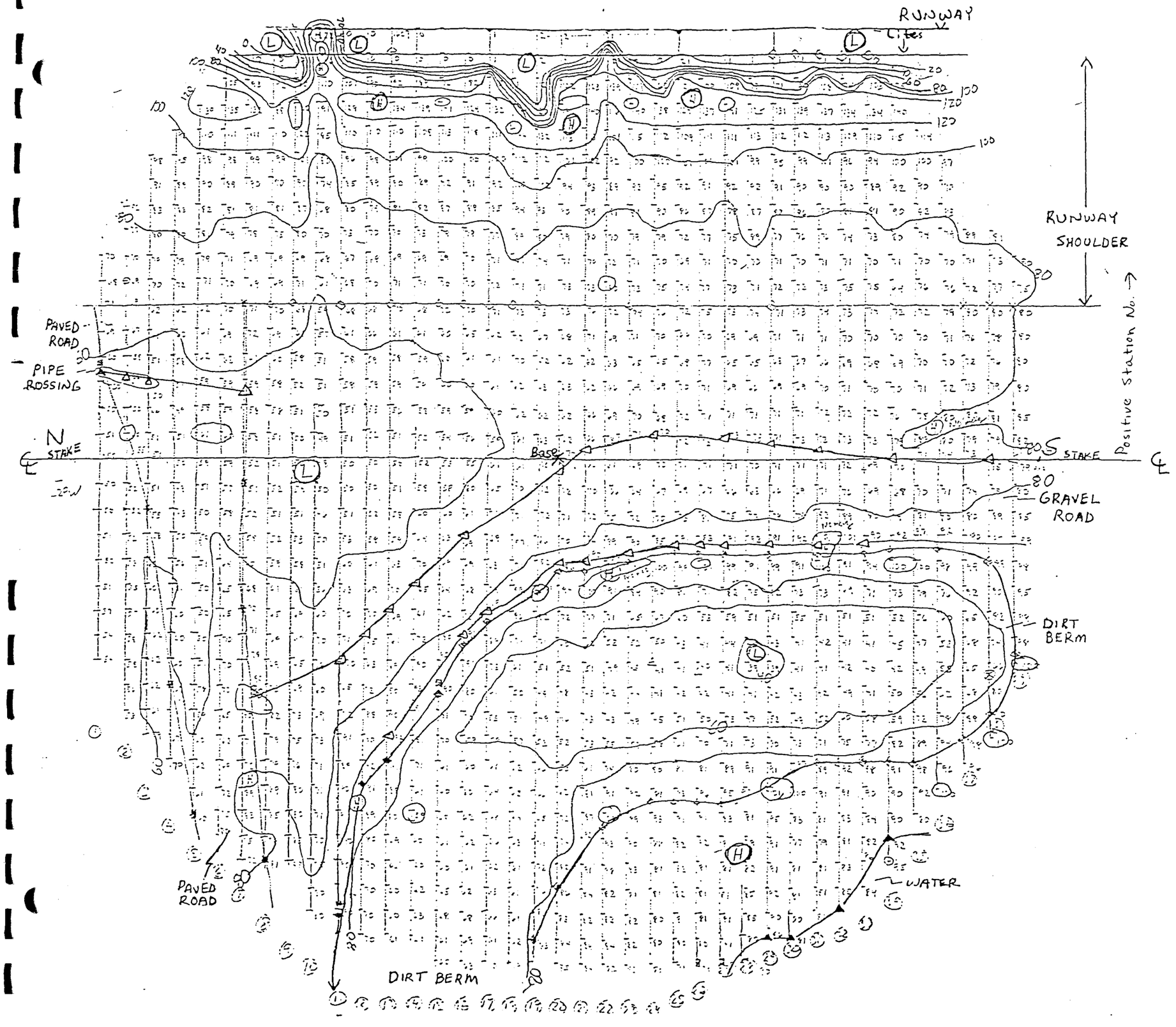
The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

SITE 14-A
MAGNETIC DATA MAP

9-87



EXPLANATION

ELECTROMAGNETIC INDUCTION SURVEY
DRIFT CORRECTED

DRAIN	○
RUNWAY SHOULDER	×
RUNWAY EDGE	●
RUNWAY LITES	◇
MONITORING WELLS	□
BERM	◆
PIPE CROSSING	△
PAVED ROAD EDGE	■
WATER	▲
GRAVEL ROAD EDGE	◁
LARGE METAL PLATE	⊗
PROFILE NO.	⊖
SCALE	1"=20'

CI = 20 mmohs/m

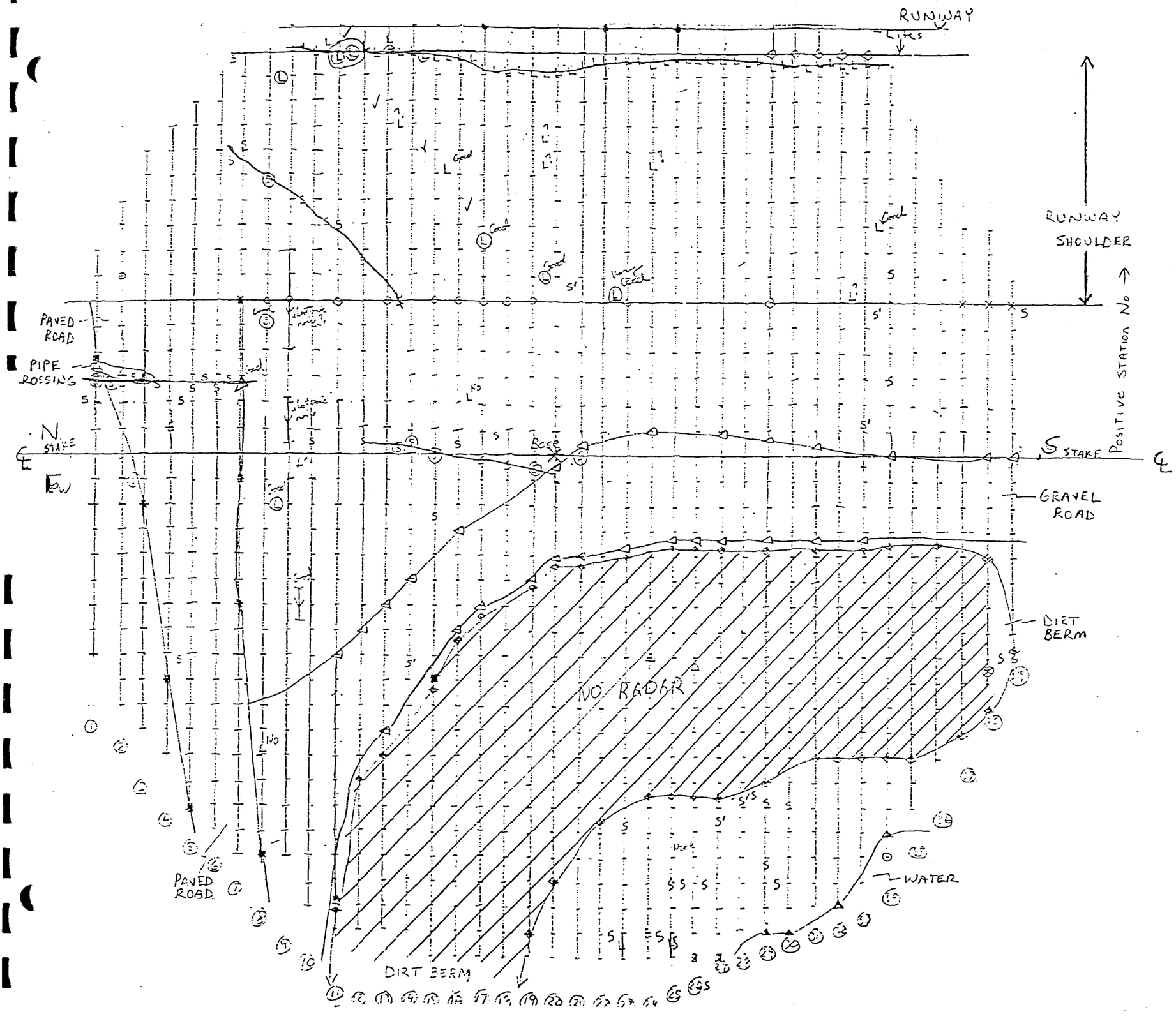
The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

SITE 14-A
EMI DATA MAP

9-87



EXPLANATION

RADAR SURVEY

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

DRAIN	○
RUNWAY SHOULDER	X
RUNWAY EDGE	●
RUNWAY LITES	◇
MONITORING WELLS	□
BERM	◆
PIPE CROSSING	△
PAVED ROAD EDGE	■
WATER	▲
GRAVEL ROAD EDGE	◁
LARGE METAL PLATE	⊗
PROFILE NO.	ⓘ
SCALE	1"=20'

The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

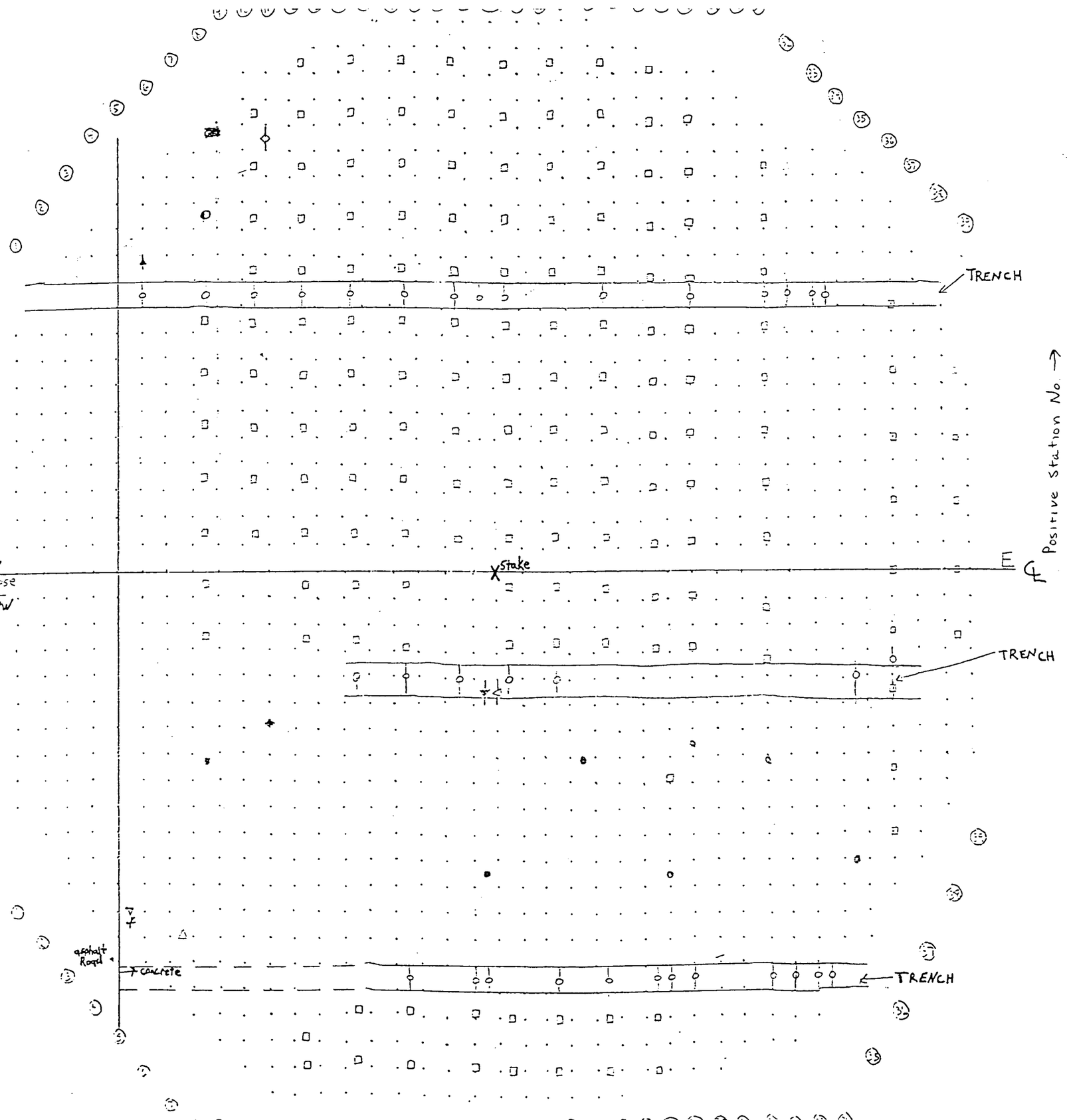
SITE 14-A
GPR DATA MAP

9-87

APPENDIX C

SITE 14-F

DATA MAPS



EXPLANATION

TRENCH	○
TIE DOWNS	□
MANHOLE COVER	■
FIRE HYDRANT	*
STEEL CAP	●
CONCRETE-FILLED HOLE	◇
VERTICAL STEEL PIPE	◆
MANHOLE	◁
ASPHALT/CONCRETE	◐
WATER MAIN CAP	△
METAL PLATE	▲
STEEL POST	▽
MANHOLE GRATE	▼
PROFILE NO.	①
SCALE	1"=20'

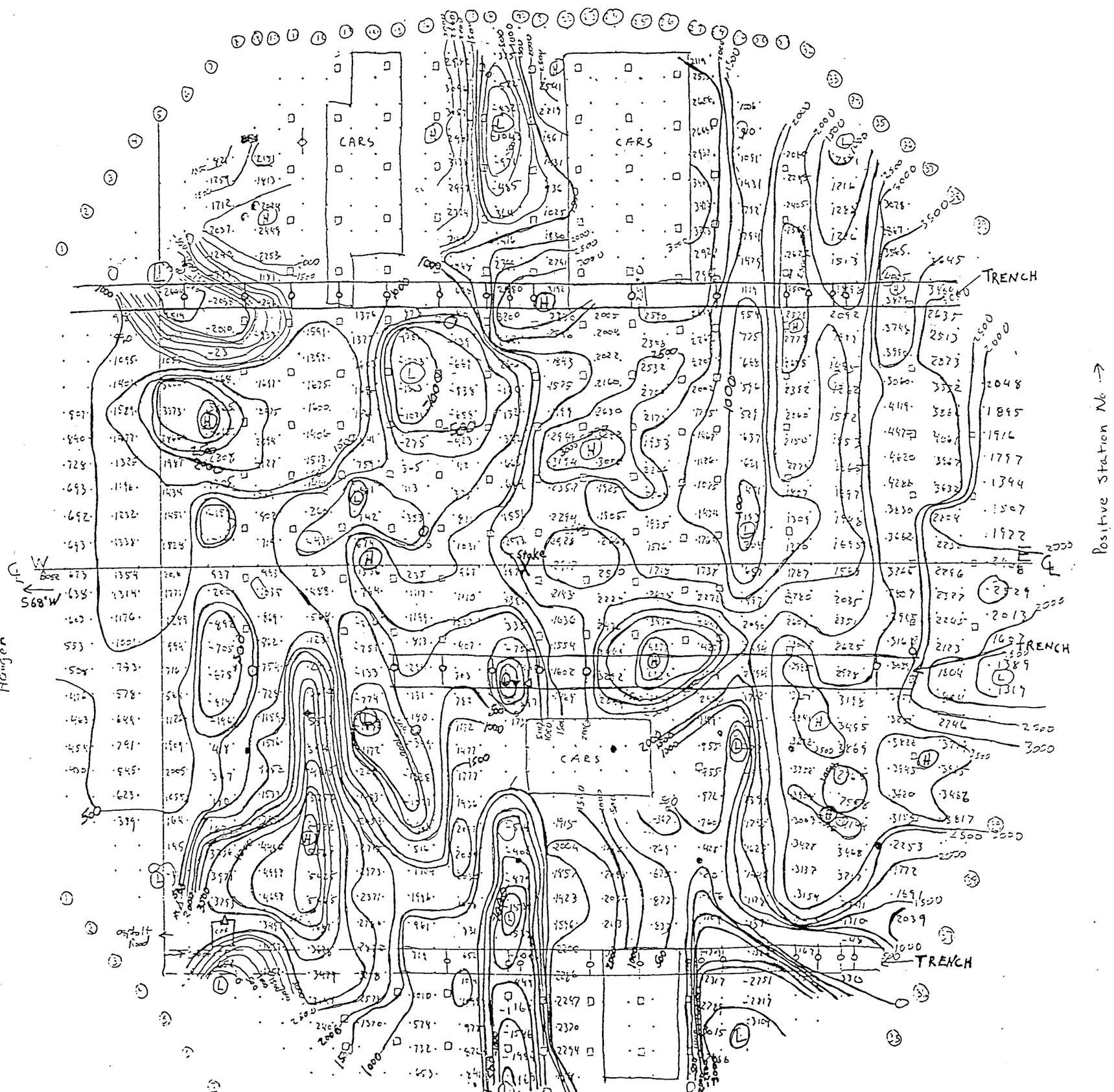
The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

SITE 14-F
BASE MAP

9-87



EXPLANATION

MAGNETIC SURVEY
DRIFT CORRECTED
—48,000 gammas

TRENCH	○
TIE DOWNS	□
MANHOLE COVER	■
FIRE HYDRANT	*
STEEL CAP	●
CONCRETE-FILLED HOLE	◇
VERTICAL STEEL PIPE	◆
MANHOLE	◁
ASPHALT/CONCRETE	◐
WATER MAIN CAP	△
METAL PLATE	▲
STEEL POST	▽
MANHOLE GRATE	▼
PROFILE NO.	①
SCALE	1"=20'

CI = 500 gammas

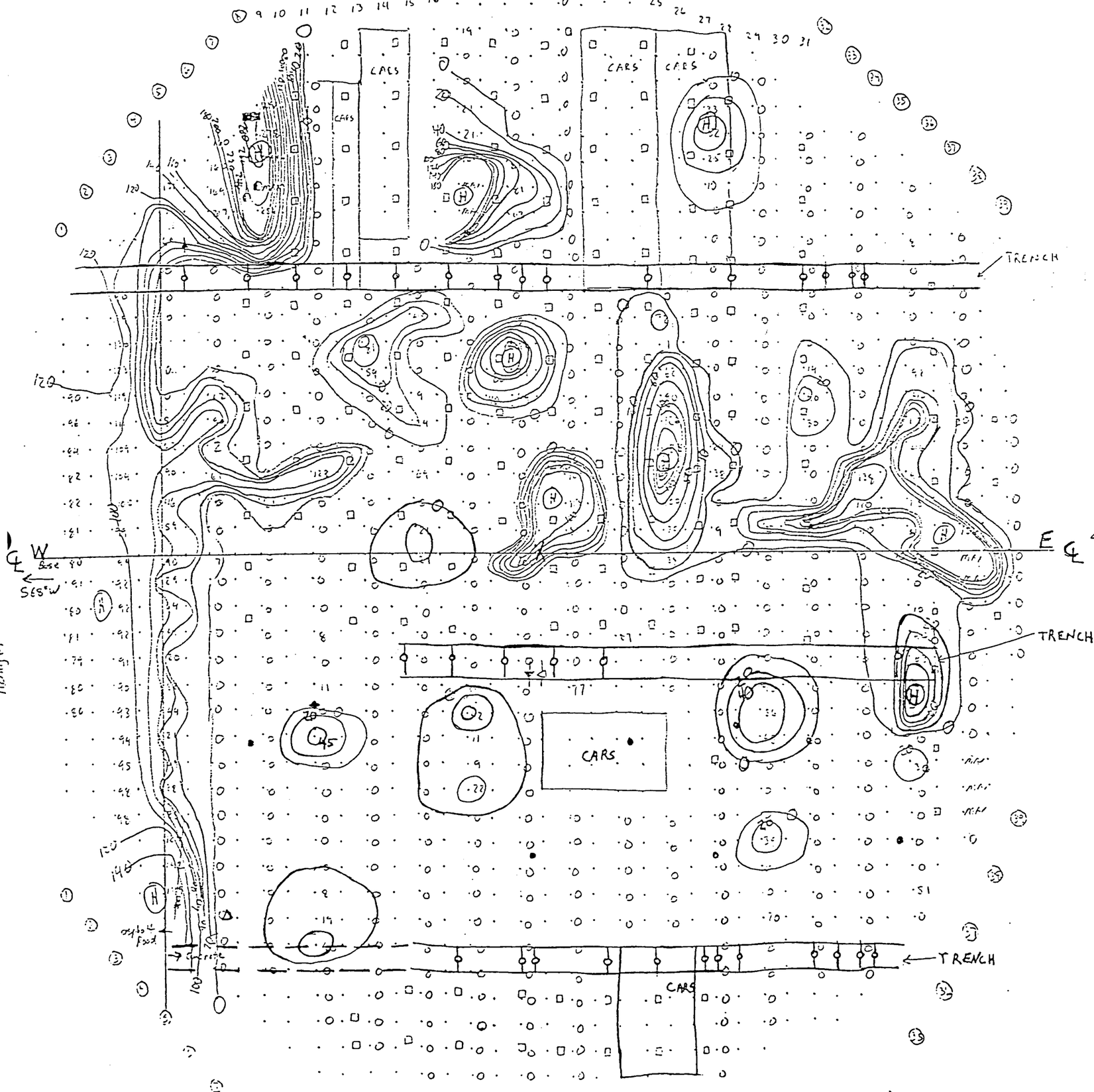
The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

SITE 14-F
MAGNETIC DATA MAP

9-87



N

EXPLANATION

ELECTROMAGNETIC INDUCTION SURVEY
DRIFT CORRECTED

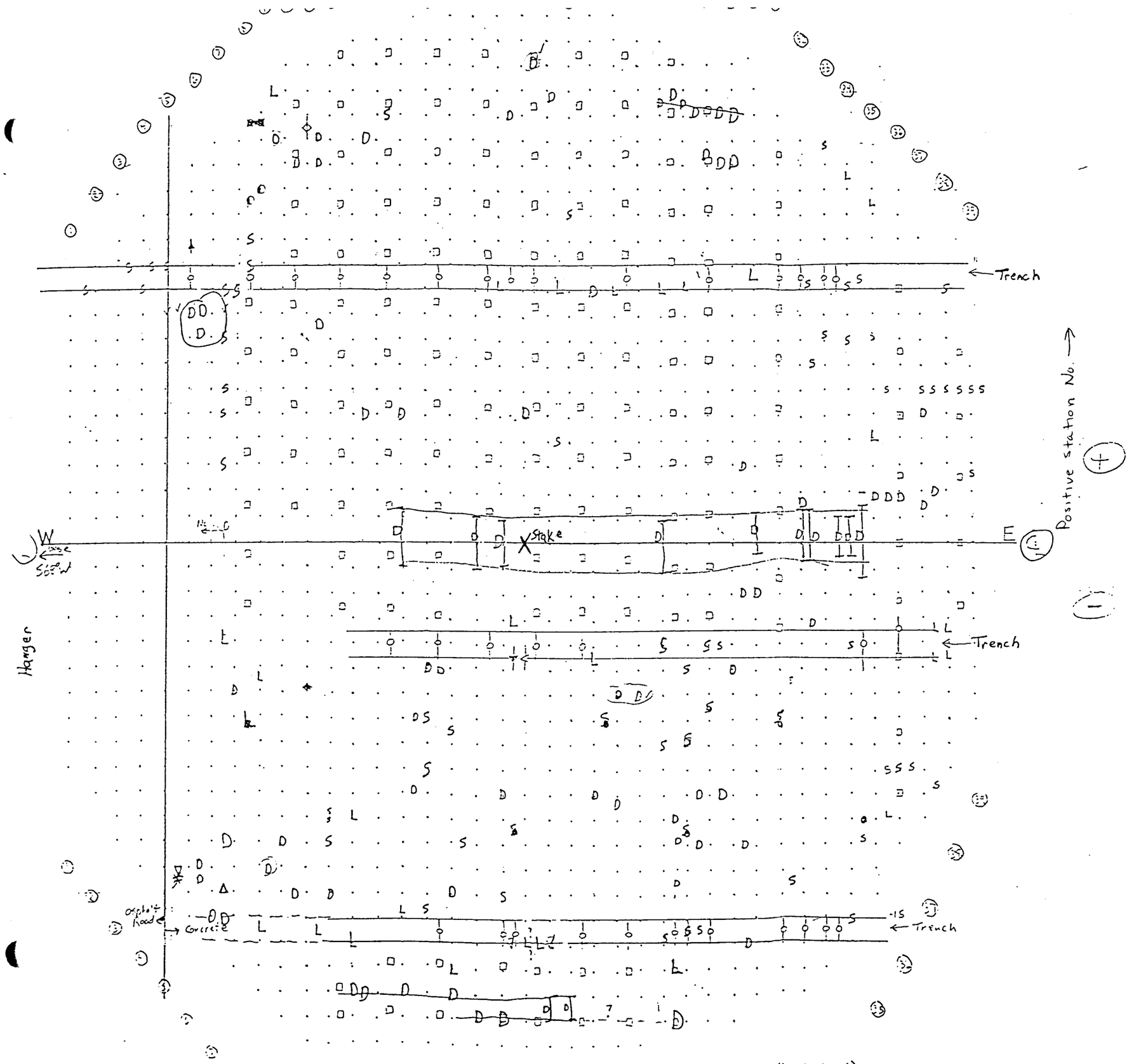
TRENCH	○
TIE DOWNS	□
MANHOLE COVER	■
FIRE HYDRANT	*
STEEL CAP	●
CONCRETE-FILLED HOLE	◇
VERTICAL STEEL PIPE	◆
MANHOLE	▽
ASPHALT/CONCRETE	◐
WATER MAIN CAP	△
METAL PLATE	▲
STEEL POST	▽
MANHOLE GRATE	▼
PROFILE NO.	①
SCALE	1"=20'

CI = 20 mmohs/m

The Earth Technology Corporation	PROJECT NO: 87-403
	KENNEDY/JENKS/CHILTON

SITE 14-F
EMI DATA MAP

9-87



N

EXPLANATION

RADAR SURVEY

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

TRENCH	○
TIE DOWNS	□
MANHOLE COVER	■
FIRE HYDRANT	*
STEEL CAP	●
CONCRETE-FILLED HOLE	◇
VERTICAL STEEL PIPE	◆
MANHOLE	◁
ASPHALT/CONCRETE	◐
WATER MAIN CAP	△
METAL PLATE	▲
STEEL POST	▽
MANHOLE GRATE	▼
PROFILE NO.	①
SCALE	1"=20'

The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

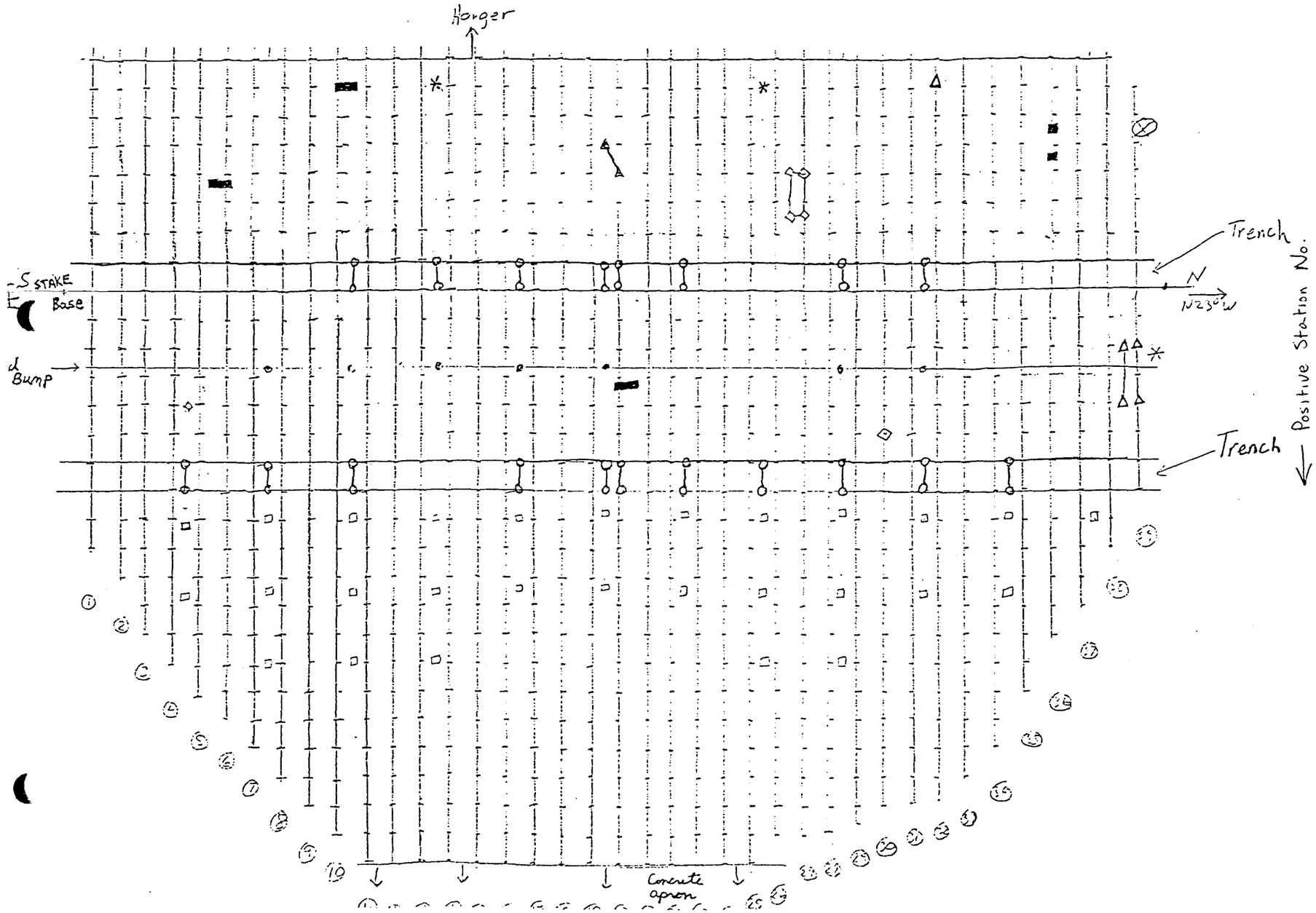
SITE 14-F
GPR DATA MAP

9-87

APPENDIX D

SITE 13-D

DATA MAPS



EXPLANATION

TRENCH	○
SPEED BUMP	●
TAXIWAY	X
TD(TIE DOWNS)	□
STEEL PIPES	△
LARGE STEEL PLATE	⊗
MANHOLE COVER	■
ELECTRICAL TRANSFORMER	▲
FIRE HYDRANT	*
PAVEMENT COLLAPSE	◇
CONCRETE APRON	Z
SCALE	1"=20'

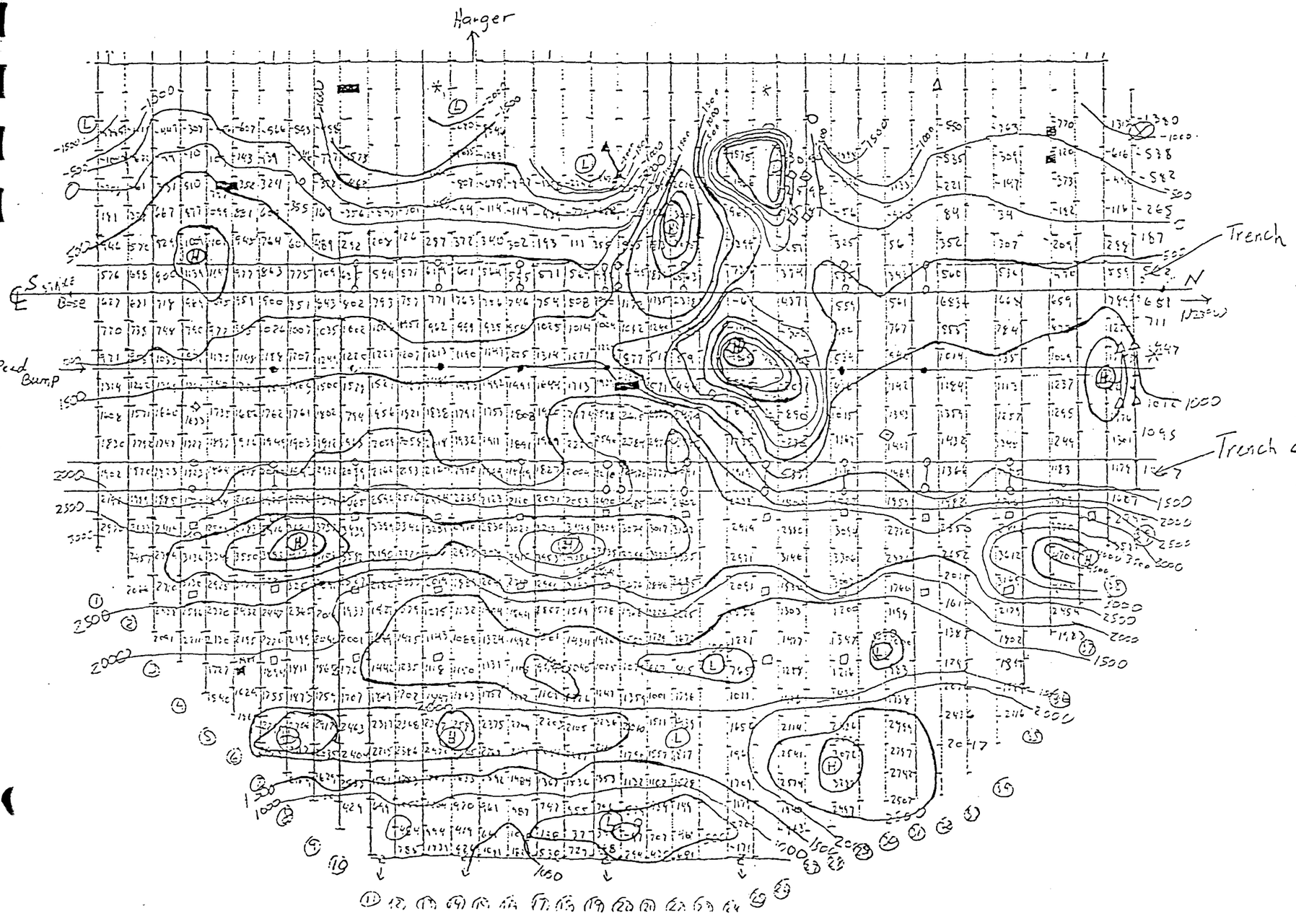
The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

SITE 13-D
BASE MAP

9-87



EXPLANATION

MAGNETIC SURVEY
DRIFT CORRECTED
−48,000 gammas

TRENCH	○
SPEED BUMP	●
TAXIWAY	X
TD(TIE DOWNS)	□
STEEL PIPES	△
LARGE STEEL PLATE	⊘
MANHOLE COVER	▣
ELECTRICAL TRANSFORMER	▲
FIRE HYDRANT	*
PAVEMENT COLLAPSE	◇
CONCRETE APRON	Z
SCALE	1"=20'

CI = 500 gammas

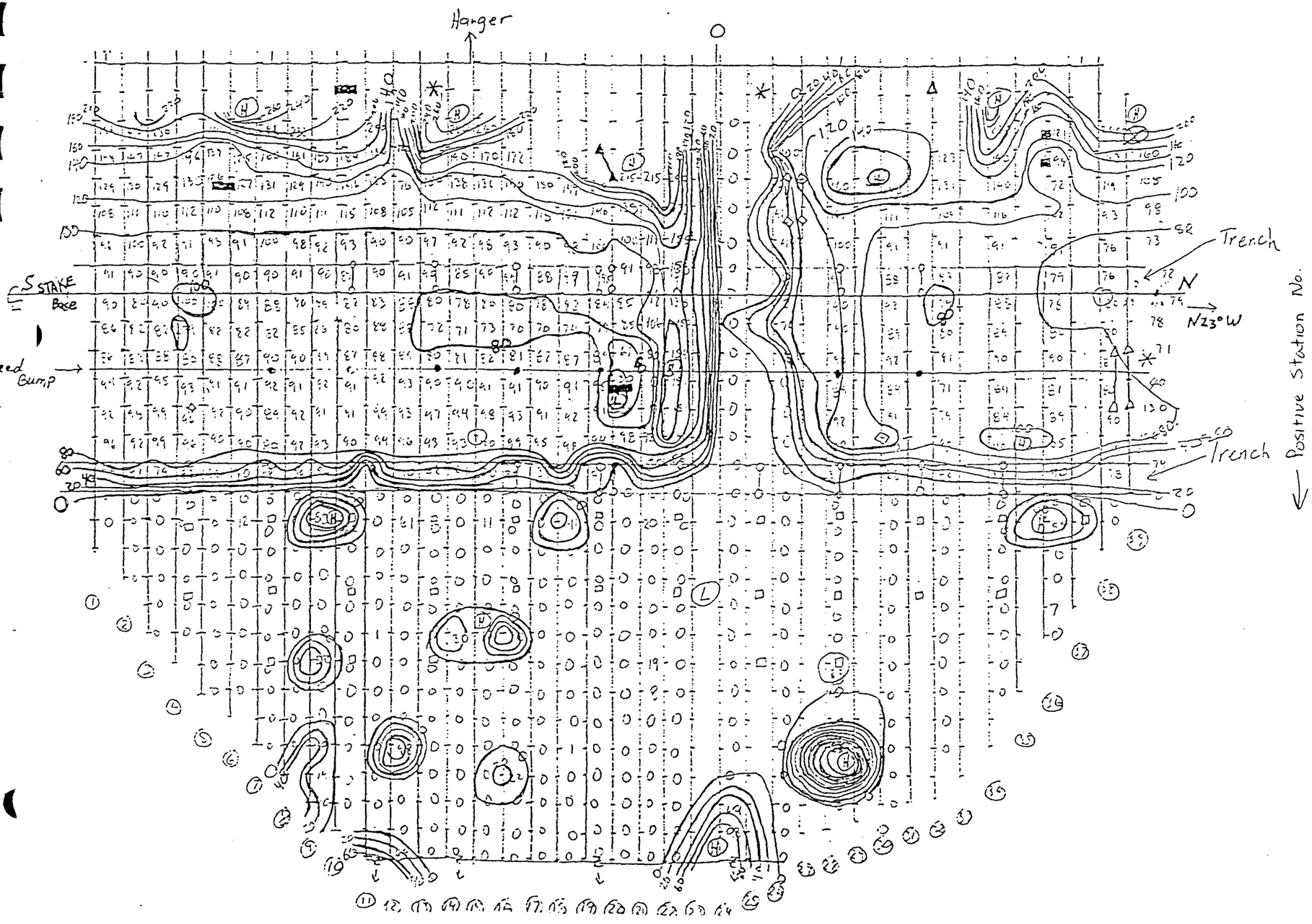
The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

SITE 13-D
MAGNETIC DATA MAP

9-87



EXPLANATION

ELECTROMAGNETIC INDUCTION SURVEY
DRIFT CORRECTED

TRENCH	○
SPEED BUMP	●
TAXIWAY	X
TD(TIE DOWNS)	□
STEEL PIPES	△
LARGE STEEL PLATE	⊗
MANHOLE COVER	▣
ELECTRICAL TRANSFORMER	▲
FIRE HYDRANT	*
PAVEMENT COLLAPSE	◇
CONCRETE APRON	⧗
SCALE	1"=20'

CI = 20 mmohs/m

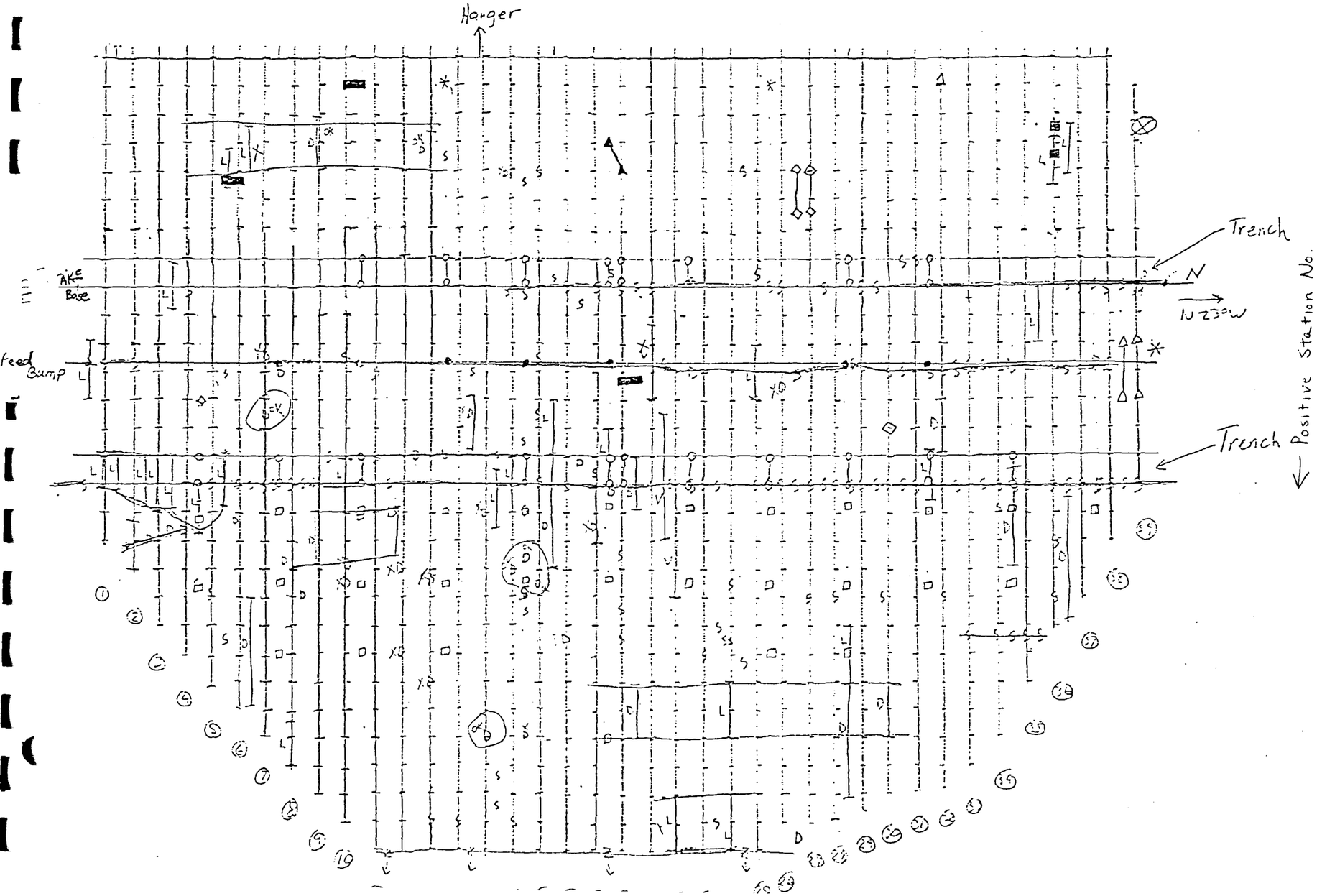
The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

SITE 13-D
EMI DATA MAP

9-87



DRAFT

EXPLANATION

RADAR SURVEY

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

TRENCH	○
SPEED BUMP	●
TAXIWAY	×
TD(TIE DOWNS)	□
STEEL PIPES	△
LARGE STEEL PLATE	⊗
MANHOLE COVER	■
ELECTRICAL TRANSFORMER	▲
FIRE HYDRANT	*
PAVEMENT COLLAPSE	◇
CONCRETE APRON	N
SCALE	1"=20'

The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

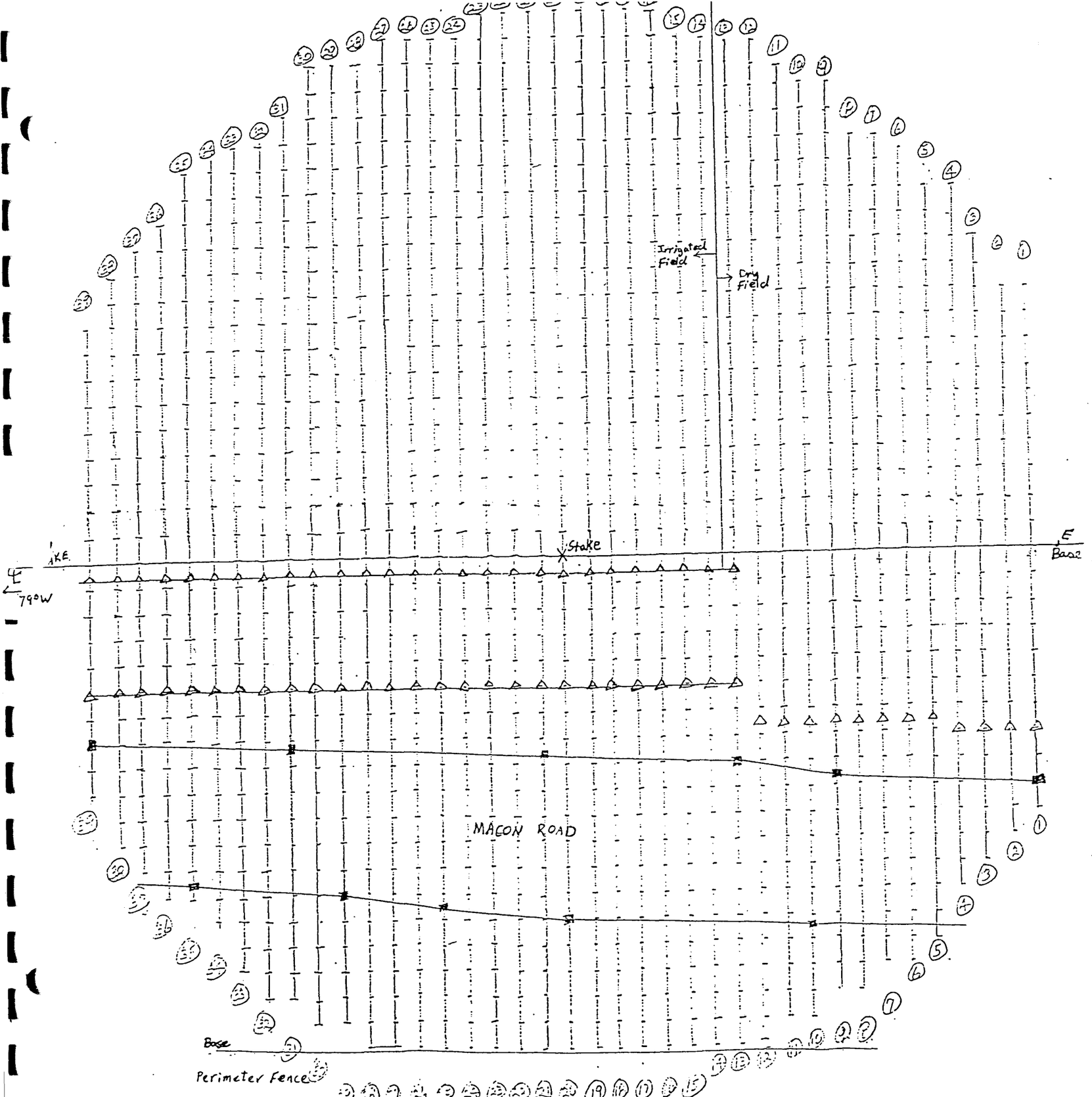
SITE 13-D
GPR DATA MAP

9-87

APPENDIX E

SITE 23-A1

DATA MAPS



EXPLANATION

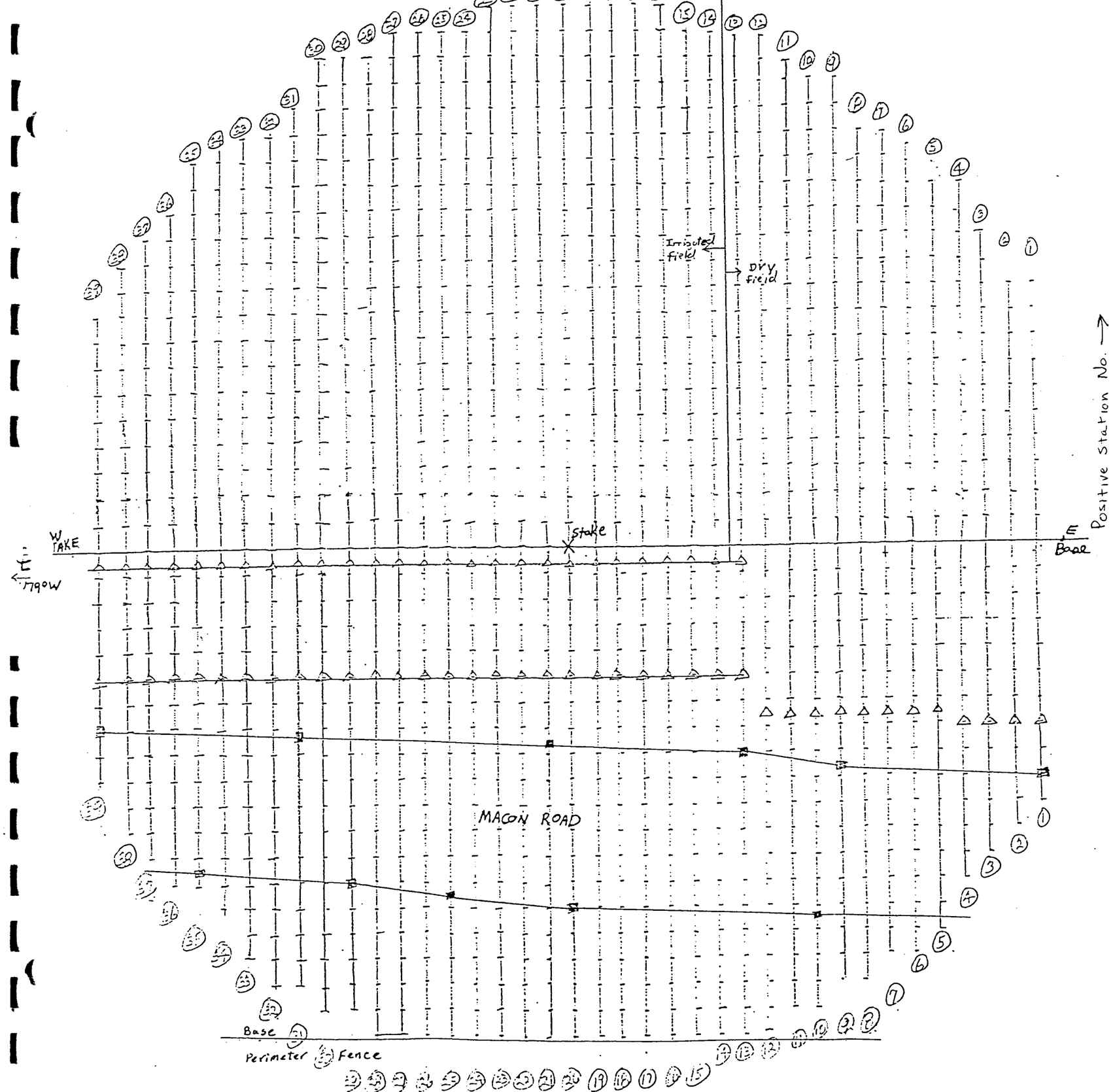
MAGNETIC SURVEY

PROFILE NO.	①
RUNWAY SHOULDER	X
PAVED ROAD EDGE	■
IRRIGATION PIPELINE	△
ABANDONED IRRIGATION WELL	⊛
SCALE	1"=20'

The Earth Technology Corporation	PROJECT NO: 87-403
	KENNEDY/JENKS/CHILTON

SITE 23-A1
MAGNETIC DATA MAP

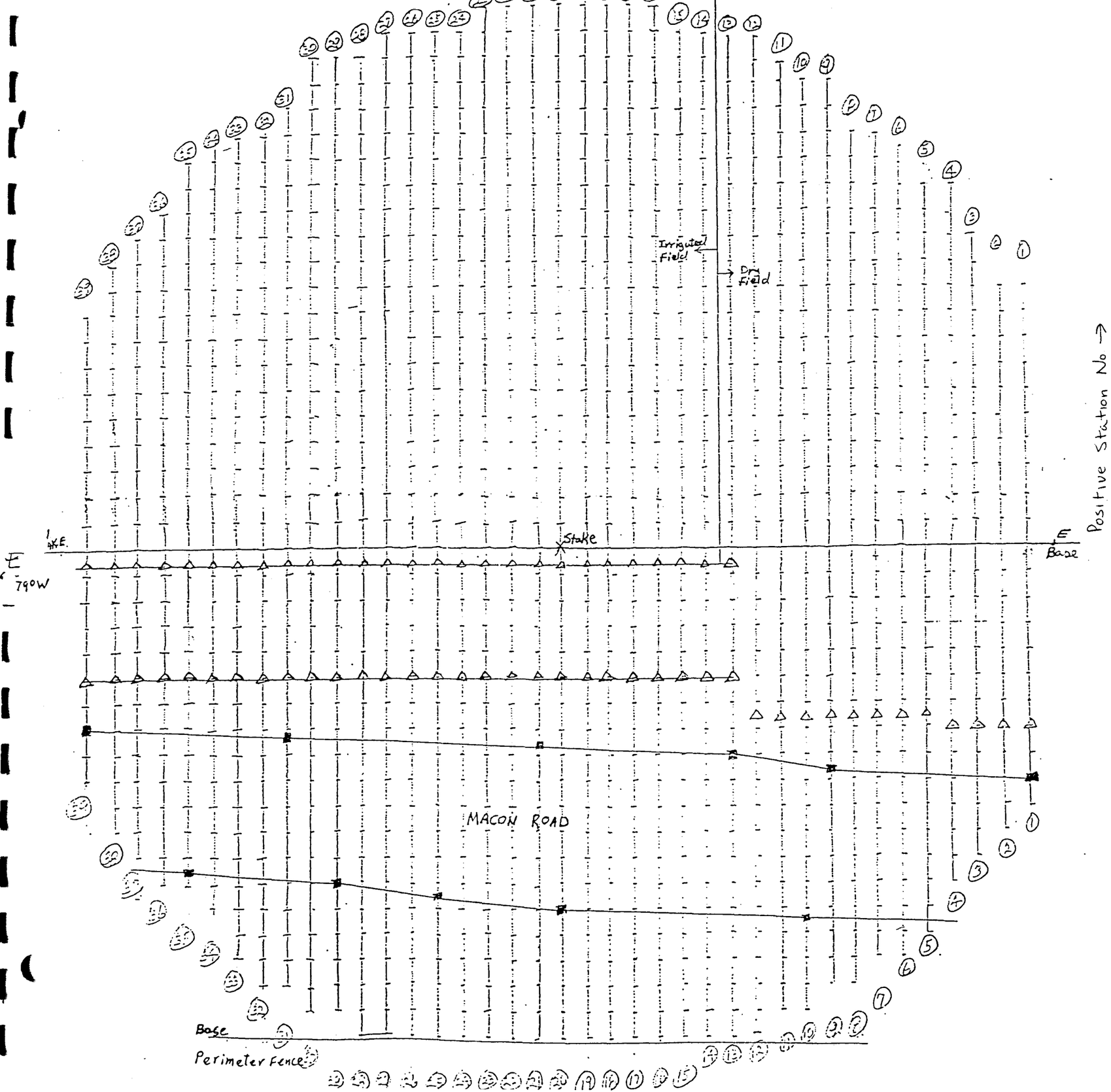
9-87



EXPLANATION

PROFILE NO.	①
RUNWAY SHOULDER	X
PAVED ROAD EDGE	■
IRRIGATION PIPELINE	△
ABANDONED IRRIGATION WELL	⊗
SCALE	1"=20'

The Earth Technology Corporation	PROJECT NO: 87-403
	KENNEDY/JENKS/CHILTON
SITE 23-A1 BASE MAP	
9-87	



N

EXPLANATION

ELECTROMAGNETIC INDUCTION SURVEY

PROFILE NO.	①
RUNWAY SHOULDER	X
PAVED ROAD EDGE	■
IRRIGATION PIPELINE	△
ABANDONED IRRIGATION WELL	⊛
SCALE	1"=20'

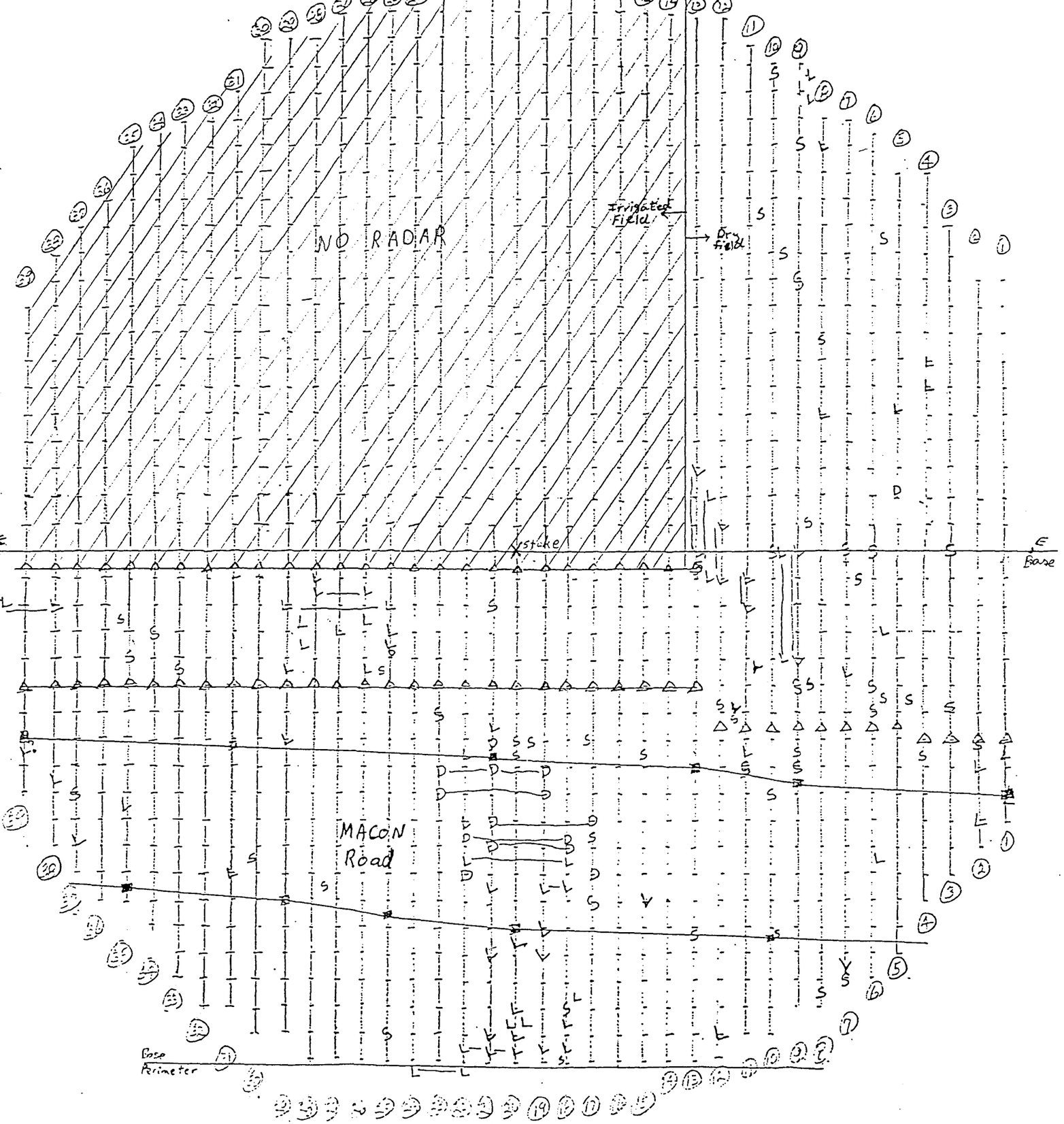
The Earth Technology Corporation

PROJECT NO: 87-403

KENNEDY/JENKS/CHILTON

SITE 23-A1
EMI DATA MAP

9-87



N

EXPLANATION

RADAR SURVEY

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

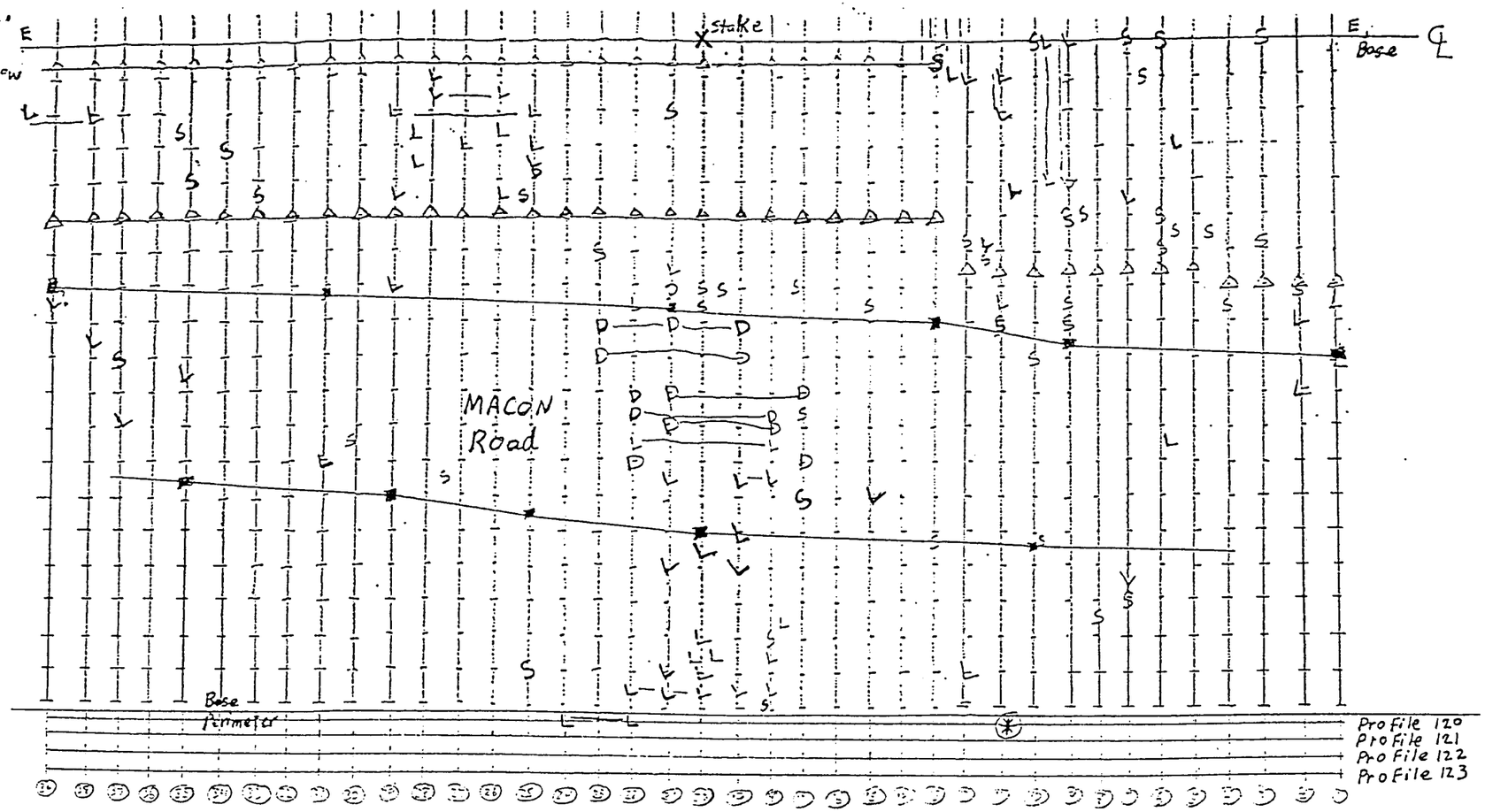
PROFILE NO.	①
RUNWAY SHOULDER	X
PAVED ROAD EDGE	■
IRRIGATION PIPELINE	△
ABANDONED IRRIGATION WELL	⊛
SCALE	1"=20'

The Earth Technology Corporation	PROJECT NO: 87-403
	KENNEDY/JENKS/CHILTON

SITE 23-A1
GPR DATA MAP

9-87

Top Half of Original
Radar Removed for Clarity



Positive station No. →

N

EXPLANATION

RADAR SURVEY – EXTENDED

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

PROFILE NO.	①
RUNWAY SHOULDER	X
PAVED ROAD EDGE	■
IRRIGATION PIPELINE	△
ABANDONED IRRIGATION WELL	⊛
SCALE	1"=20'

The Earth Technology Corporation	PROJECT NO: 87-403
	KENNEDY/JENKS/CHILTON

SITE 23-A1
GPR EXTENDED DATA MAP

9-87

APPENDIX B

GEOPHYSICAL SUBCONSULTANT'S REPORT
DATED MARCH 1988

GEOPHYSICAL SEARCH
FOR ELEVEN ABANDONED IRRIGATION WELLS
MOFFETT NAVAL AIR STATION
SUNNYVALE, CALIFORNIA

Second Phase

Prepared for:

KENNEDY/JENKS/CHILTON
657 Howard Street
San Francisco, California 94105

Prepared by:

THE EARTH TECHNOLOGY CORPORATION
3777 Long Beach Boulevard
Long Beach, California 90807

Project No. 87-403

March 1988

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1.0 INTRODUCTION

This report presents the results of the Second Phase geophysical search for eleven additional buried abandoned irrigation wells at Moffett Naval Air Station near Sunnyvale, California. Generalized well locations based on historical data are shown on Figure 1. The objective of the project was to use surface geophysical methods to search for geophysical anomalies which may represent locations of the buried abandoned wells. The same general procedures previously used for the First Phase study (Earth Technology report to Kennedy/Jenks/Chilton dated October, 1987) were followed during the present phase. The work was authorized by Kennedy/Jenks/Chilton contract number K/J/C 866078.13-G-93, Work Authorization No. 2. Field work was done during three periods: November 5-December 7, 1987, December 21-23, 1987, and January 11-18, 1988. Field work was conducted in accordance with the Kennedy/Jenks/Chilton Site Safety Plan and was coordinated by their employees, Mr. Brian Schroth and Mr. Keith Beury.

The technical rationale for using surface geophysical techniques was that they should be useful methods for locating buried wells because the wells were probably constructed from steel (ferrous) pipe. Three complementary geophysical profiling methods were used to increase the possibility of locating the wells. Profiles were obtained using magnetic, electromagnetic induction (EMI), and ground penetrating radar (GPR) methods.

Magnetic surveys measure the earth's magnetic field, which is disturbed by buried ferrous metal.

EMI surveys use the principal of electromagnetic induction to measure soil conductivity. Conductivity changes can be caused by variable geologic features (for example, groundwater zones, shallow rock, faults/fracture zones) or buried electrically conductive objects (for example, steel pipe).

GPR surveys use high frequency (MHz) electromagnetic waves to locate subsurface contrasts in dielectric properties. Dielectric changes can be caused by variable geologic features or buried conductive objects (such as steel pipe).

Each of these methods, therefore, is potentially able to locate buried steel well casing because it represents a magnetic/conductive/dielectric contrast relative to the surrounding soils.

During the First Phase study (Earth Technology, 1987) the three chosen geophysical techniques were able to locate the well at site SW-23A1 and a buried manhole cover at site SW-14C. However, it should be noted that the lack of a particular type of anomaly does not necessarily indicate that a well is not present. Any of the three geophysical techniques could fail to detect a buried irrigation well for a number of reasons. For example, the well would not be detected if, as sometimes may happen, the well is not located within the survey area. Nor would it be detected if it is buried deeper than the effective range of the instrument or if the physical properties of the well do not differ greatly from the surroundings. The limiting depth is about 15 ft feet for the EMI and probably 8 to 10 feet for the GPR. The penetration of the GPR is highly dependent on the electrical conductivity of the ground; wet clay can render GPR ineffective. Magnetic detection depends on the magnetic strength and depth of the target. If there is no iron in the well casing, it will not be detected. Detection by any of the techniques can be made unreliable by background noise caused especially by things like scrap metal, metal fences, cars, power lines, etc. The use of three complementary techniques greatly improves the likelihood of detection.

2.0 SUMMARY OF RESULTS

Several geophysical anomalies that might represent the abandoned irrigation wells were located in seven of the eleven sites (Figures 2 through 13) investigated. The survey data were processed nightly by Earth Technology's field crew. Anomalous zones in each data set were highlighted. Coincident geophysical anomalies that were not caused by obvious cultural effects (such as, underground pipes, street lamps, vehicles, and other known metallic objects) were marked as "Potential Targets" and staked in the field. All interpreted "Potential Targets" are located on magnetic anomalies that are characteristic of subsurface targets with mass equivalent to iron well casing between 650 and 1000 ft in length and 8 to 12 inches in diameter.

The survey data for each technique are shown in site maps in Appendices A through L. The "Potential Targets" shown in Figures 2 through 13 are discussed in Section 7.0. The targets with the highest probability of being the abandoned irrigation well are as follows:

Site ID	Most Probable Targets
SW-1	1,3
SW-1N	No Targets
SW-2	1,3
SW-3	No Targets
SW-6	None recommended
SW-7	1,2
SW-8	None recommended
SW-9	No Targets
SW-10	1,2
SW-11	1
15G01	No Targets
15G02	No Targets

3.0 SURVEY GRID DESIGN

The general locations (Figure 1) of buried irrigation wells were ascertained from a record search conducted by Kennedy/Jenks/Chilton (K/J/C, 1988). These general locations were staked and a circle with a 100 foot radius (centered on the stake) was marked on the ground by Kennedy/Jenks/Chilton before the geophysical investigation began. A center line was drawn through the circle and was marked at 5-foot intervals with pin flags or spray paint. These marks were used to space the profiles along which data were collected. Two additional reference lines, parallel to the center line, were constructed at a distance of 75 feet to either side of the center line. Marks on these three lines were used to align the profiles. A rope was placed perpendicular to the reference lines using the ground markings described above, and measurements were taken at 5-foot intervals. The profiles were labelled from 1 to 39; the stations were numbered with 0 at the center line, positive numbers going in one direction, and negative numbers in the opposite direction.

A different grid geometry was used at three sites. At the original SW-1 site, an east-west rectangle grid was established extending 10 feet north of the base perimeter fence to about 4 feet north of the Freeway 101 right-of-way fence. The grid was about 850 feet long (east-west) and 50 feet wide (north-south).

At sites 15G01 and 15G02, two prospective well locations were marked, about 95 ft apart, because different sources indicated conflicting locations for these two wells. Therefore, the measurement grid was constructed as a north-south ellipse with the G1 and G2 locations on the major axis (Figure 12). During the geophysical survey, the locations were moved about 150 feet to the north. Two circles each with a radius of 100 feet, were constructed and a new grid (Figure 13) was established by extending the existing profile lines from the original G1 and G2 grid. The original grid and the new grid are labelled as the west and east panels, respectively, and can be joined together using the common center line.

Once the grid geometry was constructed at each site, then all possible cultural features (picnic tables, steel drums, cars, airplanes) were removed from the site to reduce their effect on the measured data.

A base map for each site is included in the appendices. The base maps show the original stake location, profile and station locations and identifications, and potentially interfering cultural features (runways, powerlines, underground pipelines, etc.). The magnetic and EMI survey data were contoured to provide the basis for anomaly identification and the detected GPR targets were posted on the base map. The anomalies thought to be caused by nearby cultural features were identified and eliminated as possible "Potential Targets." A summary of the geophysical surveys at each site is shown in Table 1.

TABLE 1. SUMMARY OF GEOPHYSICAL SURVEY ACTIVITIES

Site ID	Description	No. of Mag Stations	Mag Coverage (linear ft)	No. of EMI Stations	EMI Coverage (linear ft)	GPR Coverage (linear ft)
KJC-1	Perimeter Fence	1,881	9,350	0	0*	19,640
KJC-1N	Irrigation Field	1,376	6,475	1,313	6,180	12,945
KJC-2	Apron-Fire Dept.	1,384	6,710	0	0*	13,470
KJC-3	BEQ Building	1,184	5,760	1,180	5,745	10,240
KJC-6	Plane Wash area	1,354	6,680	1,282	6,240	13,420
KJC-7	Galley	1,298	6,200	1,294	6,080	12,480
KJC-8	Apron-Double Hangers	1,369	6,685	0	0*	13,700
KJC-9	Taxiway-Runway	1,378	6,690	1,380	6,710	13,480
KJC-10	Apron-Plane Wash	1,379	6,585	0	0*	13,240
KJC-11	Picnic Area	1,296	6,330	1,290	6,250	12,460
KJC-15	Residential (2 areas)	2,294	11,170	2,195	10,620	22,340
Totals		16,193	78,635	9,934	47,825	157,415

* Note: The difference between the magnetic and EMI survey coverage is explained in Section 7.0.

4.0 MAGNETIC SURVEY

4.1 INSTRUMENTATION

The magnetic data were measured with an EDA proton precession magnetometer/ gradiometer, model OMNI IV. The instrument can measure the earth's total magnetic field and store this information along with profile/station data and the date/time in solid-state memory. The data are automatically transferred to a portable computer for processing and display.

This type of instrument measures the earth's magnetic field with a two-step process. First, an external coil surrounding a sensor that is full of a proton-rich fluid (kerosene) produces a magnetic field perpendicular to the earth's field. This external field polarizes the protons and forces them into alignment. When the external field is removed, the protons precess about the earth's field at the Larmor frequency, which is directly proportional to the strength of the earth's magnetic field. The instrument has a sensitivity of $\pm$ 1 gamma.

4.2 DATA ACQUISITION

The magnetic data were obtained along every accessible profile line within the grid at a site. Several precautions must be taken when collecting magnetic data. All metallic objects must be removed from the operator, and obvious metallic cultural features (scrap iron, cars, etc.) were removed from the survey area (when possible). While taking the readings, the sensors were always oriented toward magnetic north so that the external magnetic field in the sensor was normal to the earth's field. The operator always stood about the same distance away and in the same direction from the sensor while reading data. Only one operator read the data within a base loop.

A noise study was conducted during the First Phase study (Earth Technology, 1987) at site SW-14C. The purpose of this study was to determine the optimum height of the sensors. The closer the sensor is to the target and/or the larger the target, the larger the magnitude of the magnetic anomaly. As the distance (d) between the sensor and target increases, the magnitude of the

reading will decrease as a function of d^{-3} (Brewer, 1973). If the sensor is too close to the ground, surface metal debris (wire, metal hardware, rebar) will dramatically influence the readings and sometimes mask the magnetic anomaly associated with the desired target. The optimum sensor height for the second phase study was determined to be 10 feet.

A base station was established at each site in a location thought to be relatively free from nearby cultural features. Repeated readings were made at the base station every 1.5 to 2 hours during the magnetic survey to determine the rate of instrument and diurnal drift. (Diurnal drift of the earth's field is primarily due to tidal motion of the ionosphere). If not removed during data processing, the drift can distort magnetic anomalies of interest.

4.3 DATA PROCESSING

The processing of total field magnetic survey data consists of two steps. First, the drift rate within a base loop is determined from successive base readings. The drift to be removed from each measurement made between the base readings is calculated by linear interpolation versus time. The average drift rate during this survey was 15 gammas per hour. Second, an arbritary constant value (50,000 gammas) is subtracted from all the drift-corrected readings to reduce the values from five to only three digits. The data are then contoured and important anomalies highlighted. The anomalies caused by cultural features were labelled and removed from consideration. Important anomalies for the second phase study are presented in Appendices A through L.

5.0 ELECTROMAGNETIC INDUCTION SURVEY

5.1 INSTRUMENTATION

Soil conductivity measurements were made with a Geonics EM-31 terrain conductivity meter. The instrument has separate transmitting and receiving coils that act as magnetic dipoles. Small-amplitude eddy currents are induced in the ground when alternating current is applied to the transmitter coil. The resultant, secondary magnetic fields caused by the eddy currents are detected with the receiver coil. The instrument is designed so that the ratio of the received signal to the transmitted primary field is proportional to the soil conductivity. Field measurements are rapid because no direct connection with the ground is required. The meter's sensitivity is $\pm$ 1 mmhos/m.

The EM-31 consists of a 12-foot-long boom containing the transmitter and receiver coils at either end. It is operated by one person. Because of its short coil separation, the instrument gathers data predominantly from near-surface materials. The effective penetration depth, in the normal operating mode (vertical dipoles), is about 15 feet. The instrument was connected to a Polycorder data logger, which stores the soil conductivity data along with the profile/station and date/time data in solid state memory. The data were automatically transferred to a portable computer for processing and display.

5.2 DATA ACQUISITION

The EMI data were obtained along every accessible profile within the grid established at each site. EMI data were not collected at the apron sites SW-2, SW-8, and SW-10 because the metal rebar base within the concrete completely distorted and masked the measurements. EMI data were not collected at Site SW-1 between the base perimeter and Freeway 101 right-of-way fences because the metal fences distorted the data. Precautions similar to those described for the magnetic survey were also taken when collecting the EMI data. While the readings were taken, the sensor was held level with both ends of the boom about three feet above the ground. Measurements were made with

the boom in line with the profile and always pointing in the same direction, regardless of which way the profile was traversed. At every fifth station along the profile, and at obviously anomalous readings, the boom was positioned perpendicular to the profile and the reading noted. This technique can determine the long axis of a narrow conductor, such as a buried pipeline. Only one operator read the data within a base loop.

No noise study is required for the EMI survey.

The magnetic base station established at each site was also used during the EMI survey to determine instrument drift. Repeated readings were made at the base every 1.5 to 2 hours.

5.3 DATA PROCESSING

The method for processing EMI data is similar to the method described for magnetic data. The drift rate is determined from the multiple base readings and is removed from the data. The average drift rate during the survey was 1.5 mmhos/m per hour. The adjusted data are then contoured and anomalies highlighted (Appendices A through L). The anomalies caused by cultural features were labelled and removed from consideration.

6.0 GROUND PENETRATING RADAR SURVEY

6.1 INSTRUMENTATION

GPR data were taken with a Geophysical Survey System, Inc., SIR System 8 ground-penetrating radar. Impulse radar radiates repetitive, short-time duration, electromagnetic pulses into the earth from a broad bandwidth antenna placed very close to the ground surface. The equipment functions as an echo sounding system using radar pulses of only a few nanoseconds to detect and measure location and depth of reflecting discontinuities in the subsurface. Continuous profiles are generated by towing the antenna along a line and displaying the reflected signals on a graphic recorder. To obtain maximum penetration, a 120 MHz antenna was used for this survey. The effective penetration depth at the Moffett sites is estimated to be between 8 and 10 feet. The penetration was limited by a shallow water table and clay in the subsurface.

6.2 DATA ACQUISITION

The GPR data were collected continuously along every accessible profile and halfway between profiles within the grid established at each site. With this spacing, the swaths covered by the antenna housing overlapped on adjacent profiles, thus increasing the probability of detecting a small-diameter well.

As the antenna center passed by the station marks on the profiles, a fiducial mark was electronically placed on the GPR records. These marks were labelled with profile and station numbers and formed the basis for posting locations of radar targets on the base map.

No noise or resolution tests were conducted with the GPR because obtaining maximum penetration depth was the most important factor. The effective penetration depth was not determined quantitatively because a target (pipeline, storage tank) at a known depth was not available. Base stations were not reoccupied because the instrument does not produce numeric values. Thus, the concept of drift does not apply.

6.3 DATA PROCESSING

The GPR data is shown in real time in a graphic format that does not require any drift or other corrections. Anomalies were highlighted on the records and categorized as being small, large, very large, or deep metal targets. Geologic features such as trenches or dipping strata were ignored. The appropriate category symbol for each anomaly was then posted on the site's base map (Appendices A through L). The anomalies caused by known cultural features were labelled and removed from consideration. Anomalies with similar shape were connected if they formed linear features and were labelled as a probable buried cultural feature.

7.0 CONCLUSIONS

The interpretation process consisted of the following steps:

- Anomalies were identified in each of the three geophysical data sets (i.e., GPR, magnetics, and EMI)
- Anomalies associated with obvious cultural features were labelled and then removed from consideration
- Geophysical data sets were compared to find coincident anomalies
- Coincident anomalies were selected as being "Potential Targets" and were ranked at each site.

For the purpose of ranking the "Potential Targets," the magnetic data are considered to be the most diagnostic for these sites. The magnetic survey can respond to targets deeper than the estimated maximum penetration depth (10 feet) of the radar survey. Also, the magnetometer, unlike the GPR, can detect a target without passing directly over it. (Twice as many GPR profiles were obtained at each site to minimize the possibility of missing a well because it was located between profiles.) At several sites, the usefulness of the EMI data was limited by interference from cultural features. Once "Potential Targets" were identified and marked on the map, their locations were also staked in the field.

Several generalized descriptions are used in the following discussion to explain the various observed geophysical anomalies.

MAGNETIC ANOMALIES

All "Potential Targets" are located on large-amplitude magnetic anomalies that are circular in shape. The anomalies consist of a high-low pair of contour line closures that are only 5 to 20 feet apart. The pair is oriented with the low toward magnetic north (ignoring remanence). The lateral location of the source is within the steepest part of the gradient between the high-low pair. This general description represents the ideal magnetic anomaly over a small-diameter, vertical well. Any exception to this general description will be specifically noted for each "Potential Target."

EMI ANOMALIES

The majority of the data primarily respond to nearby cultural features. EMI data were not collected at four sites (SW-1, SW-2, SW-8, and SW-10) because the surrounding cultural features were completely distorting the data.

GPR ANOMALIES

GPR data collected over a buried metal object indicate very strong reflections. The GPR record over the irrigation well found at site 23-A1 during the first phase survey produced a series of narrow dark bands immediately over the well. The majority of the "Potential Targets" did not produce GPR anomalies. This does not preclude the possibility that a well is the source of the magnetic anomaly, because the effective penetration depth of the GPR is no more than 8 to 10 feet and may be much less.

The anomaly identification numbers do not represent a ranking or priority at a site.

POTENTIAL TARGETS

Site SW-1: 7 Targets
Site between Macon Road and Freeway 101 Right-of-Way

The magnetic map does not show any small-area closures except along the east-west, chain-link fence marking the base perimeter. These seven anomalies are centered on the metal fence but are still thought to represent the well because the average fence magnetic high is between 600 and 1,000 gammas and these anomalies range from 1,600 to 2,800 gammas. Therefore, the presence of the fence is contributing to the amplitude of the anomalies, but there must be either additional buried iron at these locations or remanence magnetization of the fence poles to produce these larger amplitude anomalies. There were no metal targets mapped with the GPR.

Targets 1, 2, 3 - These targets produce very characteristic magnetic anomalies that may represent the well. Target 2 is located at the eastern edge of a pair of high magnetic closures. The west closure represents the steel pole marking the high-pressure gas line.

Targets 4, 5, 6, 7 - These targets produce characteristic magnetic anomalies but are elongated in the east-west direction. This deviation from a small-area circular closure may be caused by a superimposed magnetic anomaly from the fence or may represent a buried taget that is not the small-diameter well.

Site SW-1N: No Targets
Site in Irrigated Field, North of KJC-1.

The magnetic map is almost featureless. Only the east-west trending irrigation pipeline on the surface between stations -12 and -16 produced a magnetic anomaly. There were no metal targets mapped with the GPR.

Site SW-2: 4 Targets
Site on Apron Near Fire Dept

The magnetic contour map shows four distinctive anomalies not associated with cultural features. Several magnetic targets were mapped with the GPR.

Target 1 - This target produces extremely characteristic large-amplitude magnetic anomaly that may represent the well. Even though it is located near a north-south trending trench, this target is thought to represent the well because it is not centered on the trench. The GPR data show a metal target at the steepest part of the magnetic gradient.

Target 2 - This target produced a magnetic high-low closure, except that the high is toward magnetic north. This condition can be caused by remanence magnetization of the well casing or by a combination of several anomalies from closely spaced targets, which may not be the well. As with Target 1, this target is not thought to be associated with the trench.

Target 3, 4 - These targets produce low-amplitude and elongated magnetic anomalies. The GPR data show a weak reflector near each anomaly, but these are not considered to be associated with the buried target causing the magnetic anomalies because they are not located near the steep magnetic gradient.

Site SW-3: No Targets
Site at BEQ Building

The magnetic map shows a relatively smooth gradient dipping towards the building. The only features in the map are caused by a steel pole and a street light. No metal targets were mapped with the GPR.

Site SW-6: 2 Targets
Site Within Plane Wash Area

The magnetic map is dominated by the northwest- to north-trending metal fence. The magnetic anomalies along the fence have the same general amplitude and

shape and therefore are not thought to represent the well near the fence (as with site SW-1). No metal targets were mapped with the GPR.

Targets 1, 2 - These targets produce magnetic high-low pairs that may represent the well. EMI data show a low-amplitude anomaly trending north-south roughly centered on the steam pipeline. This EMI and anomaly passes through these two targets. Therefore, the targets may be associated with the pipeline, which generally has no magnetic expression.

Site SW-7: 2 Targets
Site Near Galley Building

The magnetic map shows two anomalies not associated with cultural features. Several metal targets were mapped with the GPR.

Target 1 - This target produces a characteristic magnetic anomaly that may represent the well. The GPR shows a metal target located at the steepest part of the magnetic gradient. The magnetic anomaly is not thought to be associated with the north-south trending storm drain because the magnetic anomaly is circular not linear, as expected from the shape of the drain.

Target 2 - This target produces a characteristic magnetic anomaly that may represent the well. EMI data show a low-amplitude ridge, which may represent a buried pipeline trending north-south through this anomaly. The pipeline must be buried at least 8 feet deep because no metal targets were mapped with the GPR.

Site SW-8: 4 Targets
Site on Apron Near Double Hangers

The magnetic map is very distorted by surrounding cultural features. Several metal targets were mapped with the GPR.

Target 1 - This target produces a magnetic high-low pair that is large-amplitude but is elongated east-west with the high toward magnetic north. Superimposed magnetic anomalies from surrounding cultural features could have caused the elongation, and remanence magnetization of the well casing could cause the high-low reversal. The GPR shows a metal target located within the steepest part of the magnetic gradient.

Target 2 - This target produces a magnetic high-low pair that is elongated east-west and may represent the well. The GPR shows a metal target located within the steepest part of

the magnetic gradient. This target could also be caused by the two nearby, east-west trending buried pipelines. These pipelines do not cause continuous magnetic anomalies along their length but still could be the source of this magnetic anomaly.

Targets 3, 4 - These targets produce large-amplitude magnetic anomalies that may represent the well, but they are centered on the east-west trending trench. These anomalies are thought to be caused by man-made objects within the trench.

Site SW-9: No Targets
Site Between Taxiway and Runway

The magnetic map does not show any features except one that is too small in amplitude to be the well. No metal targets were mapped with the GPR.

Site SW-10: 3 Targets
Site on Apron East of the Plane Wash Area

The magnetic map is very distorted by surrounding cultural features. Several metal targets were mapped by the GPR.

Target 1 - This target produces a magnetic high-low pair that is elongated east-west and may represent the well. The anomaly also may be caused by a probable east-west trending buried pipeline mapped by the GPR. This possible pipeline passes through the magnetic gradient and could cause the elongation of the anomaly.

Targets 2, 3 - These targets produce magnetic high-low pairs that are elongated east-west and may represent the well. Surrounding cultural features could cause the elongation.

Site SW-11: 2 Targets
Site on Baseball Field and Picnic Area

The magnetic map is dominated by the gazebo and the metal fence separating the baseball field from the picnic area. Several metal targets were mapped with the GPR.

Target 1 - This target produces a characteristic magnetic anomaly that may represent the well. The anomaly is thought to represent the well even though it is located on the metal fence that produces a north-south trending magnetic high along its length. If the anomaly was solely caused by the fence end, then the steepest part of the magnetic gradient would be located on the fence

end. Instead, the gradient is located about 15 feet to the south.

Target 2 - This target produces a small-amplitude magnetic high-low pair that may represent the well.

Sites 15G01 and 15G02:

No Targets
Sites Within Residential Area

The magnetic map for the east and west panels and the GPR data show only anomalies caused by cultural features.

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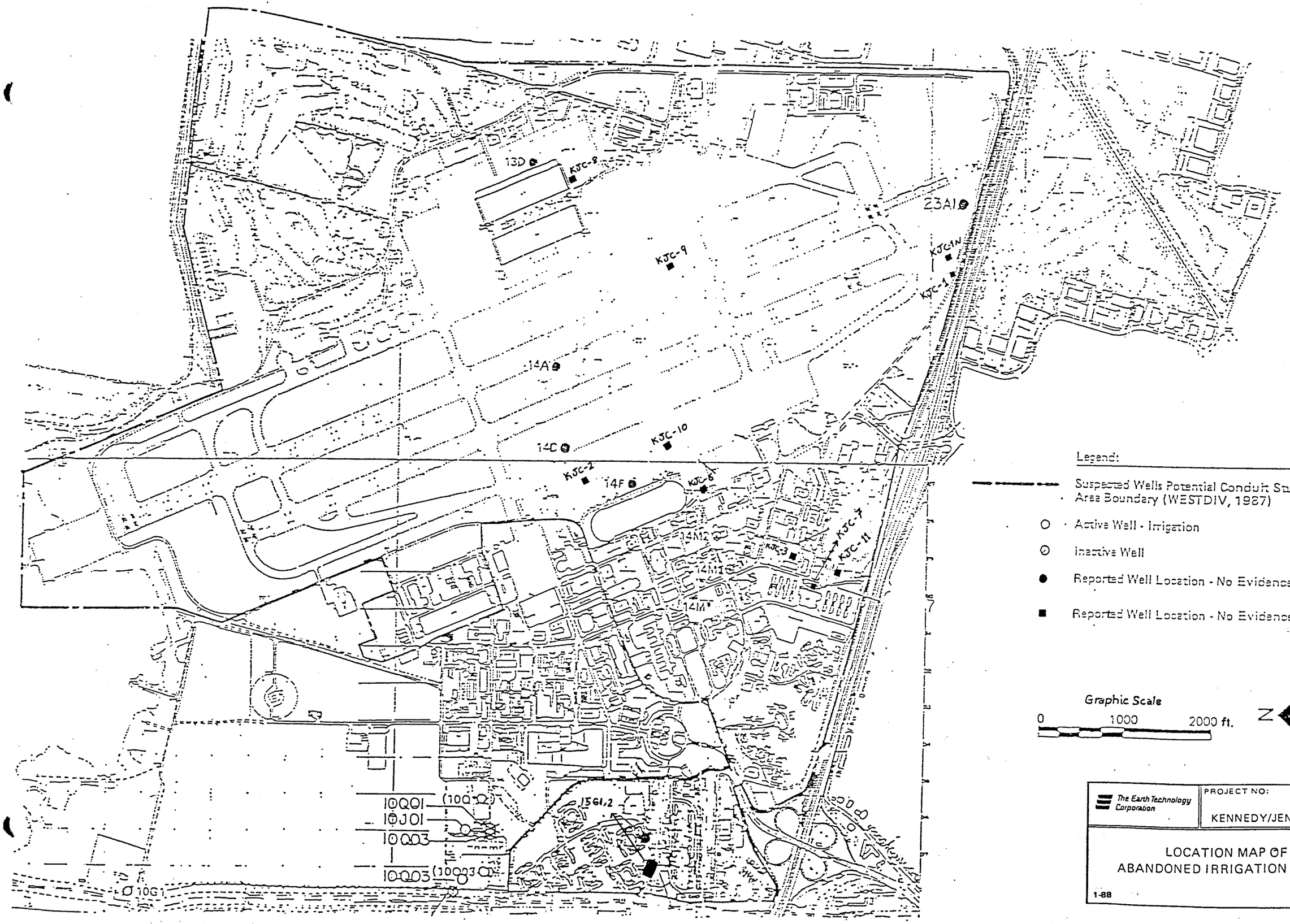
The Earth Technology Corporation, 1987. Geophysical Search for Abandoned Irrigation Wells, Moffett Naval Air Station, Sunnyvale, California: Report to K/J/C, October 1987, project No. 87-403.

WESTDIV, 1987. Draft Work Plan for Potential Conduit Study, Naval Air Station-Moffett Field, prepared by West Central Environmental Section, Western Division, Naval Facilities Engineering Command.



Legend:

- Suspected Wells Potential Conduit Study Area Boundary (WESTDIV, 1987)
- ○ Active Well - Irrigation
- ⊘ Inactive Well
- ● Reported Well Location - No Evidence - Phase 1
- ■ Reported Well Location - No Evidence - Phase 2

Graphic Scale

0 1000 2000 ft.

N

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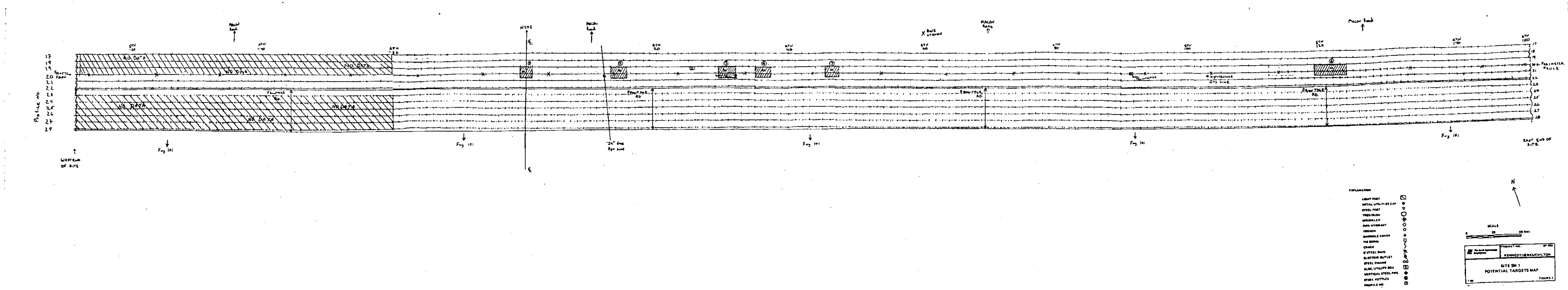
KENNEDY/JENKS/CHILTON

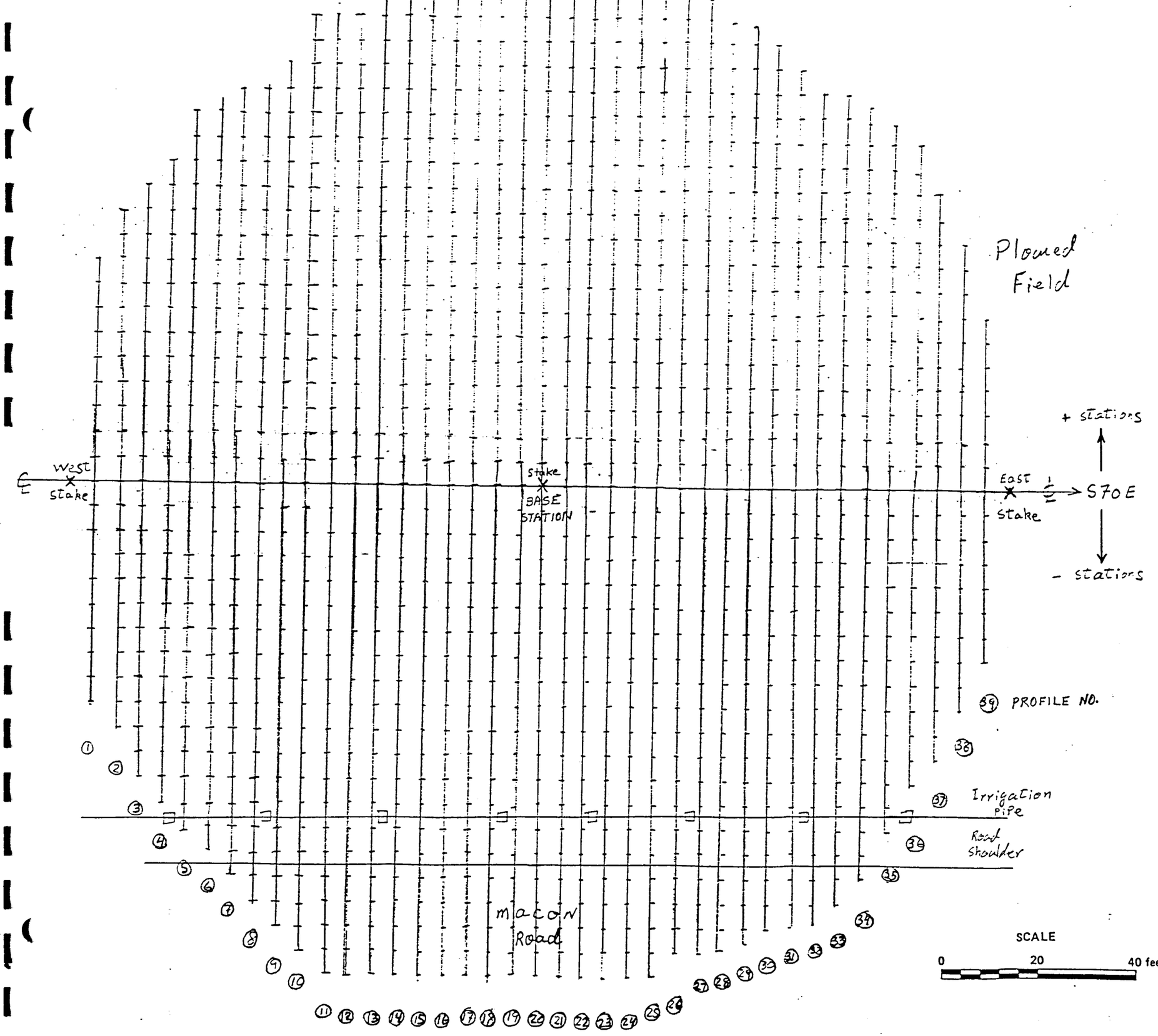
LOCATION MAP OF ABANDONED IRRIGATION WELLS

1-88

FIGURE 1



WEST END OF SITE
EAST END OF SITE
PROFILE NO
NO DATA
Fwy 101
PERIMETER FENCE
N
EXPLANATION
LIGHT POST
METAL UTILITIES CAP
STEEL POST
TREE/BUSH
SPRINKLER
FIRE HYDRANT
TRENCH
MANHOLE COVER
TIE DOWN
CRACK
STEEL RING
ELECTRIC OUTLET
STEEL CHANNEL
ELEC. UTILITY BOX
VERTICAL STEEL PIPE
STEEL KETTLES
PROFILE NO.
SCALE
0
20
40 feet
PROJECT NO.
KENNEDY/JENKS/CHILTON
SITE SW-1
POTENTIAL TARGETS MAP
FIGURE 2



N

EXPLANATION

A = RADAR, MAGNETIC, EMI RESPONSE
R = RADAR ONLY RESPONSE
M = MAGNETIC ONLY RESPONSE
E = EMI ONLY RESPONSE
1-5 = TARGET PRIORITY RATING

LIGHT POST
METAL UTILITIES CAP
STEEL POST
TREE/BUSH
SPRINKLER
FIRE HYDRANT
TRENCH
MANHOLE COVER
TIE DOWN
CRACK
8' STEEL RING
ELECTRIC OUTLET
STEEL CHAINS
ELEC. UTILITY BOX
VERTICAL STEEL PIPE
STEEL KETTLES
PROFILE NO.

NO TARGETS

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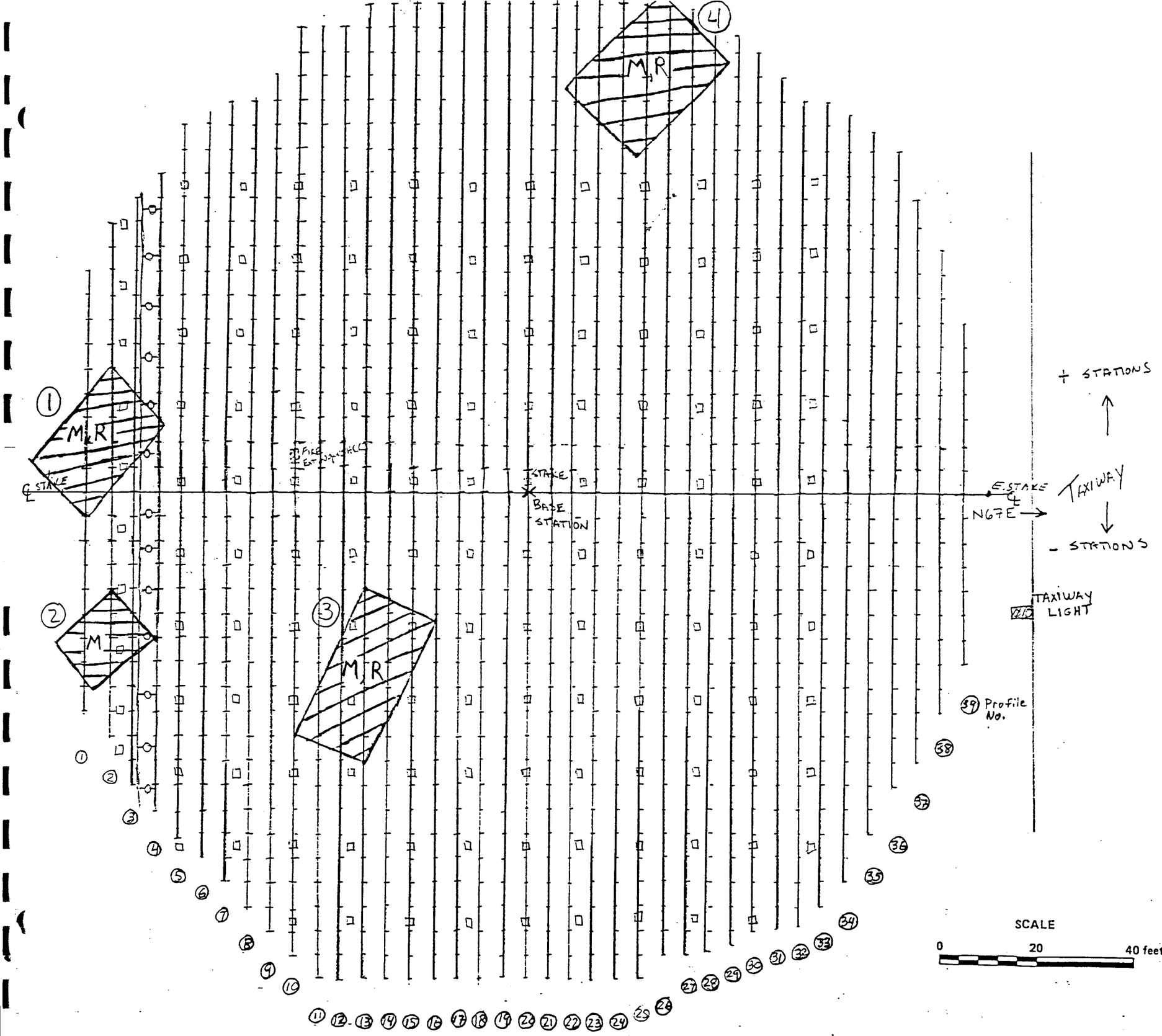
SITE SW-1N

POTENTIAL TARGETS MAP

1-88

FIGURE 3



N

EXPLANATION

A = RADAR, MAGNETIC, EMI RESPONSE
R = RADAR ONLY RESPONSE
M = MAGNETIC ONLY RESPONSE
E = EMI ONLY RESPONSE
1-5 = TARGET PRIORITY RATING

- LIGHT POST
- METAL UTILITIES CAP
- STEEL POST
- TREE/BUSH
- SPRINKLER
- FIRE HYDRANT
- TRENCH
- MANHOLE COVER
- TIE DOWN
- CRACK
- 8" STEEL RING
- ELECTRIC OUTLET
- STEEL CHAINS
- ELEC. UTILITY BOX
- VERTICAL STEEL PIPE
- STEEL KETTLES
- PROFILE NO.

SCALE

0 20 40 feet

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KENNEDY/JENKS/CHILTON

SITE SW-2
POTENTIAL TARGETS MAP

1-88

FIGURE 4

BUILDING

PLANTER

Concrete Storage

3 WATER COVERS

STEEL STORM DRAIN

STONE TRASH BARREL

STEEL ELEC. COVER

Planter

PLANTER

PLANTER

N

+ stations

N. STAKE

N15E

℄ BASE STATION

- stations

℄ S. STAKE

STAKE

GRASS

BBQ BUILDING

CONCRETE

ASPHALT

2 WATER COVERS

PROFILE NO.

PLANTER

planter

WATER COVER

STEEL ELEC. COVER

CONCRETE

ACTIVE WELL

ASPHALT ROAD

EXPLANATION

LIGHT POST	
METAL UTILITIES CAP	●
STEEL POST	▽
TREE/BUSH	
SPRINKLER	✳
FIRE HYDRANT	◇
TRENCH	○
MANHOLE COVER	▲
TIE DOWN	□
CRACK	
8" STEEL RING	
ELECTRIC OUTLET	
STEEL CHAINS	
ELEC. UTILITY BOX	E
VERTICAL STEEL PIPE	◆
STEEL KETTLES	Ⓚ
PROFILE NO.	①

NO TARGETS

SCALE

0 20 40 feet

The Earth Technology Corporation

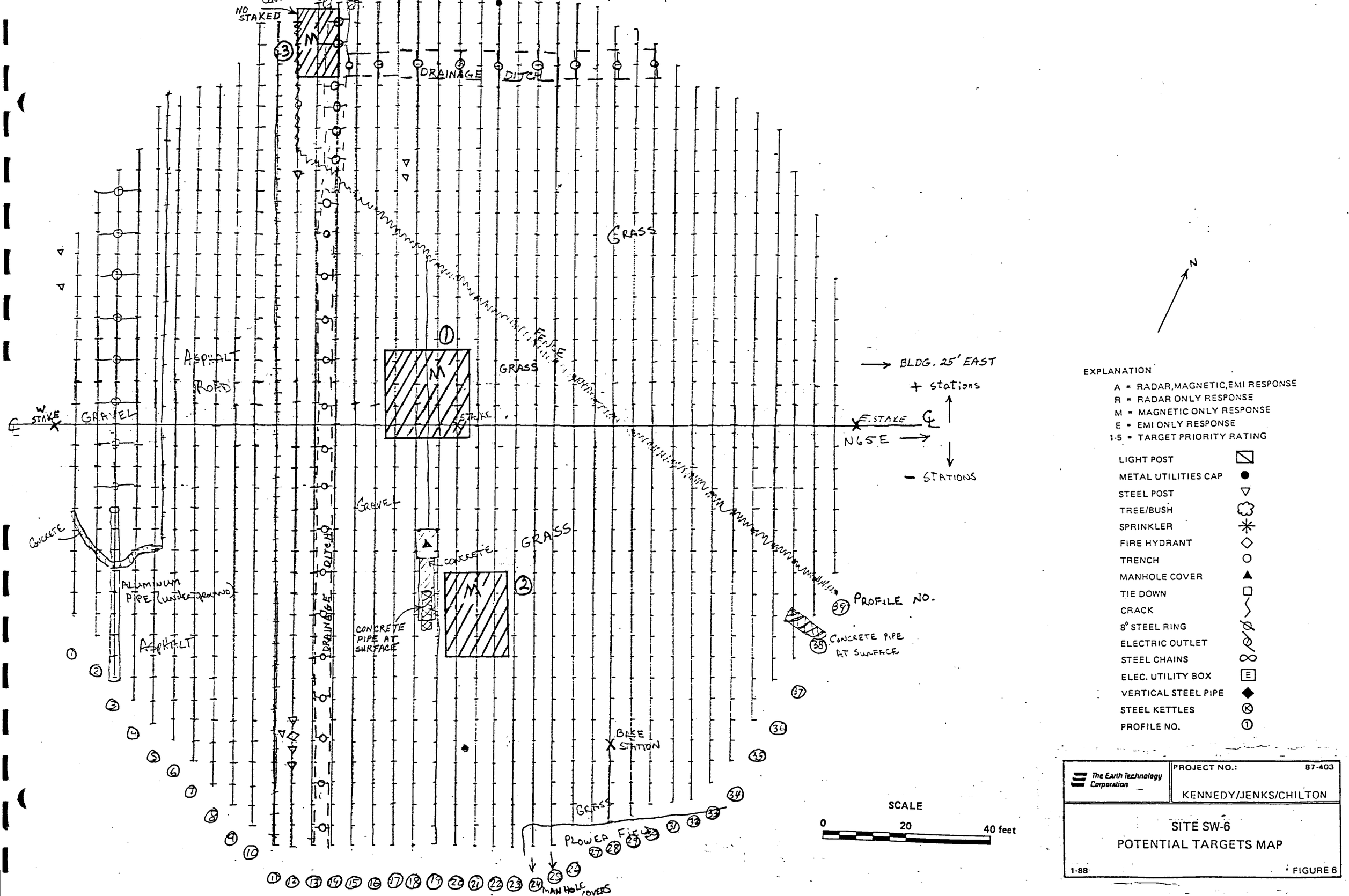
PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-3
POTENTIAL TARGETS MAP

1-88

FIGURE 5



The Earth Technology Corporation

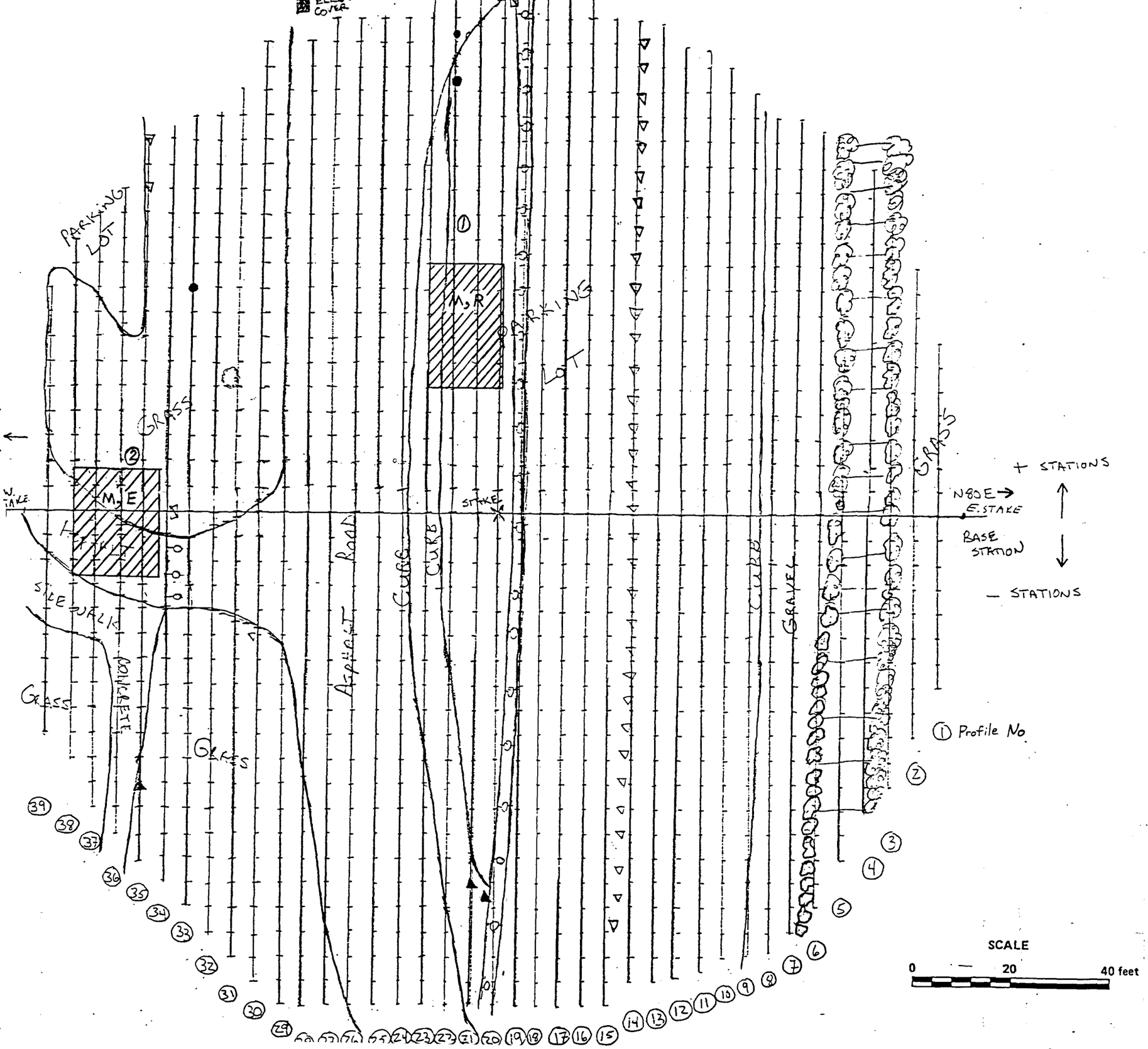
PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-6
POTENTIAL TARGETS MAP

1-88

FIGURE 6



N

EXPLANATION

A = RADAR, MAGNETIC, EMI RESPONSE
R = RADAR ONLY RESPONSE
M = MAGNETIC ONLY RESPONSE
E = EMI ONLY RESPONSE
1-5 = TARGET PRIORITY RATING

LIGHT POST	▨
METAL UTILITIES CAP	●
STEEL POST	▽
TREE/BUSH	✿
SPRINKLER	✳
FIRE HYDRANT	◇
TRENCH	○
MANHOLE COVER	▲
TIE DOWN	□
CRACK	⌇
8" STEEL RING	⌀
ELECTRIC OUTLET	⌀
STEEL CHAINS	∞
ELEC. UTILITY BOX	E
VERTICAL STEEL PIPE	◆
STEEL KETTLES	⊗
PROFILE NO.	①

The Earth Technology Corporation

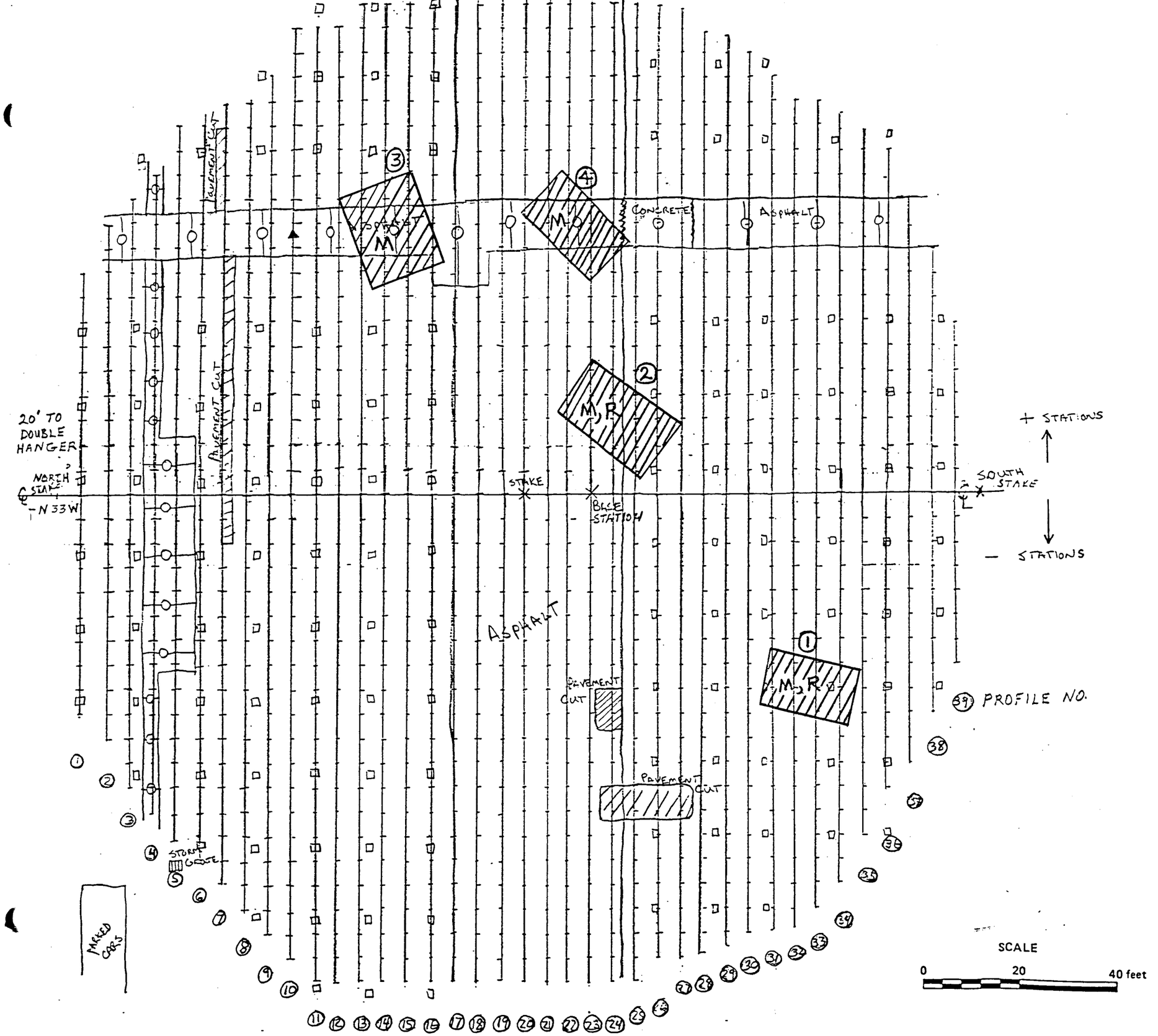
PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-7
POTENTIAL TARGETS MAP

1-88

FIGURE 7



EXPLANATION

A = RADAR, MAGNETIC, EMI RESPONSE
R = RADAR ONLY RESPONSE
M = MAGNETIC ONLY RESPONSE
E = EMI ONLY RESPONSE
1-5 = TARGET PRIORITY RATING

LIGHT POST	▨
METAL UTILITIES CAP	●
STEEL POST	▽
TREE/BUSH	✿
SPRINKLER	✳
FIRE HYDRANT	◇
TRENCH	○
MANHOLE COVER	▲
TIE DOWN	□
CRACK	⟋
8" STEEL RING	⌀
ELECTRIC OUTLET	⌀
STEEL CHAINS	∞
ELEC. UTILITY BOX	E
VERTICAL STEEL PIPE	◆
STEEL KETTLES	Ⓚ
PROFILE NO.	①

SCALE
0 20 40 feet

The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-8
POTENTIAL TARGETS MAP

1-88

FIGURE 8

Edge of Runway ≈100ft West of Site 9

Edge of Asphalt Runway Shoulder ≈50' West of Site 9

N

- stations

S STAKE

STAKE

BASE STATION

N STAKE

℄ PARALLEL TO RUNWAYS

N 23°W

+ stations

39 PROFILE NO.

EXPLANATION

A = RADAR, MAGNETIC, EMI RESPONSE
R = RADAR ONLY RESPONSE
M = MAGNETIC ONLY RESPONSE
E = EMI ONLY RESPONSE
1-5 = TARGET PRIORITY RATING

LIGHT POST	▨
METAL UTILITIES CAP	●
STEEL POST	▽
TREE/BUSH	✿
SPRINKLER	✳
FIRE HYDRANT	◇
TRENCH	○
MANHOLE COVER	▲
TIE DOWN	□
CRACK	⟩
8" STEEL RING	⊘
ELECTRIC OUTLET	⊘
STEEL CHAINS	∞
ELEC. UTILITY BOX	E
VERTICAL STEEL PIPE	◆
STEEL KETTLES	Ⓚ
PROFILE NO.	①

NO TARGETS

SCALE

0 20 40 feet

The Earth Technology Corporation

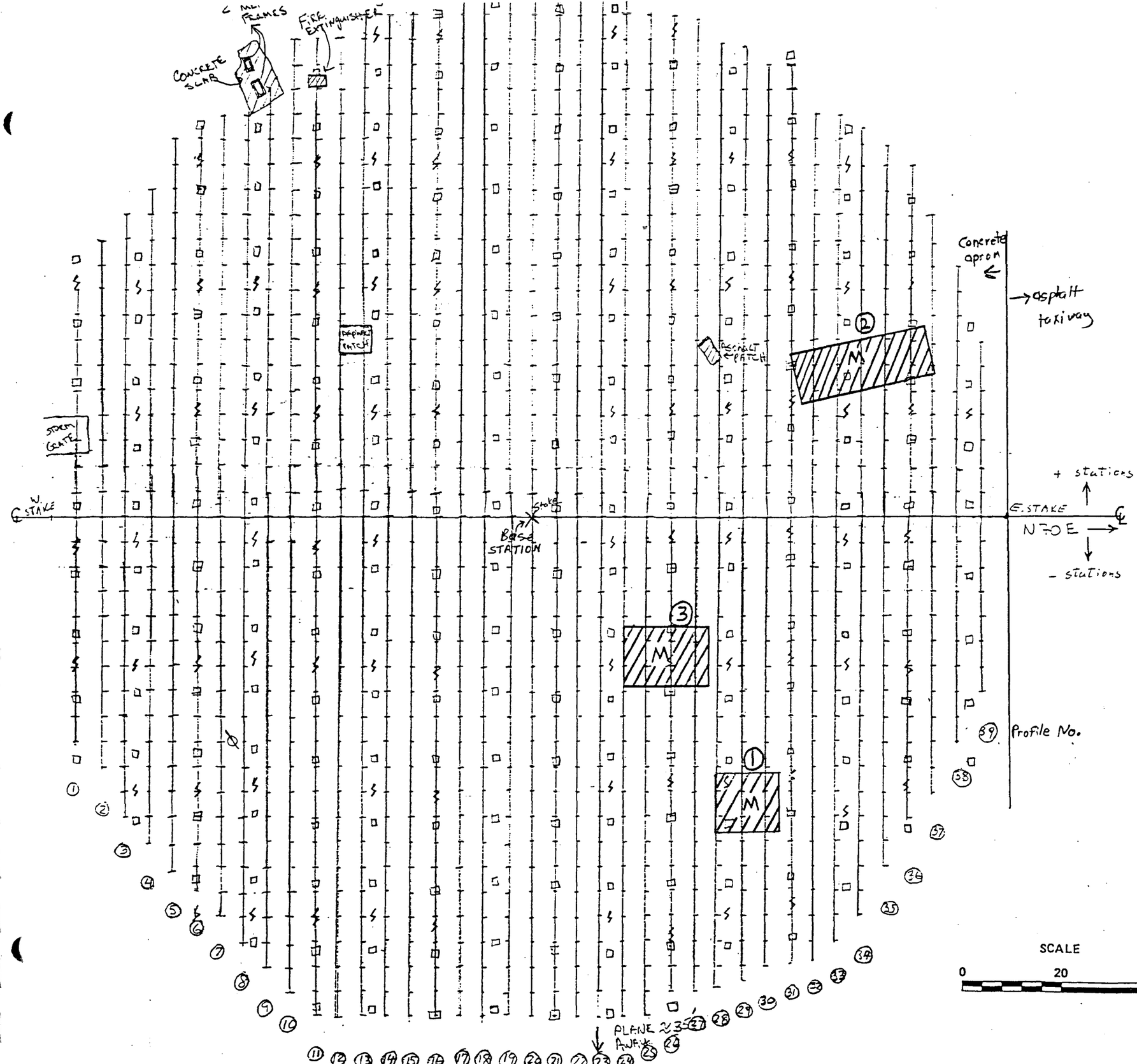
PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-9
POTENTIAL TARGETS MAP

1-88

FIGURE 9



The Earth Technology Corporation

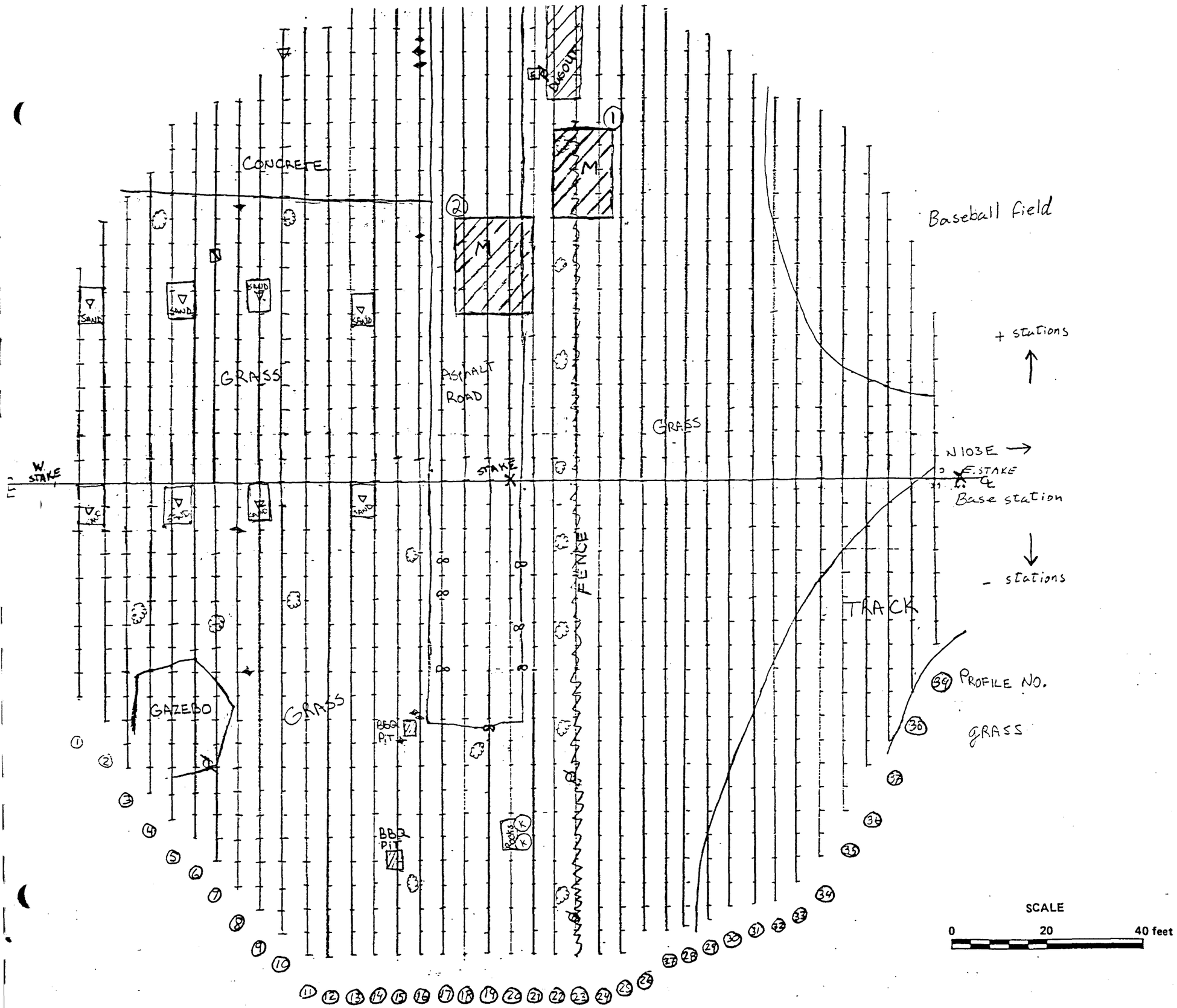
PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-10
POTENTIAL TARGETS MAP

1-88

FIGURE 10



N

EXPLANATION

A = RADAR, MAGNETIC, EMI RESPONSE
R = RADAR ONLY RESPONSE
M = MAGNETIC ONLY RESPONSE
E = EMI ONLY RESPONSE
1-5 = TARGET PRIORITY RATING

- LIGHT POST
- METAL UTILITIES CAP
- STEEL POST
- TREE/BUSH
- SPRINKLER
- FIRE HYDRANT
- TRENCH
- MANHOLE COVER
- TIE DOWN
- CRACK
- 8" STEEL RING
- ELECTRIC OUTLET
- STEEL CHAINS
- ELEC. UTILITY BOX
- VERTICAL STEEL PIPE
- STEEL KETTLES
- PROFILE NO.

SCALE
0 20 40 feet

The Earth Technology Corporation

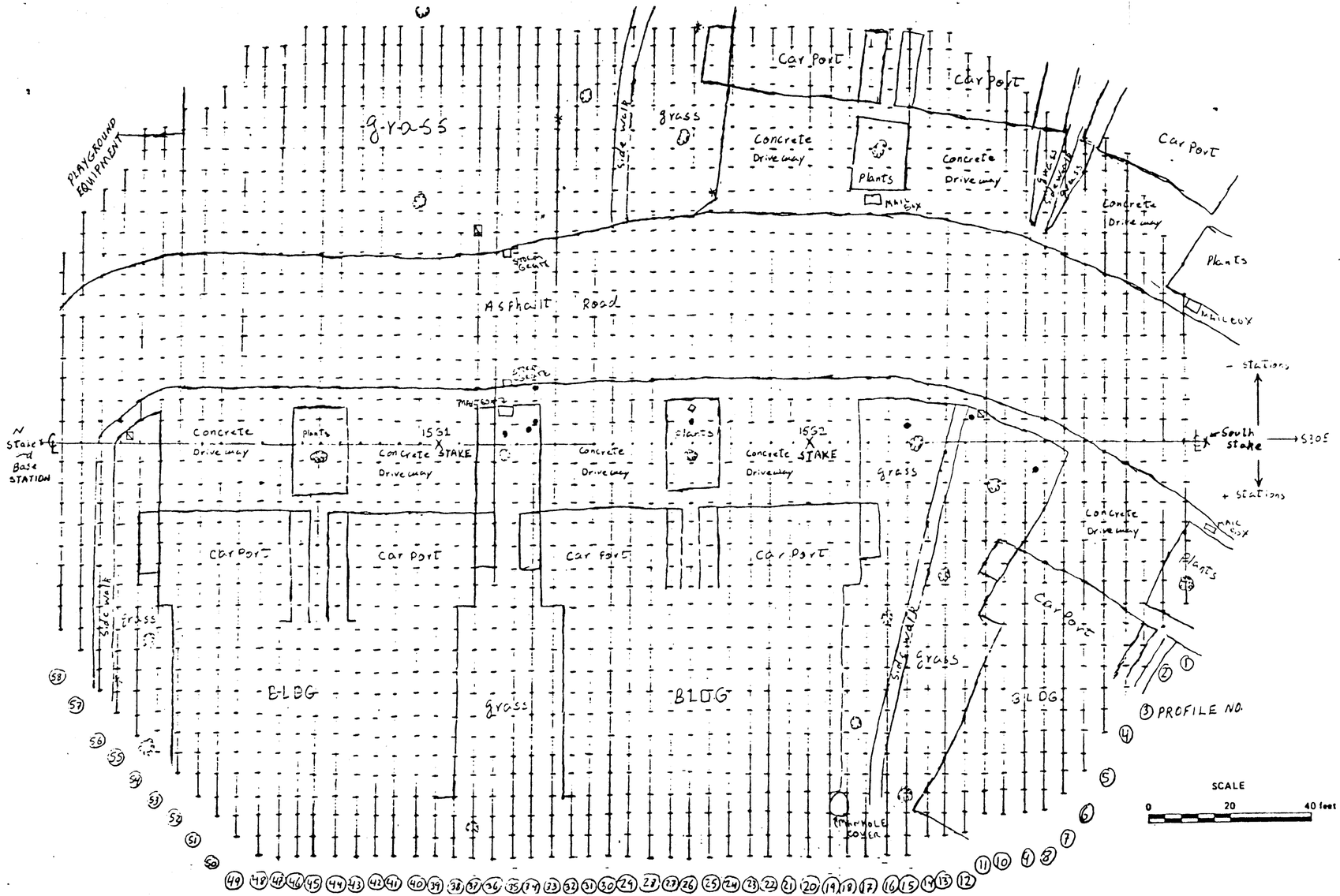
PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-11
POTENTIAL TARGETS MAP

1-88

FIGURE 11



N

EXPLANATION

A = RADAR, MAGNETIC, EMI RESPONSE
R = RADAR ONLY RESPONSE
M = MAGNETIC ONLY RESPONSE
E = EMI ONLY RESPONSE
1-5 = TARGET PRIORITY RATING

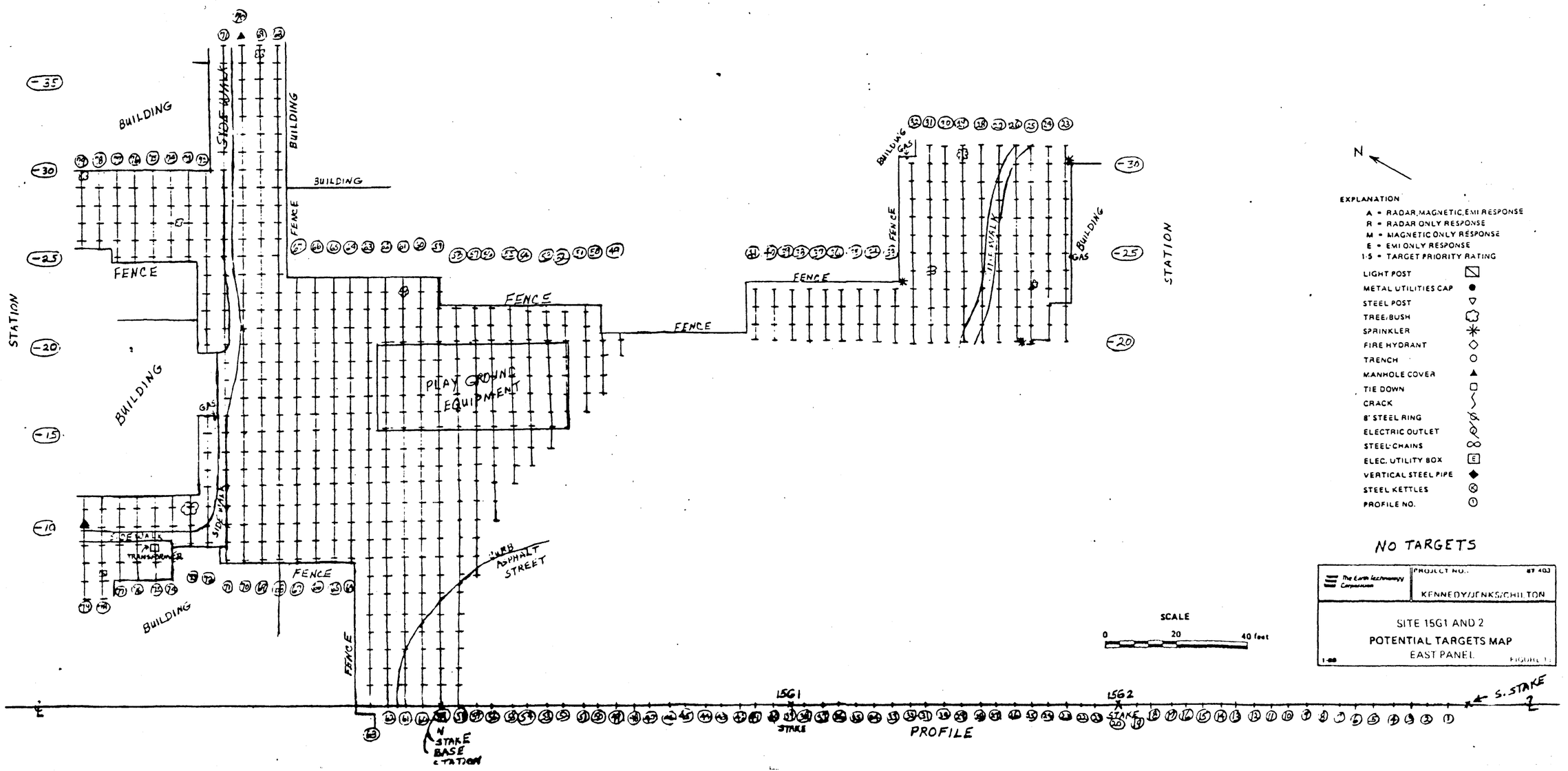
LIGHT POST	▨
METAL UTILITIES CAP	●
STEEL POST	▽
TREE/BUSH	⬡
SPRINKLER	✳
FIRE HYDRANT	◇
TRENCH	○
MANHOLE COVER	▲
TIE DOWN	□
CRACK	∿
8" STEEL RING	⌀
ELECTRIC OUTLET	⌀
STEEL CHAINS	∞
ELEC. UTILITY BOX	E
VERTICAL STEEL PIPE	◆
STEEL KETTLES	⊗
PROFILE NO.	①

NO TARGETS

The Earth Technology Corporation	PROJECT NO.: 87-403
	KENNEDY/JENKS/CHILTON

SITE 15G1 AND 2
POTENTIAL TARGETS MAP
WEST PANEL

1-88 FIGURE 12


BUILDING
STEEL POSTS
BUILDING
BUILDING
FENCE
FENCE
FENCE
FENCE
FENCE
STATION
STATION
-35
-30
-25
-20
-15
-10
-30
-25
-20
BUILDING
BUILDING
GAS
PLAY GROUND EQUIPMENT
SIDEWALK
TRANSFORMER
CURB
ASPHALT STREET
BUILDING
GAS
FENCE
SIDEWALK
BUILDING
GAS
N
EXPLANATION
A = RADAR, MAGNETIC, EMI RESPONSE
R = RADAR ONLY RESPONSE
M = MAGNETIC ONLY RESPONSE
E = EMI ONLY RESPONSE
1-5 = TARGET PRIORITY RATING
LIGHT POST
METAL UTILITIES CAP
STEEL POST
TREE/BUSH
SPRINKLER
FIRE HYDRANT
TRENCH
MANHOLE COVER
TIE DOWN
CRACK
8" STEEL RING
ELECTRIC OUTLET
STEEL CHAINS
ELEC. UTILITY BOX
VERTICAL STEEL PIPE
STEEL KETTLES
PROFILE NO.
NO TARGETS
SCALE
0
20
40 feet
PROJECT NO.: 87 403
KENNEDY/JENKS/CHILTON
SITE 15G1 AND 2
POTENTIAL TARGETS MAP
EAST PANEL
FIGURE 1
15G1
STAKE
15G2
STAKE
S. STAKE
N STAKE BASE STATION
PROFILE

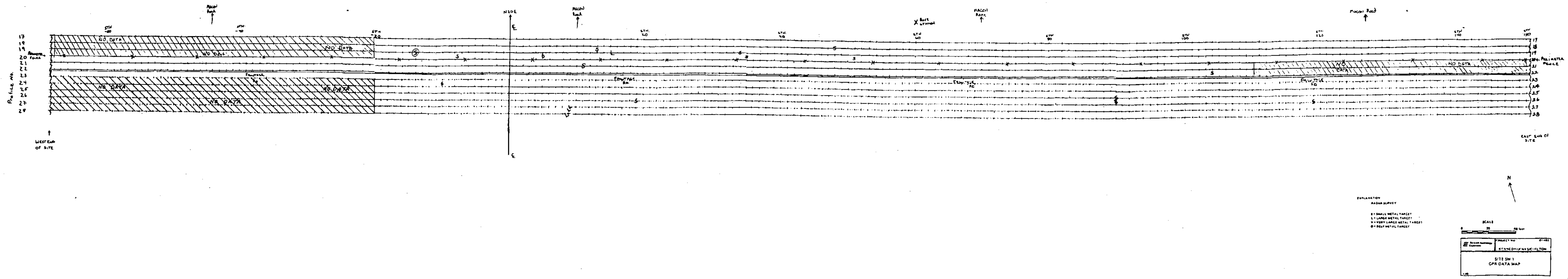
APPENDIX A

SITE SW-1

DATA MAPS

SITE SW-1 -
BASE MAP

- STATIONS
+ STATIONS
BASE STATION
MACON ROAD
MACON ROAD
MACON ROAD
MACON ROAD
PROFILE NO.
PERIMETER FENCE
EXPLANATION
MAGNETIC SURVEY
DRIFT CORRECTED
~50,000 gammas
C.I. = 200 gammas
SCALE
0
20
40 feet
PROJECT NO.
87-083
KENNEDY/JENKS/CHILTON
SITE SW-1
MAGNETIC DATA MAP
1-68

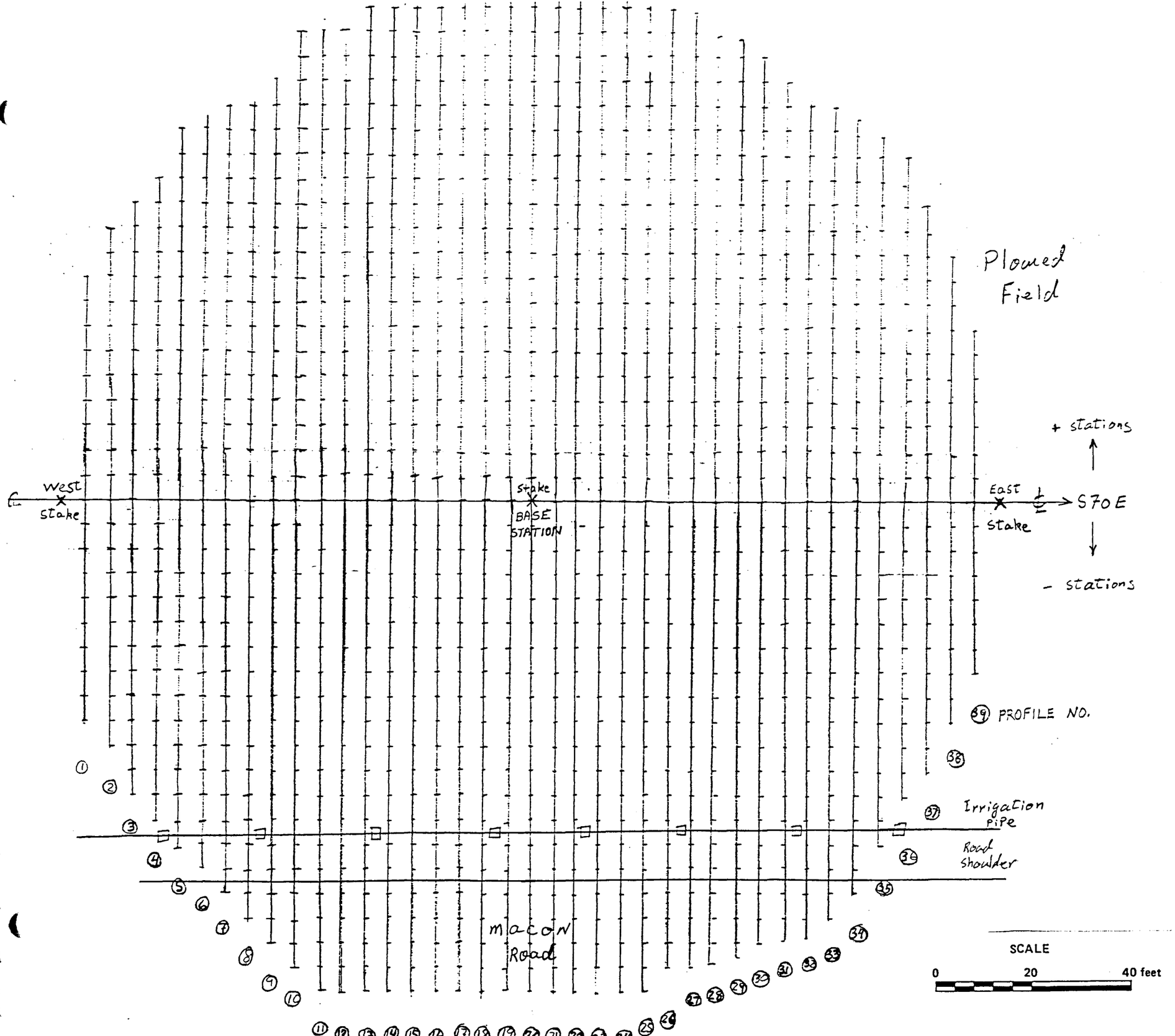


NO DATA
PERIMETER FENCE
WEST END OF SITE
EAST END OF SITE
N
EXPLANATION
RADAR SURVEY
S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
SCALE
0 20 40 feet
KENNEDY/JENKS/CHILTON
SITE SW 1
GPR DATA MAP

APPENDIX B

SITE SW-1N

DATA MAPS



N

EXPLANATION

- LIGHT POST
- METAL UTILITIES CAP
- STEEL POST
- TREE/BUSH
- SPRINKLER
- FIRE HYDRANT
- TRENCH
- MANHOLE COVER
- TIE DOWN
- CRACK
- 8' STEEL RING
- ELECTRIC OUTLET
- STEEL CHAINS
- ELEC. UTILITY BOX
- VERTICAL STEEL PIPE
- STEEL KETTLES
- PROFILE NO.

SCALE

0 20 40 feet

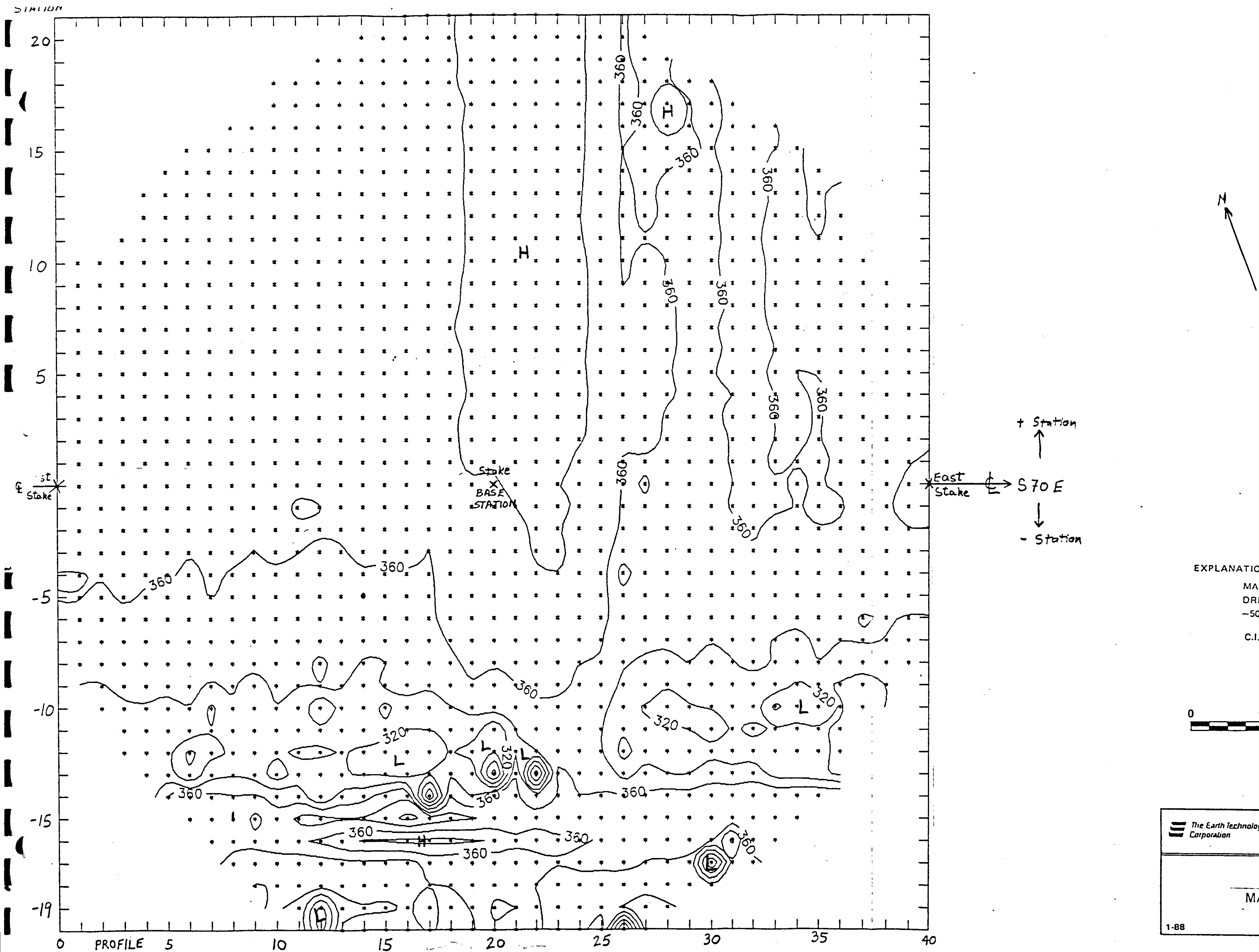
The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-1N
BASE MAP

1-88



EXPLANATION

MAGNETIC SURVEY
DRIFT CORRECTED
−50,000 gammas

C.I. = 20 gammas

SCALE

0 20 40 feet

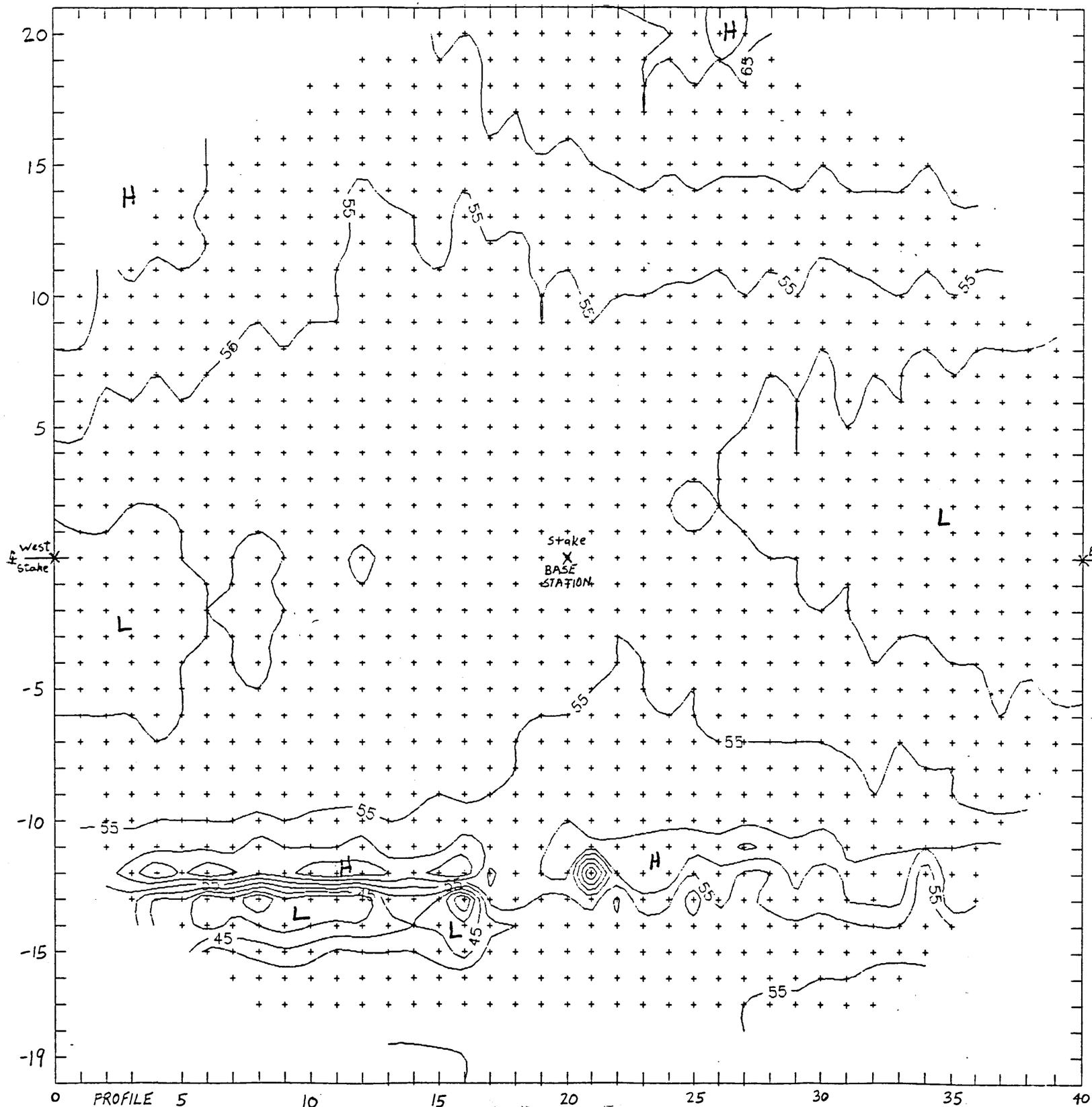
The Earth Technology Corporation

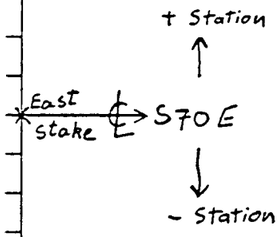
PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-1N
MAGNETIC DATA MAP

1-88





EXPLANATION

ELECTROMAGNETIC INDUCTION SURVEY
DRIFT CORRECTED

C.I. = 5 mmhos/m

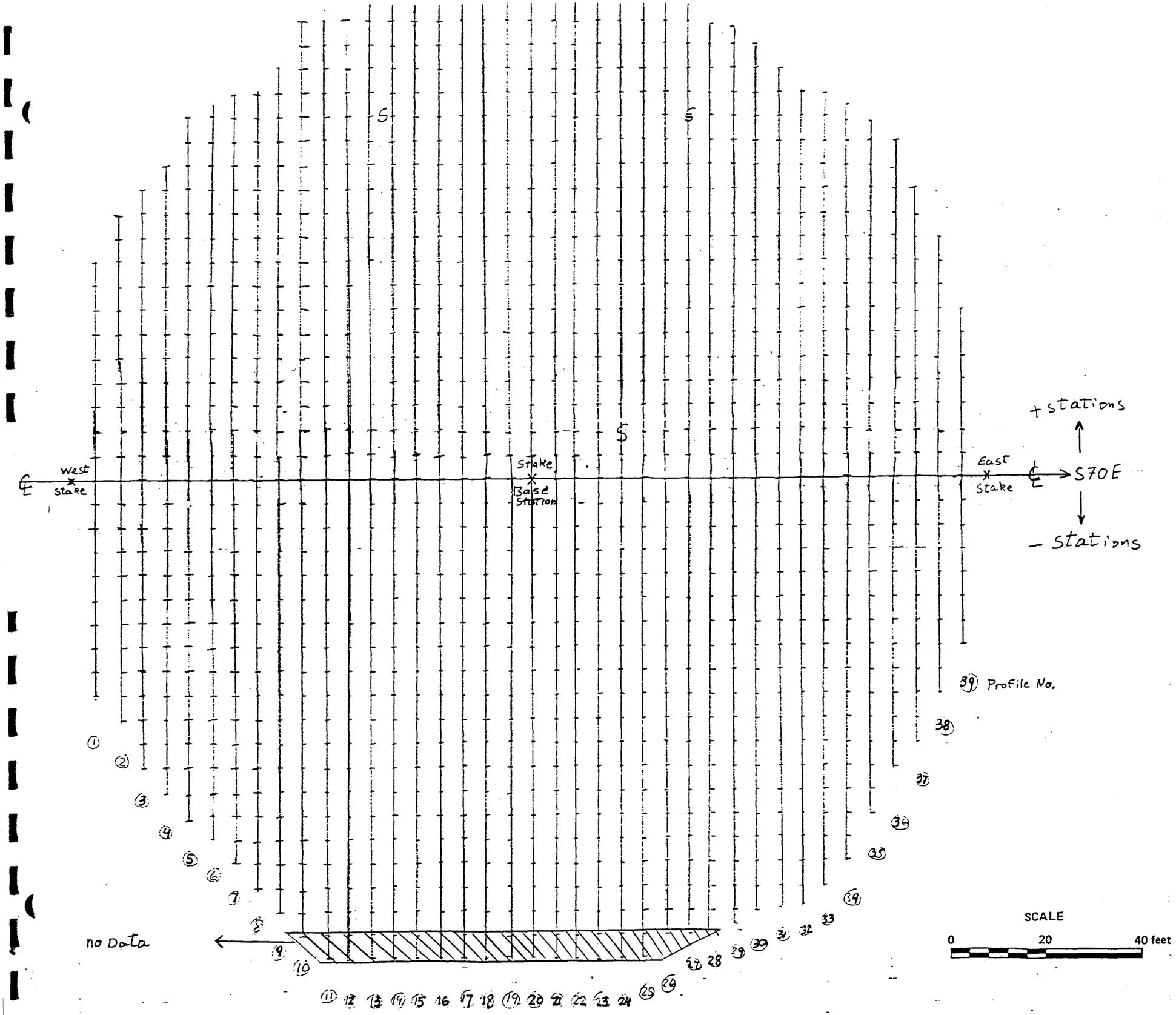
SCALE

0 20 40 feet

The Earth Technology Corporation	PROJECT NO.: 87-403
	KENNEDY/JENKS/CHILTON

SITE SW-1N
EMI DATA MAP

1-88



N

EXPLANATION

RADAR SURVEY

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

SCALE

0 20 40 feet

The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

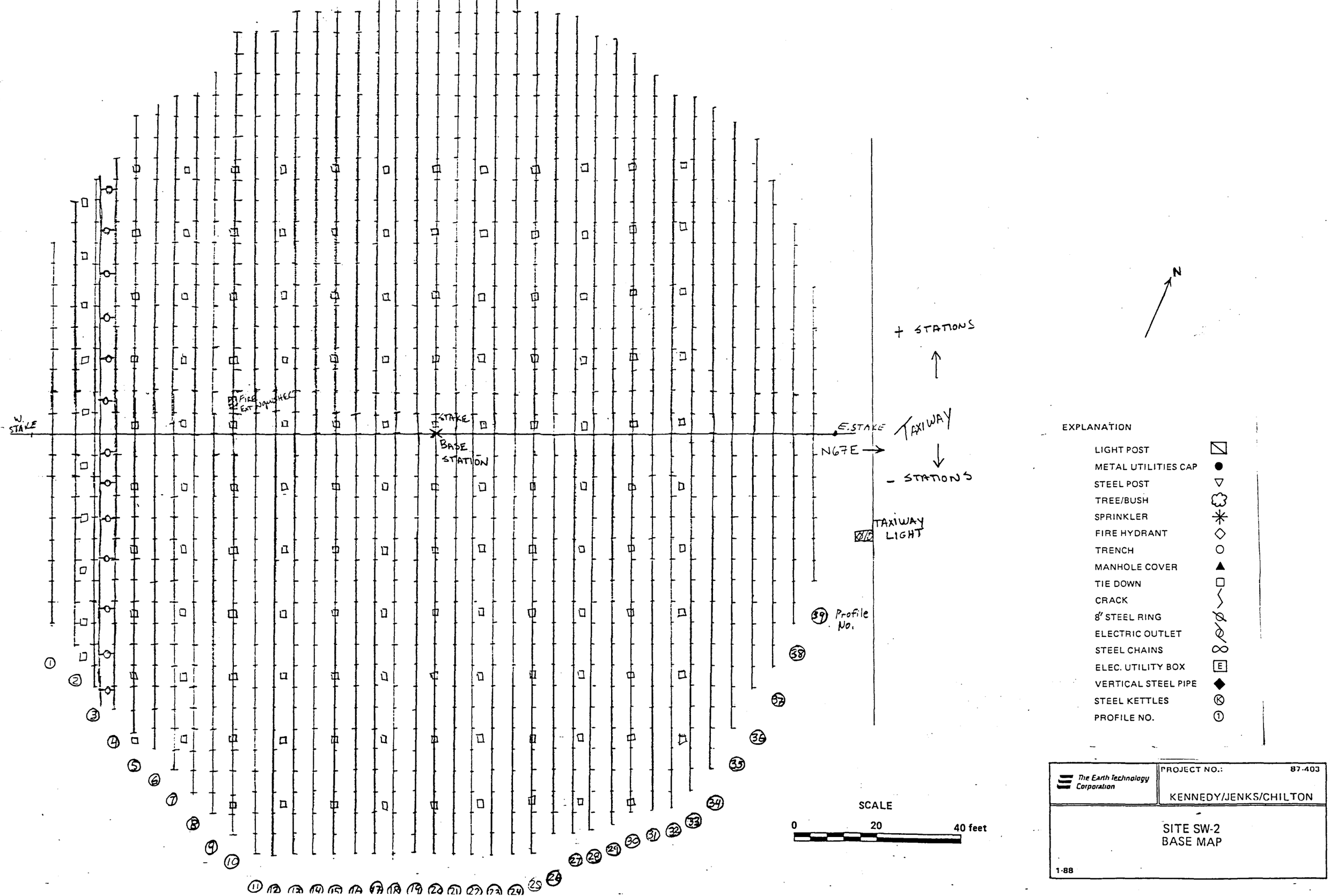
SITE SW-1N
GPR DATA MAP

1-88

APPENDIX C

SITE SW-2

DATA MAPS



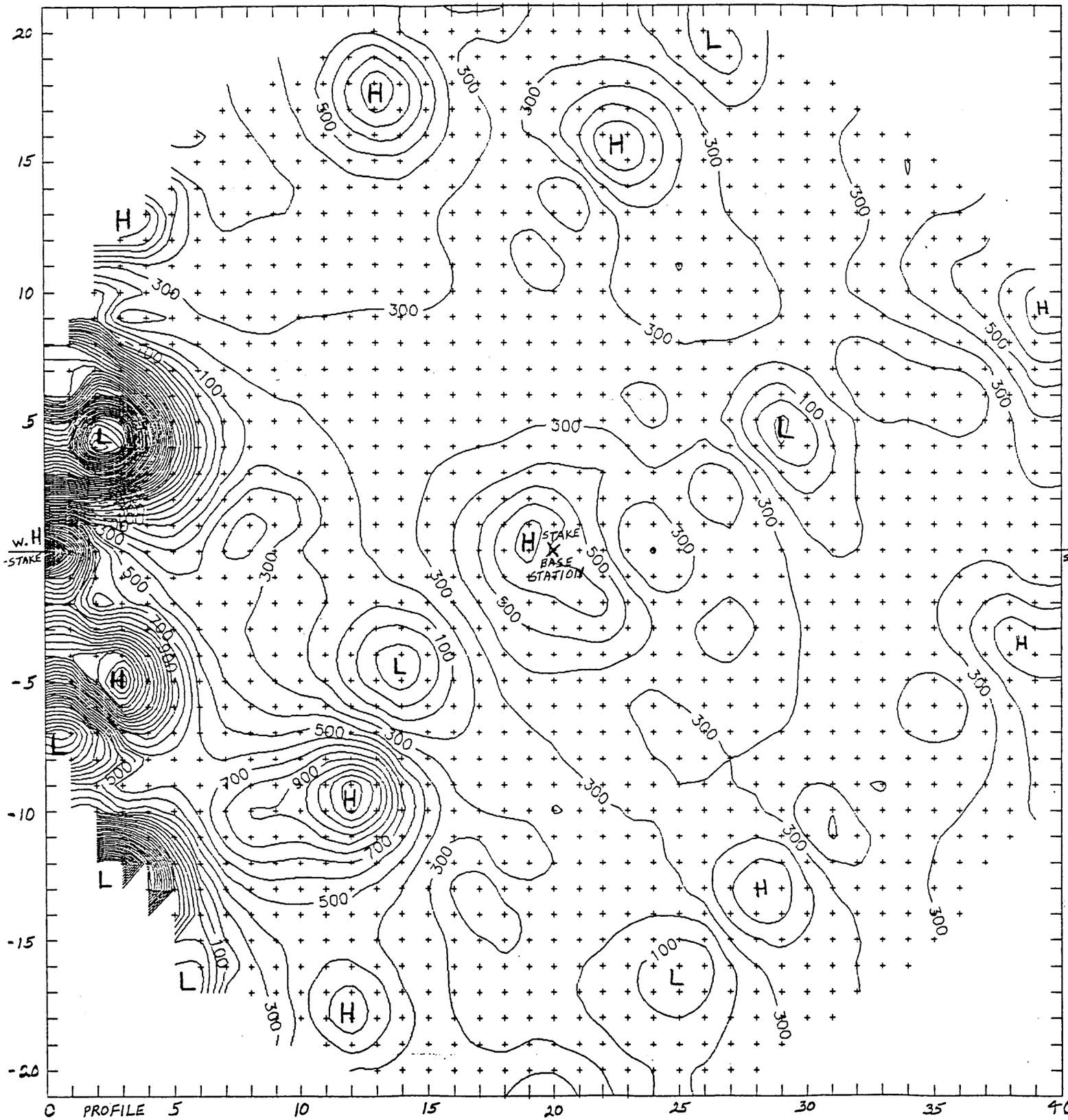
The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-2 BASE MAP

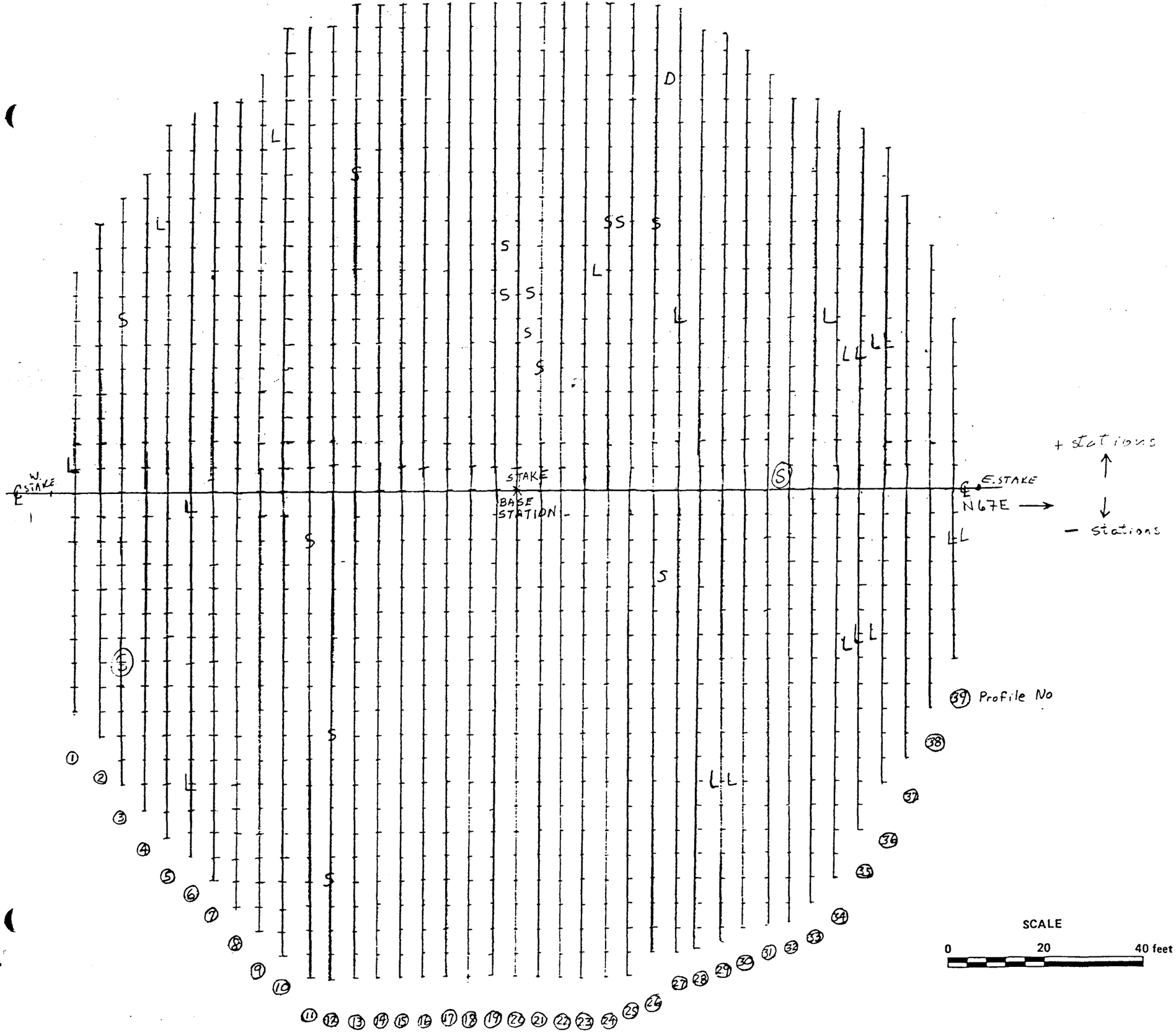
1-88



The Earth Technology Corporation	PROJECT NO.: 87-403
	KENNEDY/JENKS/CHILTON

SITE SW-2
MAGNETIC DATA MAP

1-88



EXPLANATION

RADAR SURVEY

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

SCALE

0 20 40 feet

The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW–2
GPR DATA MAP

1-88

APPENDIX D

SITE SW-3

DATA MAPS

BUILDING

PLANTER

Concrete Stoop

3 WATER COVERS

STEEL STORM BRAKE

STONE TRASH BARREL

STEEL ELEC. COVER

Planter

PLANTER

N

+ stations

N. STAKE N 15 E

℄ BASE STATION

- stations

℄ S. STAKE

STAKE

GRASS

BEQ BUILDING

CONCRETE

ASPHALT

2 WATER COVERS

PROFILE NO.

Planter

Planter

Planter

WATER COVER

STEEL ELEC. COVER

CONCRETE COVER

ACTIVE WELL

ASPHALT ROAD

EXPLANATION

LIGHT POST	
METAL UTILITIES CAP	●
STEEL POST	▽
TREE/BUSH	
SPRINKLER	✳
FIRE HYDRANT	◇
TRENCH	○
MANHOLE COVER	▲
TIE DOWN	□
CRACK	
8" STEEL RING	
ELECTRIC OUTLET	
STEEL CHAINS	
ELEC. UTILITY BOX	E
VERTICAL STEEL PIPE	◆
STEEL KETTLES	
PROFILE NO.	①

SCALE

0 20 40 feet

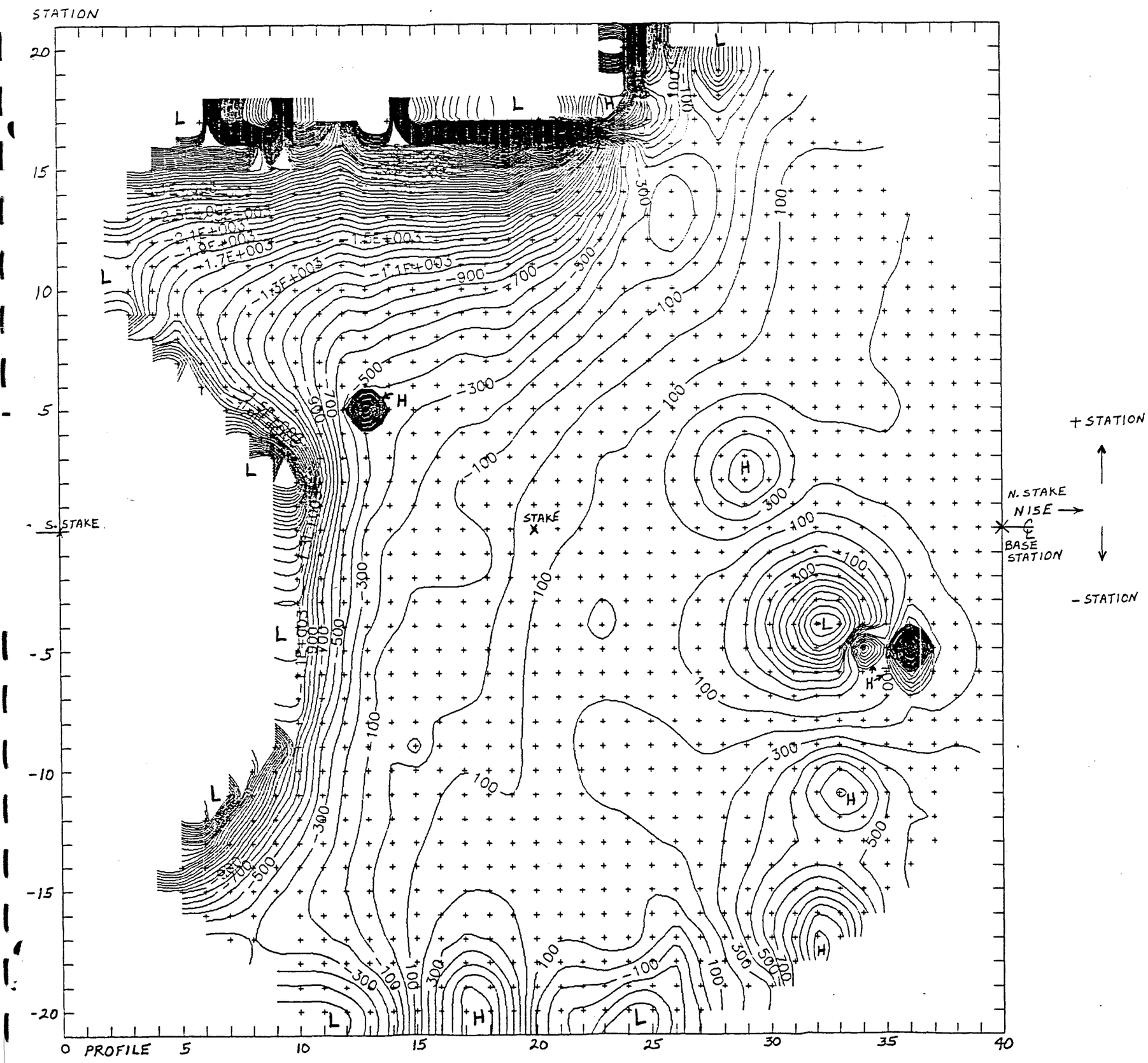
The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-3
BASE MAP

1-88



EXPLANATION

MAGNETIC SURVEY
DRIFT CORRECTED
-50,000 gammas

C.I. = 100 gammas

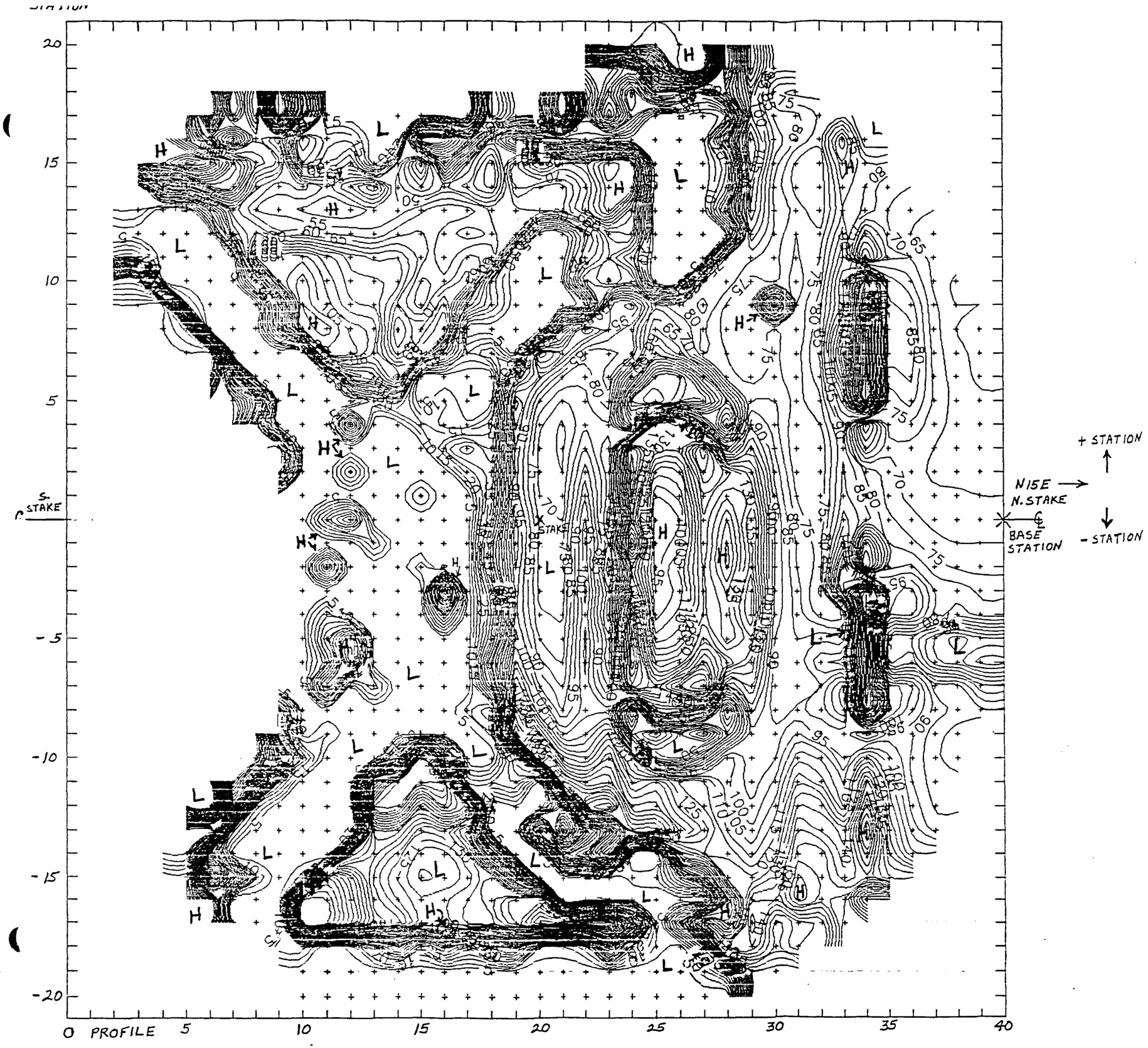
SCALE

0 20 40 feet

The Earth Technology Corporation	PROJECT NO.: 87-403
	KENNEDY/JENKS/CHILTON

SITE SW-3
MAGNETIC DATA MAP

1-88.



EXPLANATION

ELECTROMAGNETIC INDUCTION SURVEY
DRIFT CORRECTED

C.I. = 5 mmhos/m

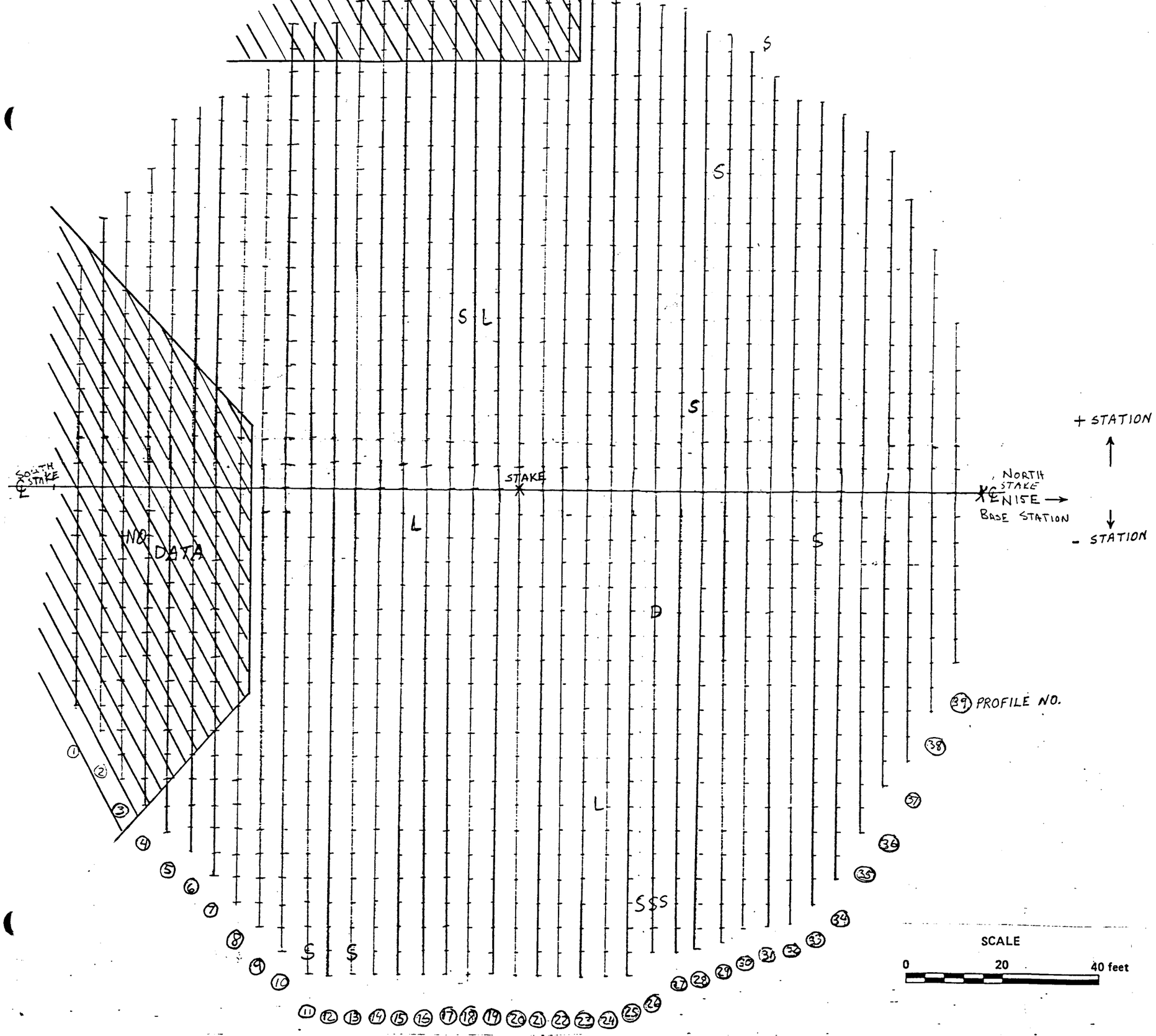
SCALE

0 20 40 feet

The Earth Technology Corporation	PROJECT NO.: 87-403
	KENNEDY/JENKS/CHILTON

SITE SW-3
EMI DATA MAP

1-88



The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

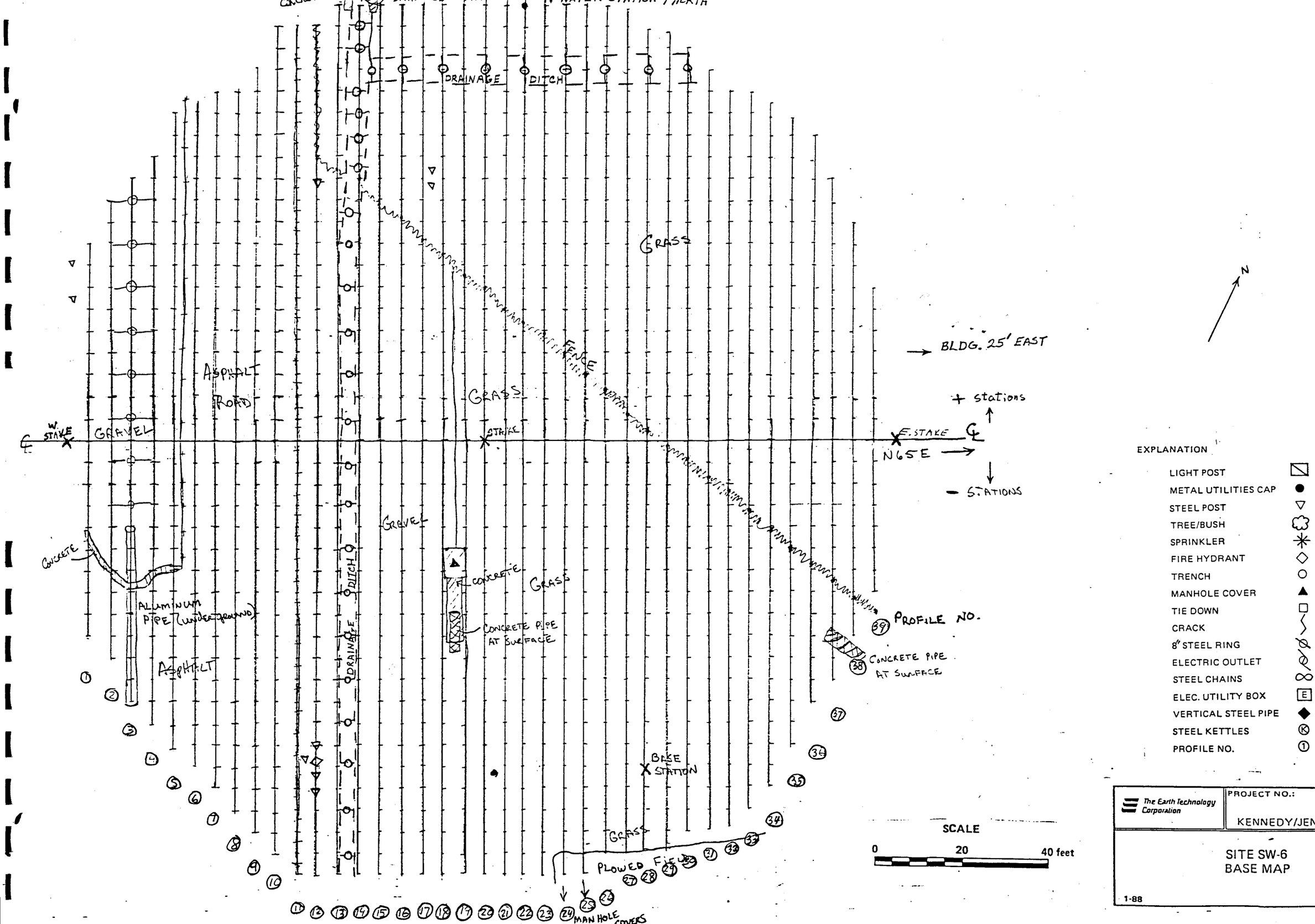
SITE SW-3
GPR DATA MAP

1-88

APPENDIX E

SITE SW-6

DATA MAPS



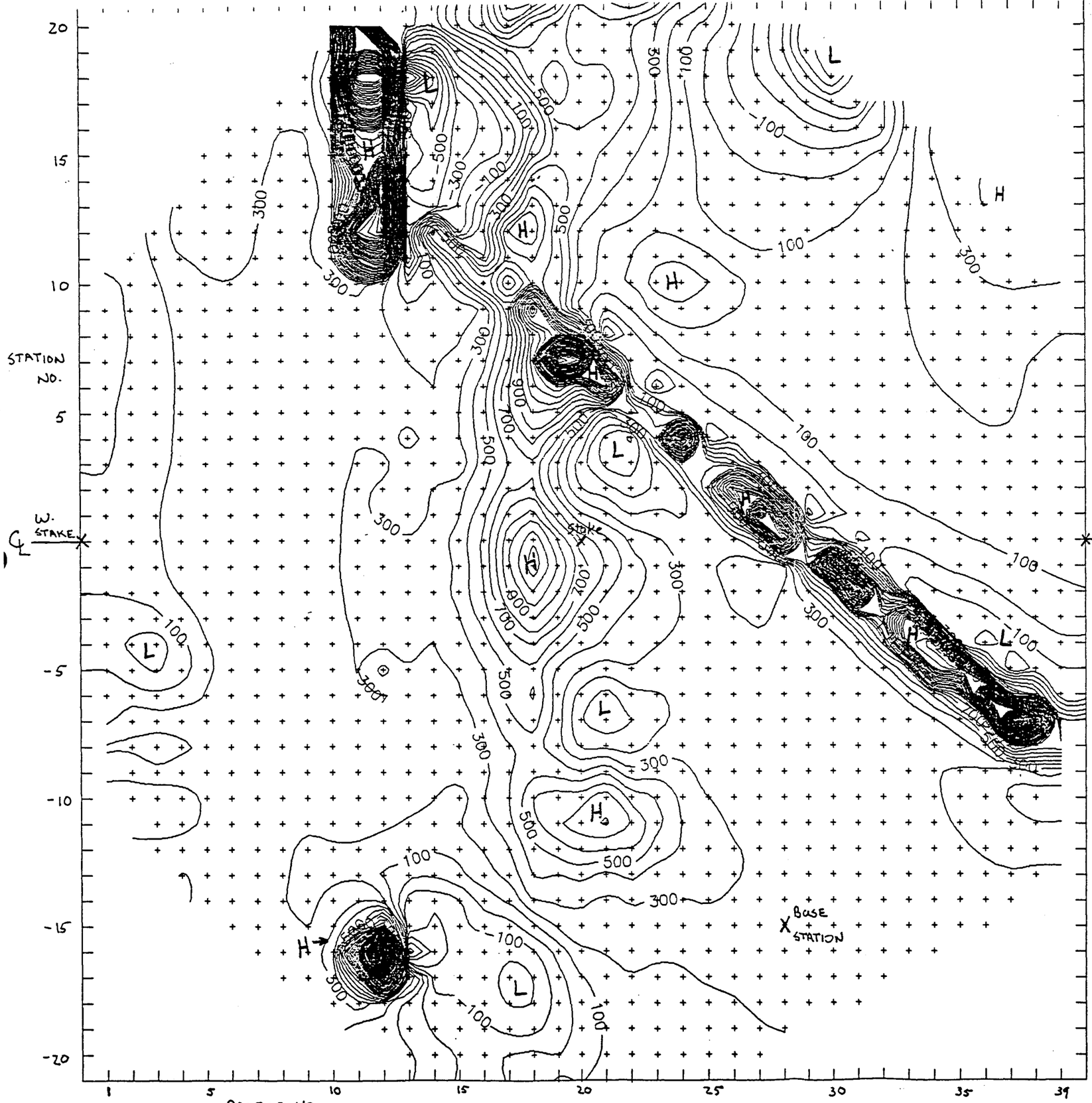
The Earth Technology Corporation

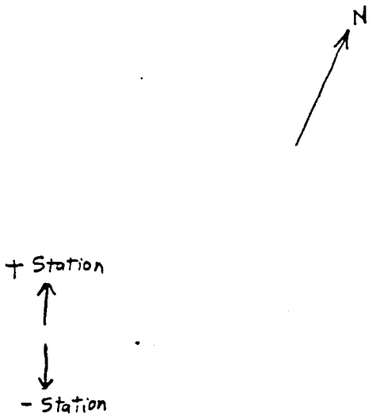
PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-6 BASE MAP

1-88





EXPLANATION

MAGNETIC SURVEY
DRIFT CORRECTED
—50,000 gammas

C.I. = 100 gammas

SCALE

0 20 40 feet

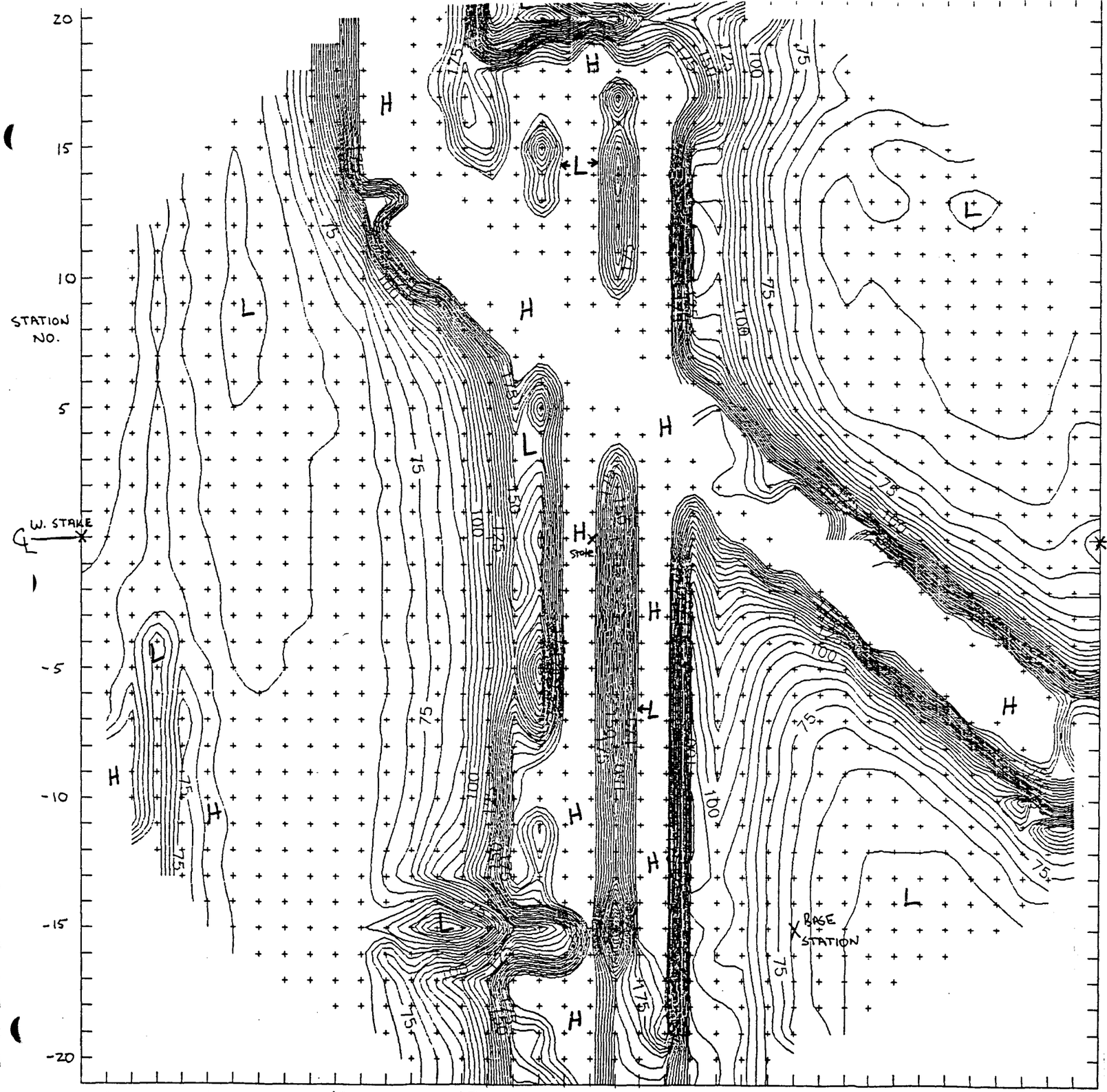
The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-6
MAGNETIC DATA MAP

1-88



EXPLANATION

ELECTROMAGNETIC INDUCTION SURVEY
DRIFT CORRECTED
C.I. = 5 mmhos/m

SCALE

0 20 40 feet

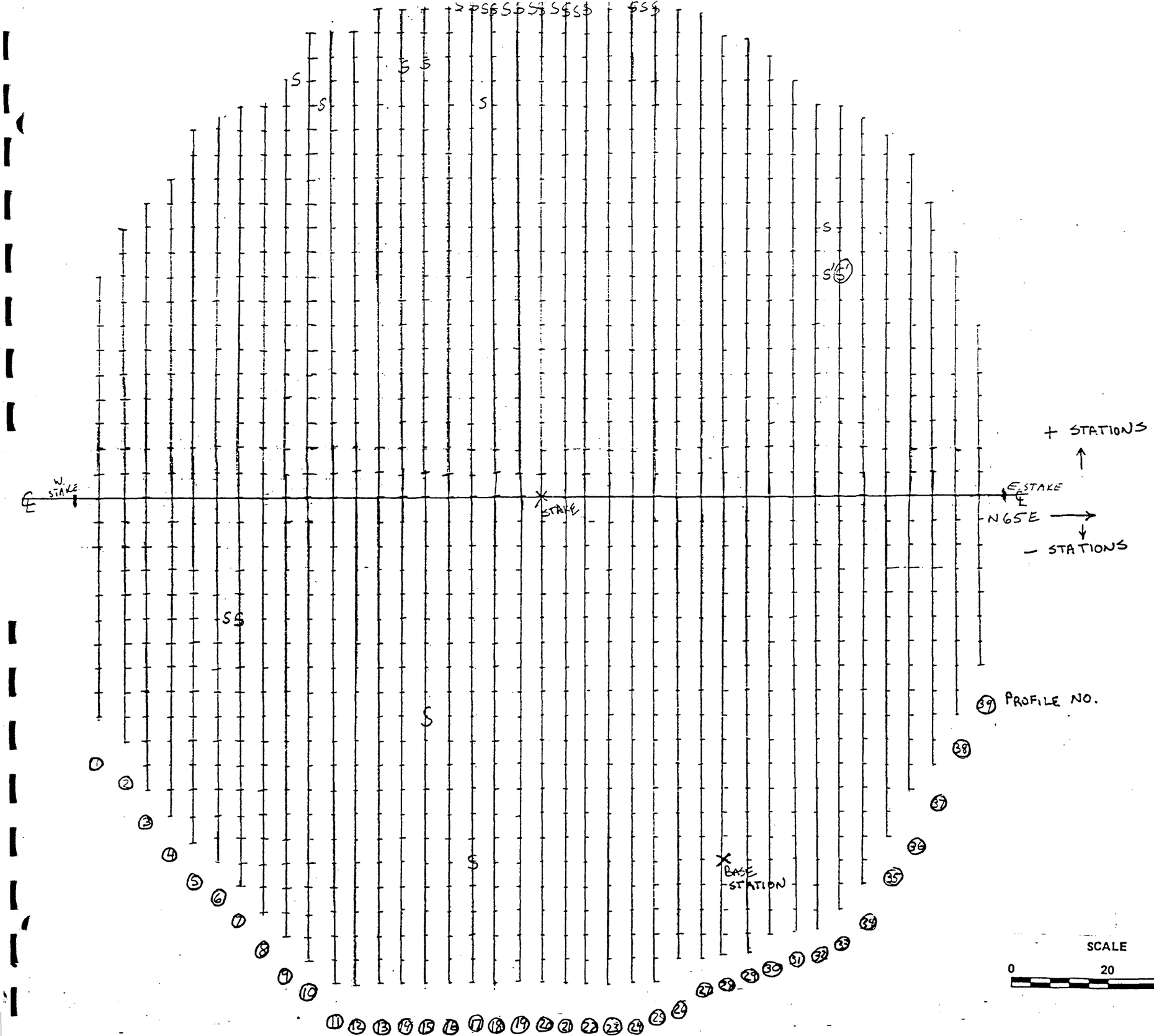
The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-6
EMI DATA MAP

1-88



N

EXPLANATION

RADAR SURVEY

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

SCALE

0 20 40 feet

The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

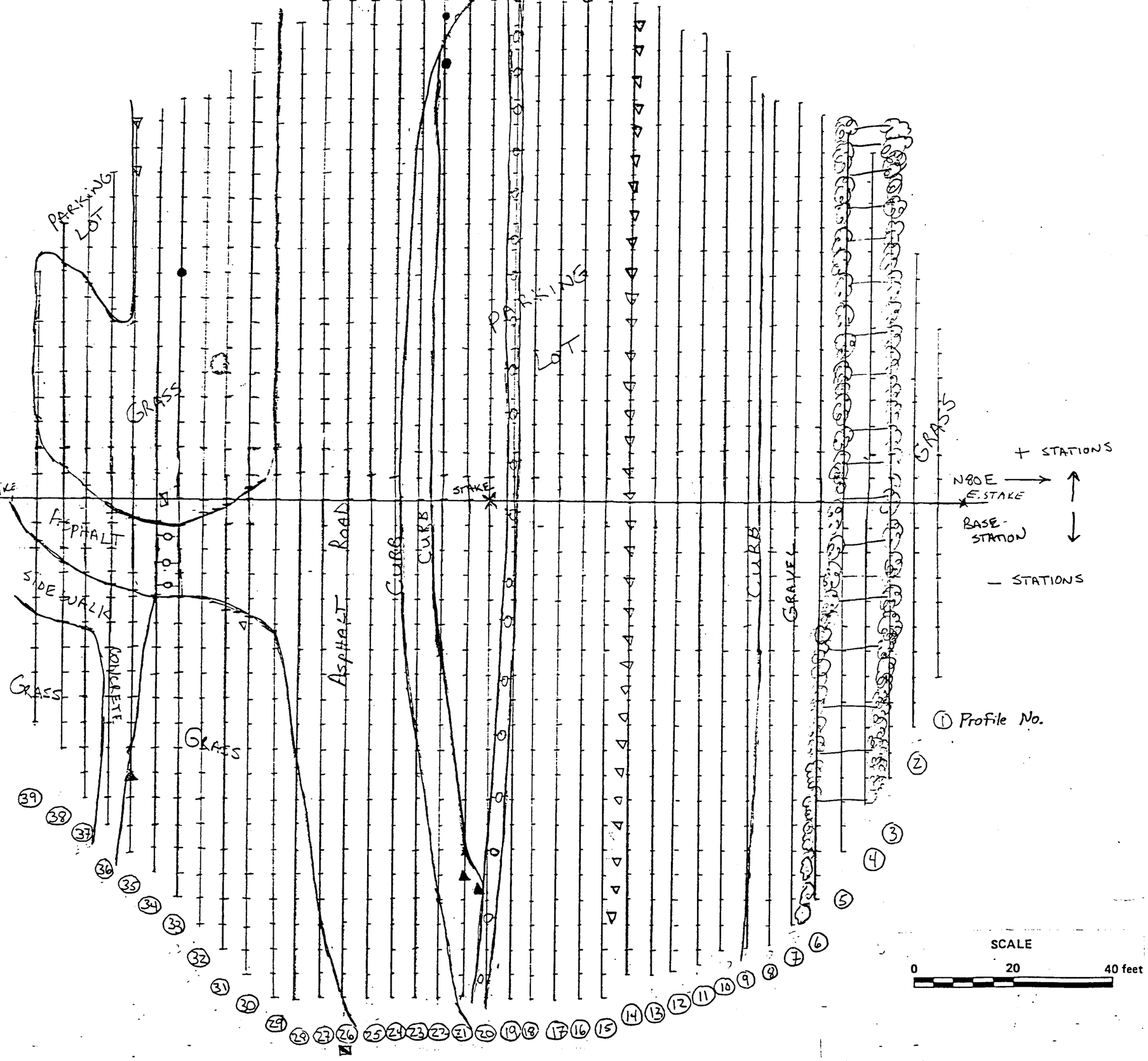
SITE SW-6
GPR DATA MAP

1-88

APPENDIX F

SITE SW-7

DATA MAPS



N

EXPLANATION

- LIGHT POST
- METAL UTILITIES CAP
- STEEL POST
- TREE/BUSH
- SPRINKLER
- FIRE HYDRANT
- TRENCH
- MANHOLE COVER
- TIE DOWN
- CRACK
- 8" STEEL RING
- ELECTRIC OUTLET
- STEEL CHAINS
- ELEC. UTILITY BOX
- VERTICAL STEEL PIPE
- STEEL KETTLES
- PROFILE NO.

SCALE

0 20 40 feet

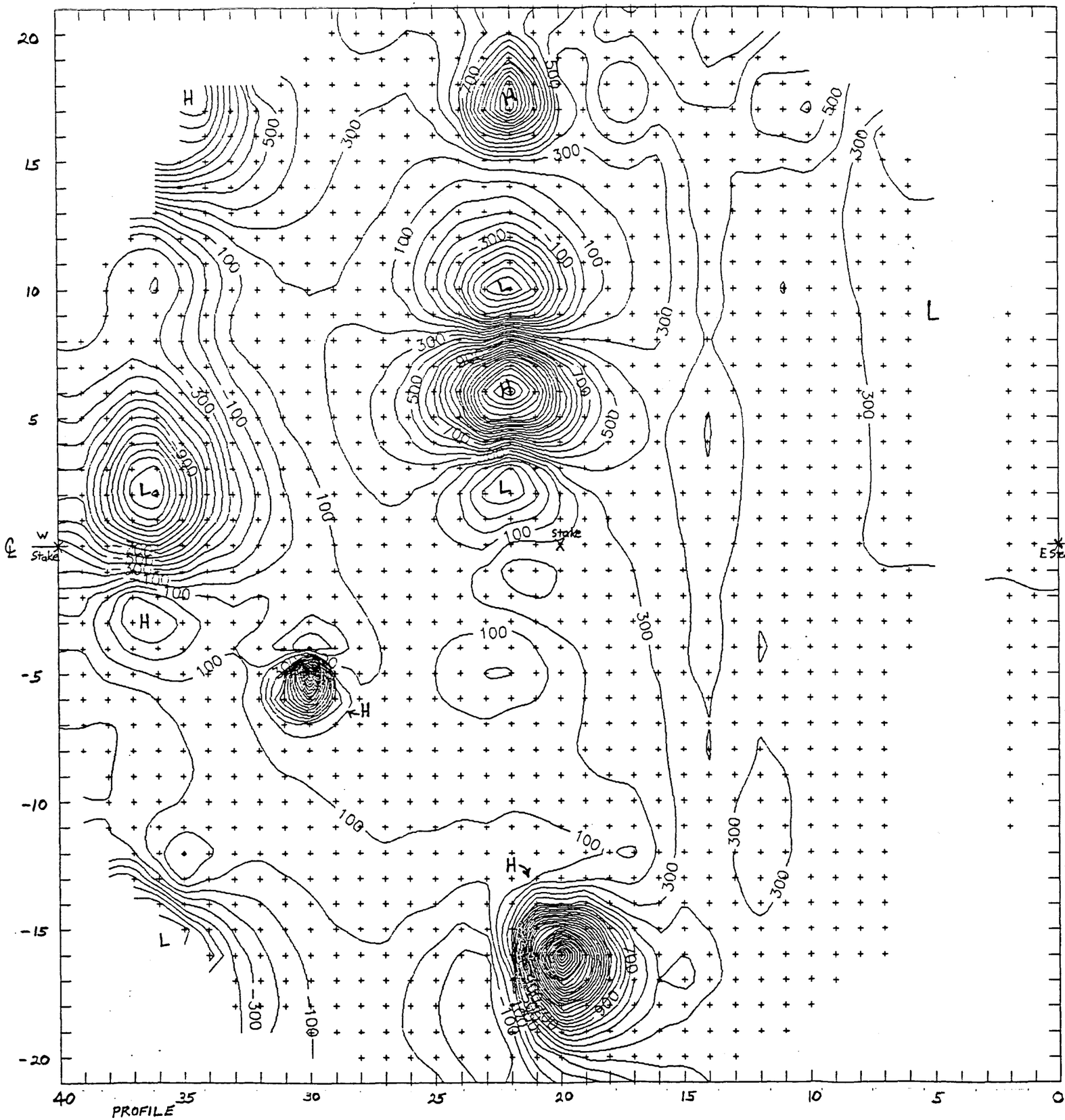
The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-7 BASE MAP

1-88



EXPLANATION

MAGNETIC SURVEY
DRIFT CORRECTED
−50,000 gammas

C.I. = 100 gammas

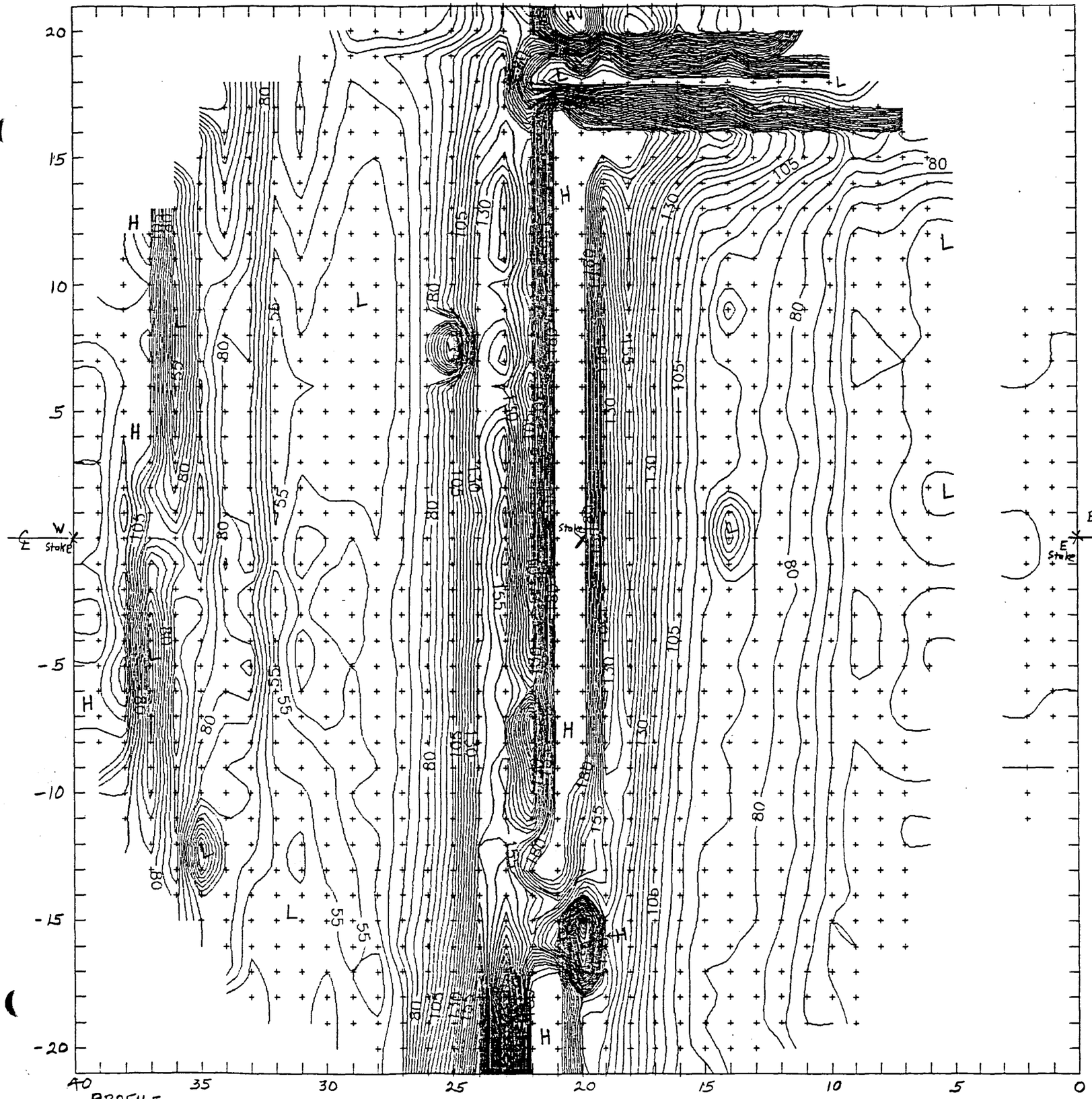
SCALE

0 20 40 feet

The Earth Technology Corporation	PROJECT NO.: 87-403
	KENNEDY/JENKS/CHILTON

SITE SW-7
MAGNETIC DATA MAP

1-88



EXPLANATION

ELECTROMAGNETIC INDUCTION SURVEY
DRIFT CORRECTED

C.I. = 5 mmhos/m

SCALE

0 20 40 feet

The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-7
EMI DATA MAP

1-88

W. STAKE

STAKE

N 80 E

E. STAKE

BASE STATION

+ STATIONS

− STATIONS

N

(1) Profile No.

EXPLANATION

RADAR SURVEY

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

SCALE

0 20 40 feet

The Earth Technology Corporation	PROJECT NO.: 87-403
	KENNEDY/JENKS/CHILTON

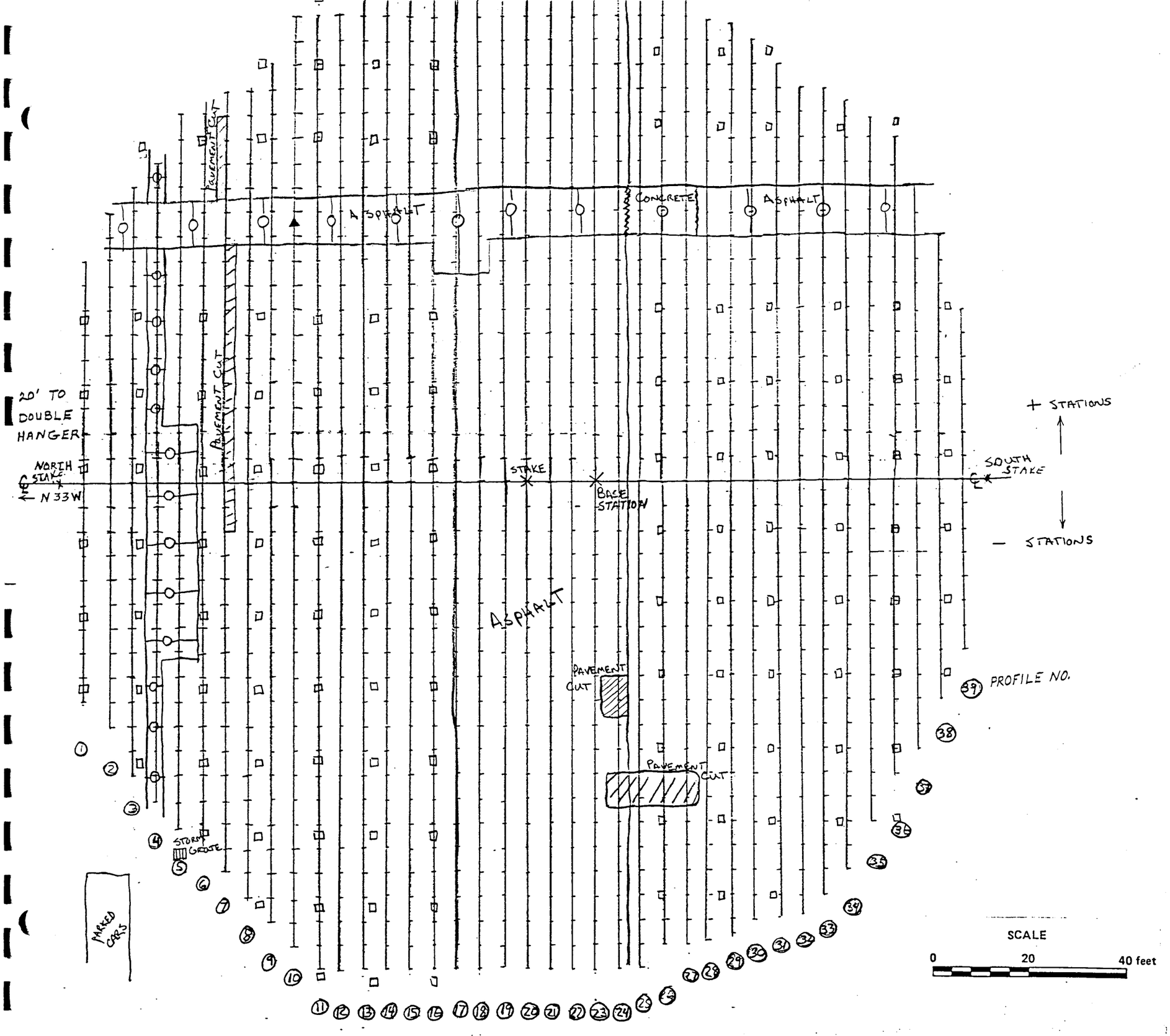
SITE SW-7
GPR DATA MAP

1-88

APPENDIX G

SITE SW-8

DATA MAPS



EXPLANATION

LIGHT POST	▨
METAL UTILITIES CAP	●
STEEL POST	▽
TREE/BUSH	✿
SPRINKLER	✳
FIRE HYDRANT	◇
TRENCH	○
MANHOLE COVER	▲
TIE DOWN	□
CRACK	〉
8" STEEL RING	⌀
ELECTRIC OUTLET	⌀
STEEL CHAINS	∞
ELEC. UTILITY BOX	E
VERTICAL STEEL PIPE	◆
STEEL KETTLES	Ⓚ
PROFILE NO.	①

SCALE

0 20 40 feet

The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-8 BASE MAP

1-88

20' TD DOUBLE HANGER

NORTH ℄ STAKE

← N33W

℄ STAKE

CASE STATION

℄ STAKE

+ stations

South

- stations

N

PROFILE NO.

EXPLANATION

RADAR SURVEY

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

SCALE

0 20 40 feet

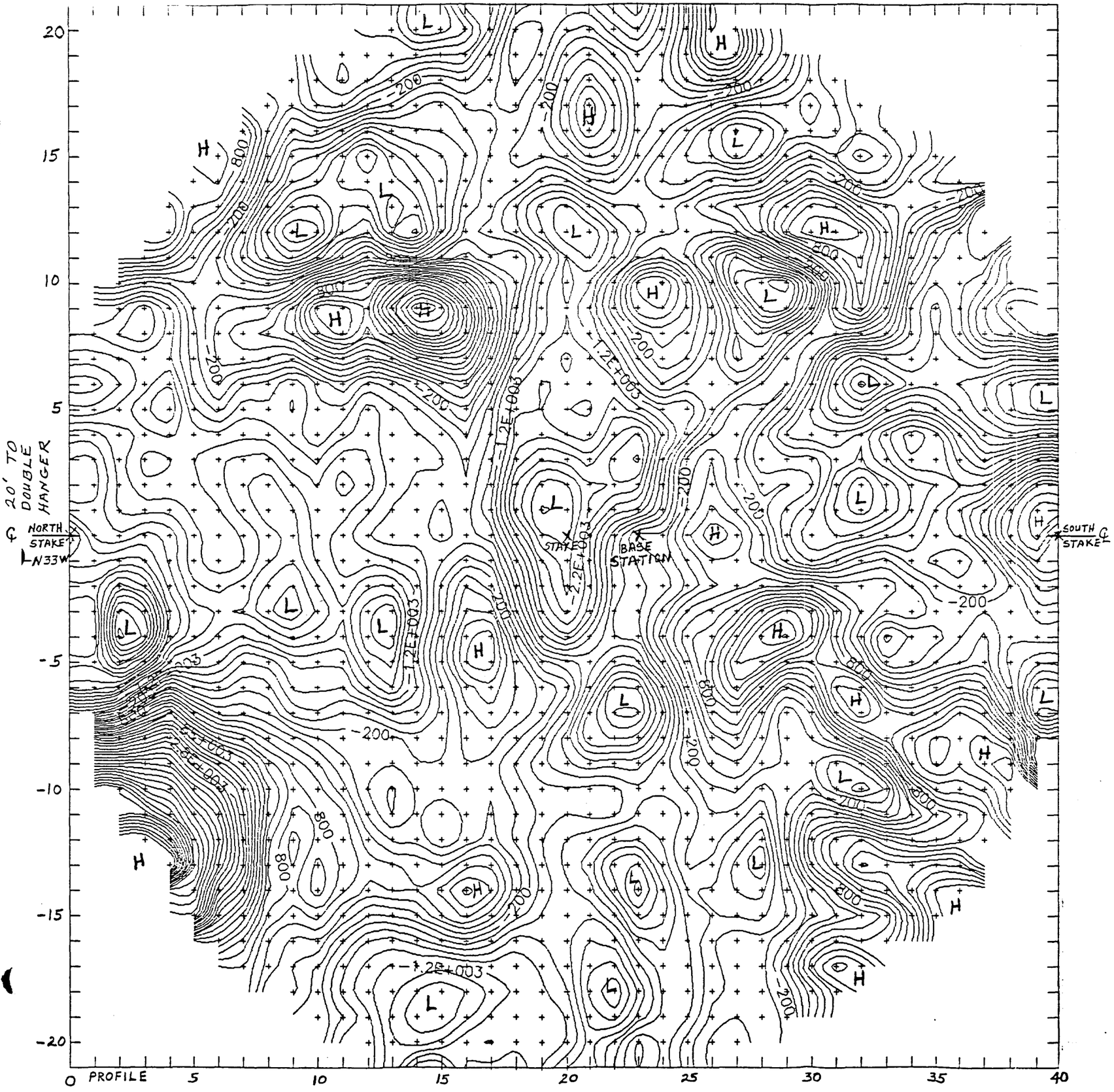
The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-8
GPR DATA MAP

1-88



N

+ Station

- Station

EXPLANATION

MAGNETIC SURVEY
DRIFT CORRECTED
-50,000 gammas

C.I. = 200 gammas

SCALE

0 20 40 feet

The Earth Technology Corporation	PROJECT NO.: 87-403
	KENNEDY/JENKS/CHILTON

SITE SW-8
MAGNETIC DATA MAP

1-88

APPENDIX H

SITE SW-9

DATA MAPS

Edge of Runway ≈100ft West of Site 9

Edge of Asphalt Runway shoulder ≈50' West of Site 9

N

- Stations

S STAKE

STAKE

BASE STATION

N STAKE

PARALLEL TO RUNWAYS

N 23 W

+ Stations

39 PROFILE NO.

EXPLANATION

LIGHT POST	
METAL UTILITIES CAP	●
STEEL POST	▽
TREE/BUSH	
SPRINKLER	✳
FIRE HYDRANT	◇
TRENCH	○
MANHOLE COVER	▲
TIE DOWN	□
CRACK	
8" STEEL RING	
ELECTRIC OUTLET	
STEEL CHAINS	∞
ELEC. UTILITY BOX	E
VERTICAL STEEL PIPE	◆
STEEL KETTLES	Ⓚ
PROFILE NO.	①

SCALE

0 20 40 feet

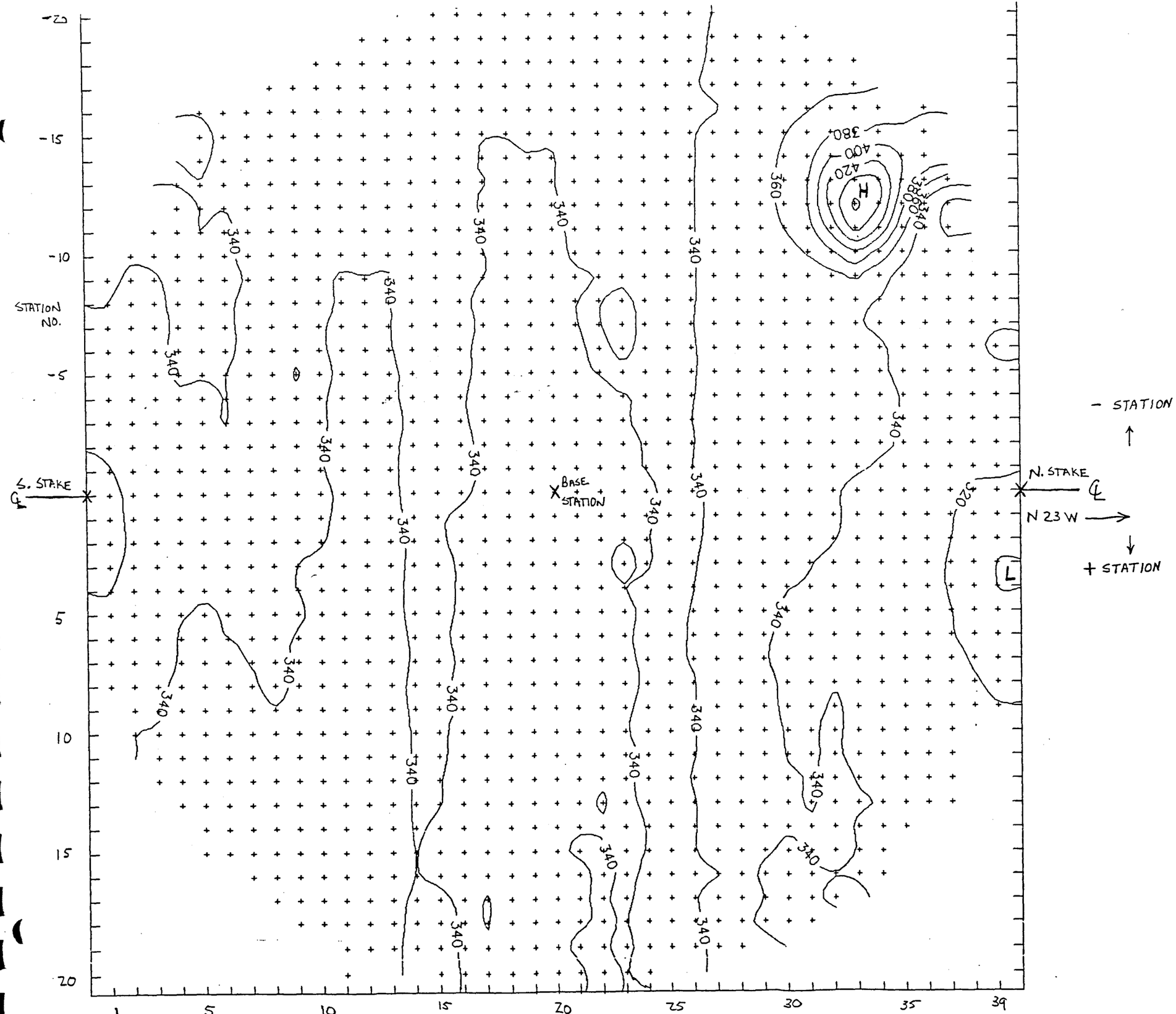
The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-9
BASE MAP

1-88



N

\- STATION

+ STATION

EXPLANATION

MAGNETIC SURVEY
DRIFT CORRECTED
−50,000 gammas
C.I. = 20 gammas

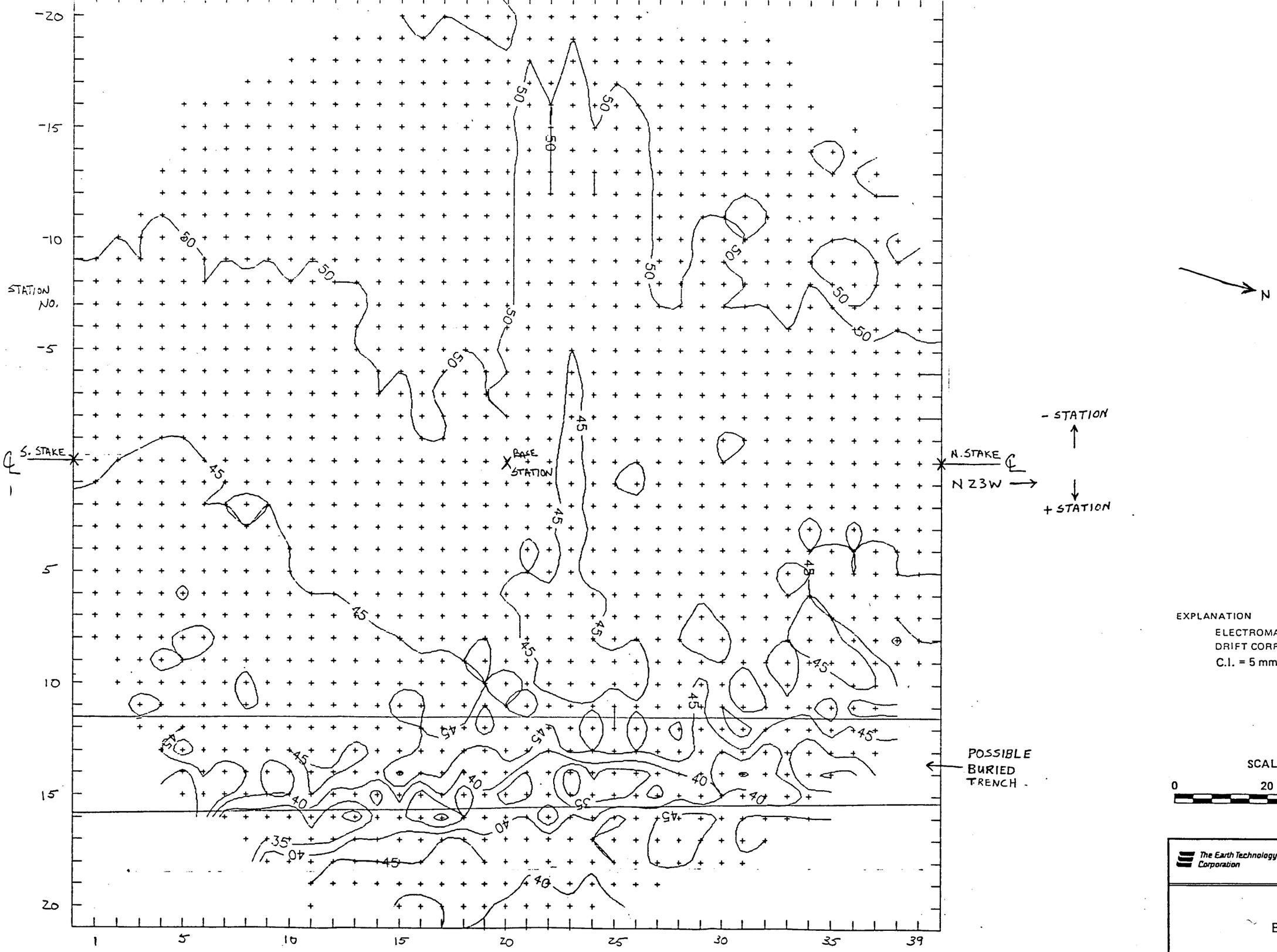
SCALE

0 20 40 feet

The Earth Technology Corporation	PROJECT NO.: 87-403
	KENNEDY/JENKS/CHILTON

SITE SW-9
MAGNETIC DATA MAP

1-88



EXPLANATION

ELECTROMAGNETIC INDUCTION SURVEY
DRIFT CORRECTED
C.I. = 5 mmhos/m

SCALE

0 20 40 feet

The Earth Technology Corporation

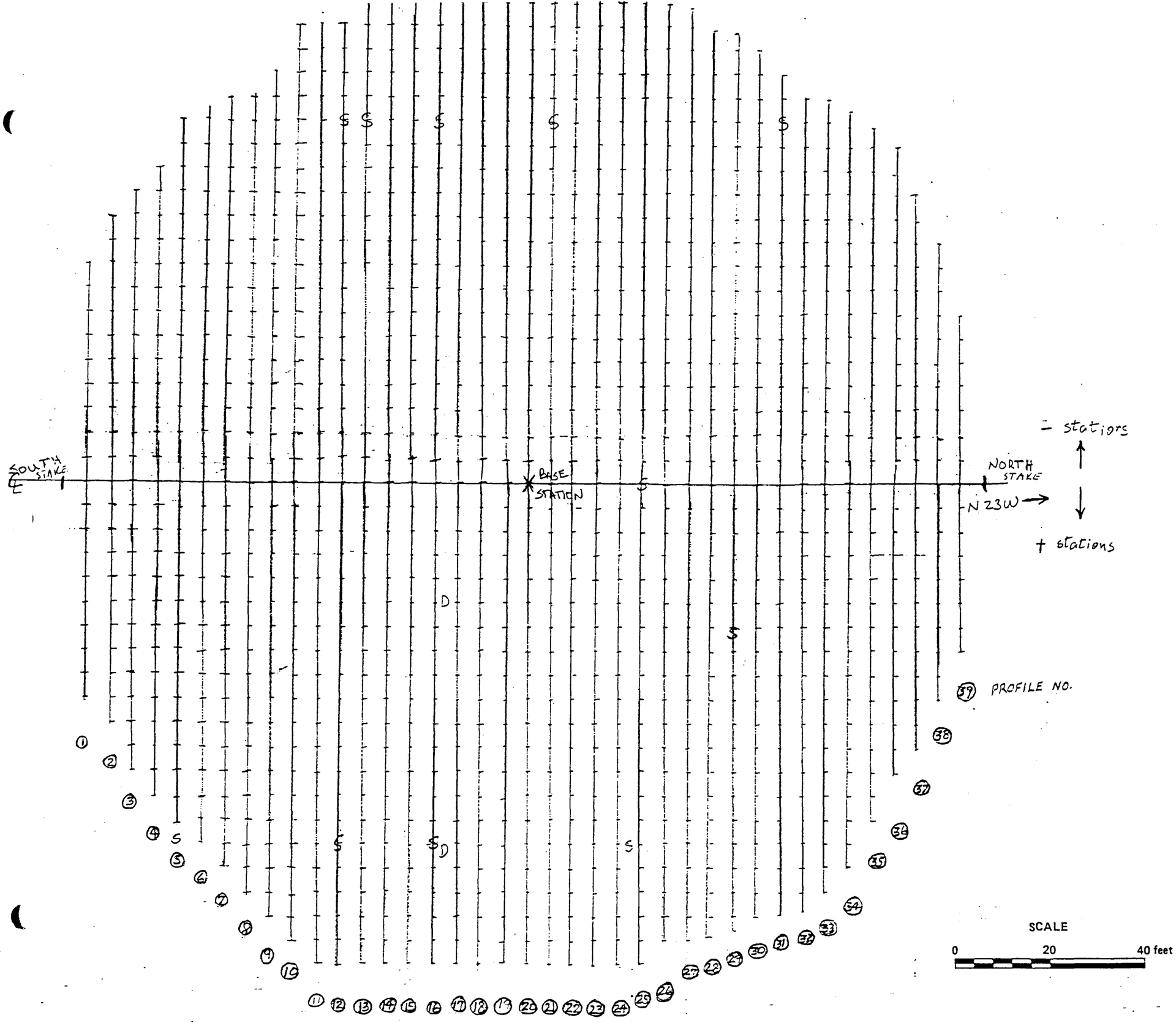
PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-9

EMI DATA MAP

1-88



EXPLANATION

RADAR SURVEY

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

The Earth Technology Corporation	PROJECT NO.: 87-403
	KENNEDY/JENKS/CHILTON

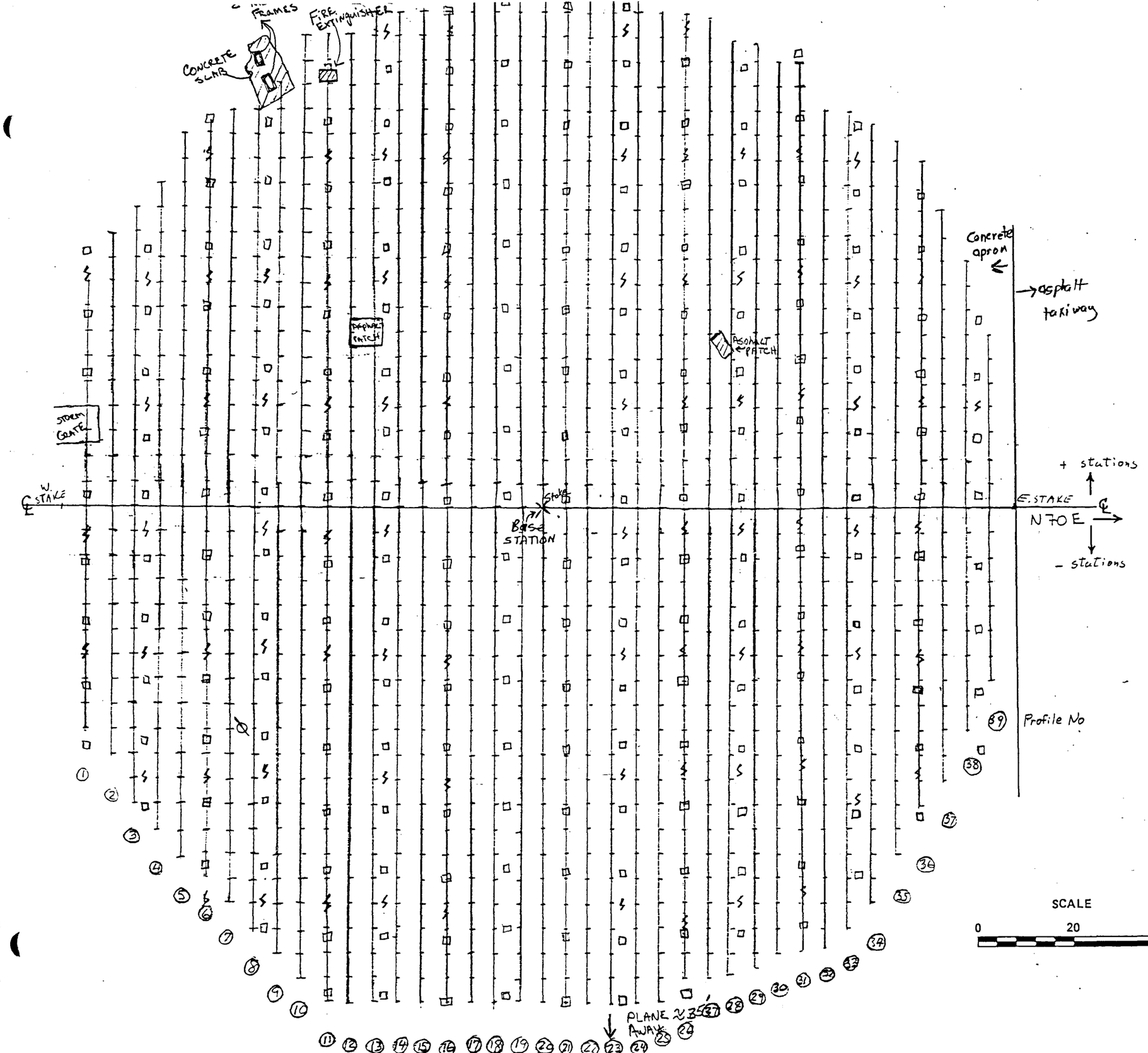
SITE SW-9
GPR DATA MAP

1-88

APPENDIX I

SITE SW-10

DATA MAPS



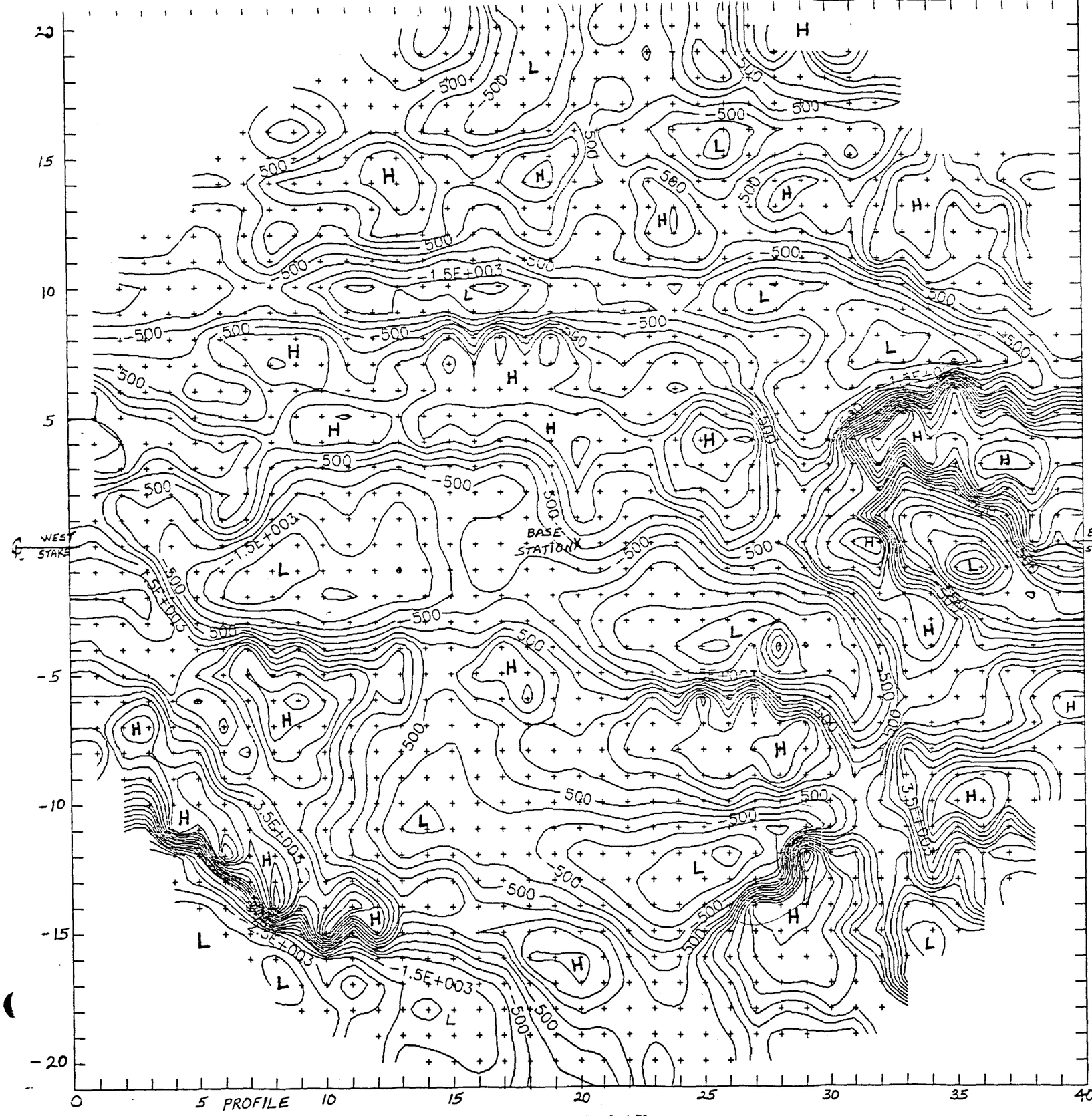
The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-10 BASE MAP

1-88



N

+ Station

N70E

- Station

EXPLANATION

MAGNETIC SURVEY
DRIFT CORRECTED
−50,000 gammas

C.I. = 500 gammas

SCALE

0 20 40 feet

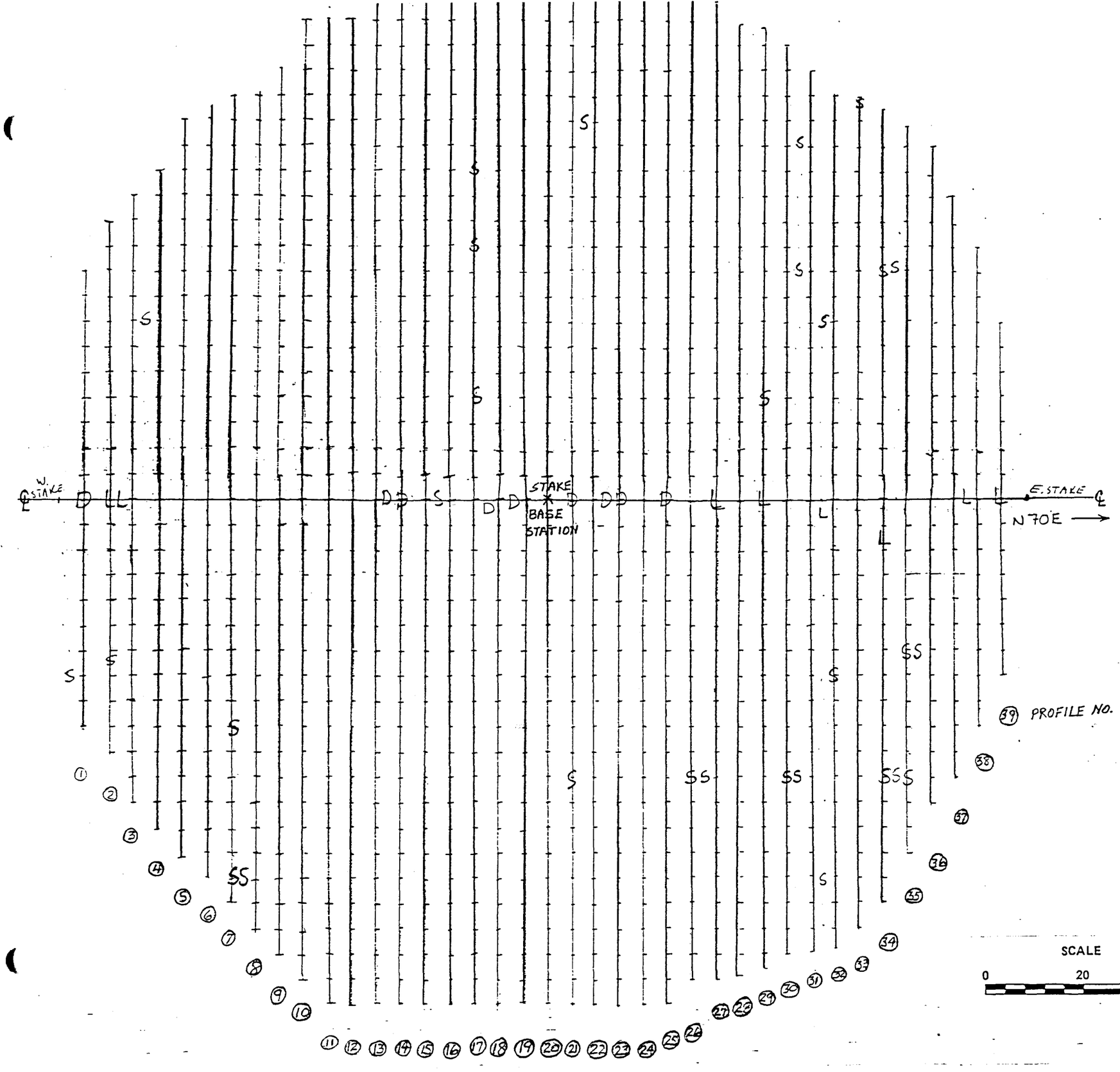
The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-10
MAGNETIC DATA MAP

1-88



N

EXPLANATION

RADAR SURVEY

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

SCALE

0 20 40 feet

The Earth Technology Corporation	PROJECT NO.: 87-403
	KENNEDY/JENKS/CHILTON

SITE SW-10
GPR DATA MAP

1-88

APPENDIX J

SITE SW-11

DATA MAPS

CONCRETE

Baseball field

+ stations

N

GRASS

ASPHALT ROAD

GRASS

N103E →

W. STAKE

STAKE

E. STAKE

Base station

DIGOUT

SAND

SAND

SAND

SAND

SAND

SAND

SAND

SAND

FENCE

GAZEBO

GRASS

BBQ Pit

BBQ Pit

BBQ

TRACK

- stations

(39) PROFILE NO.

GRASS

(36)

(37)

(38)

(35)

(34)

(33)

(32)

(31)

(30)

(29)

(28)

(27)

(26)

(25)

(24)

(23)

(22)

(21)

(20)

(19)

(18)

(17)

(16)

(15)

(14)

(13)

(12)

(11)

(10)

(9)

(8)

(7)

(6)

(5)

(4)

(3)

(2)

(1)

EXPLANATION

LIGHT POST	▨
METAL UTILITIES CAP	●
STEEL POST	▽
TREE/BUSH	✿
SPRINKLER	✳
FIRE HYDRANT	◇
TRENCH	○
MANHOLE COVER	▲
TIE DOWN	□
CRACK	⟋
8" STEEL RING	⌀
ELECTRIC OUTLET	⌀
STEEL CHAINS	∞
ELEC. UTILITY BOX	E
VERTICAL STEEL PIPE	◆
STEEL KETTLES	Ⓚ
PROFILE NO.	①

SCALE

0 20 40 feet

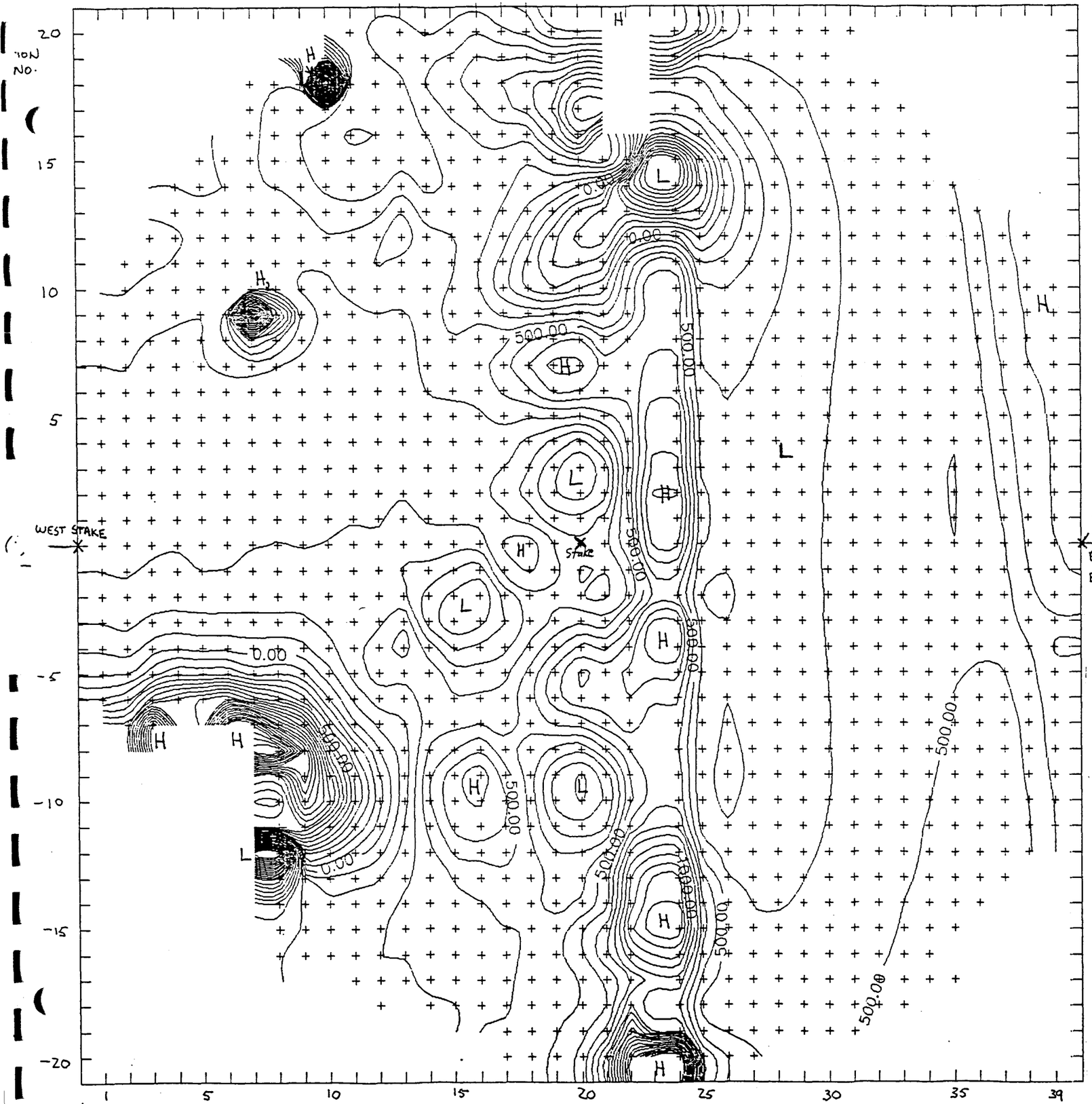
The Earth Technology Corporation

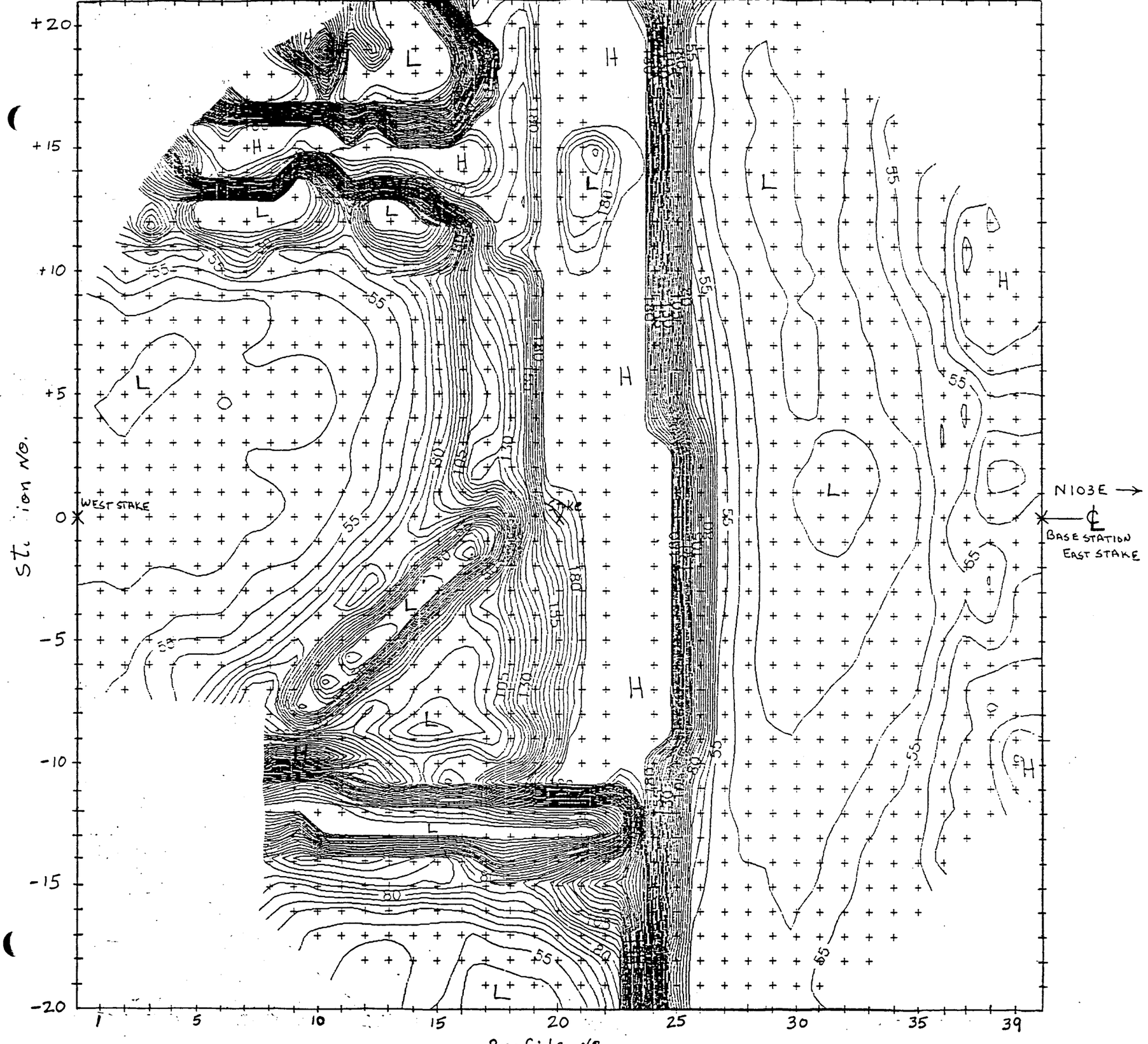
PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-11
BASE MAP

1-88


WEST STAKE
Stake
N103E
Base Station
East Stake
+ Station
- Station
N
EXPLANATION
MAGNETIC SURVEY
DRIFT CORRECTED
−50,000 gammas
C.I. = 100 gammas
SCALE
0
20
40 feet
The Earth Technology Corporation
PROJECT NO.: 87-403
KENNEDY/JENKS/CHILTON
SITE SW-11
MAGNETIC DATA MAP
1-88



EXPLANATION

ELECTROMAGNETIC INDUCTION SURVEY
DRIFT CORRECTED
C.I. = 5 mmhos/m

SCALE

0 20 40 feet

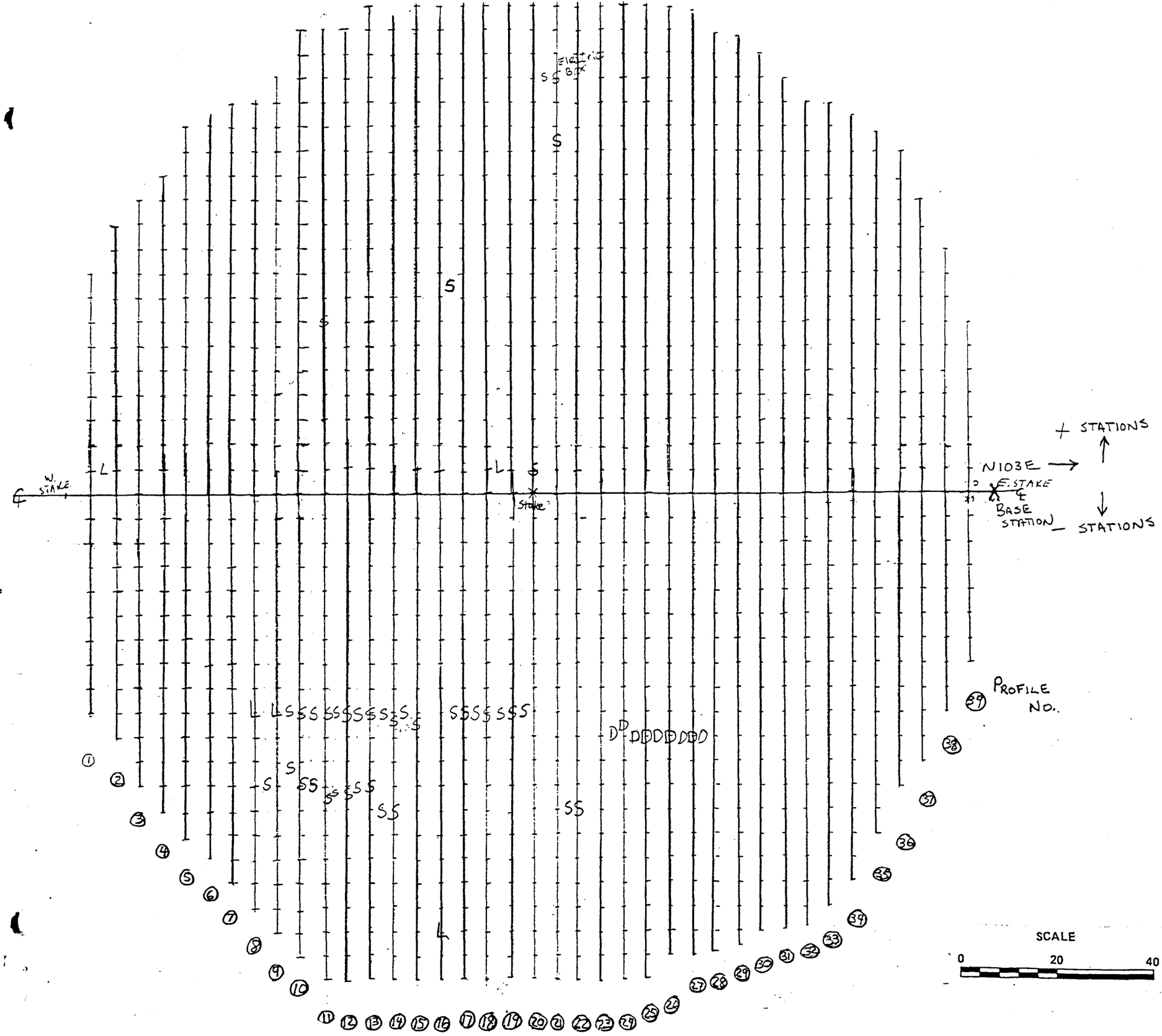
The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE SW-11
EMI DATA MAP

1-88



EXPLANATION

RADAR SURVEY

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

SCALE

0 20 40 feet

The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

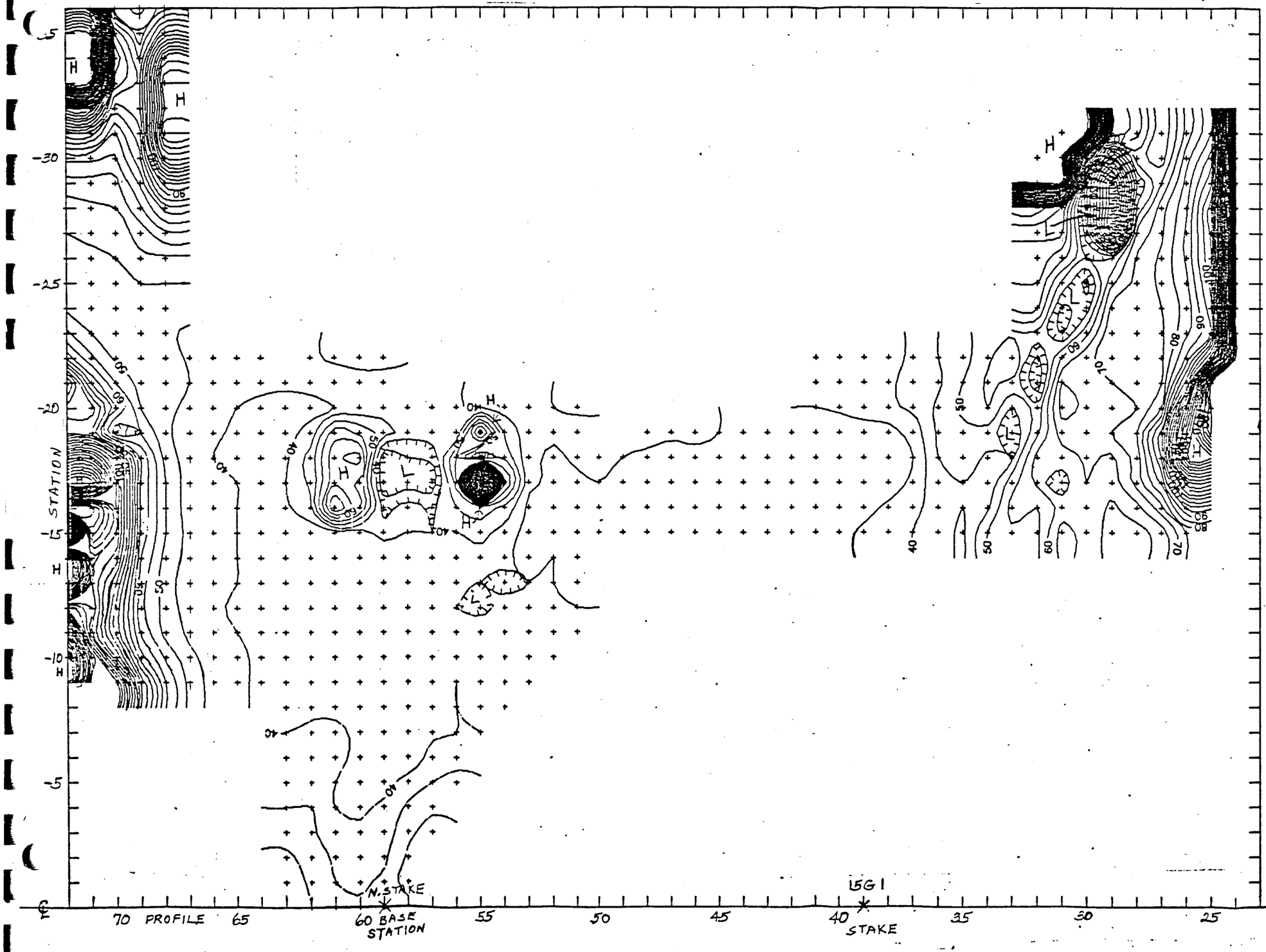
SITE SW-11
GPR DATA MAP

1-88

APPENDIX K

SITES 15G1 and 2

DATA MAPS



N

EXPLANATION

ELECTROMAGNETIC INDUCTION SURVEY
DRIFT CORRECTED

C.I. = 5 mmhos/m

SCALE

0 20 40 feet

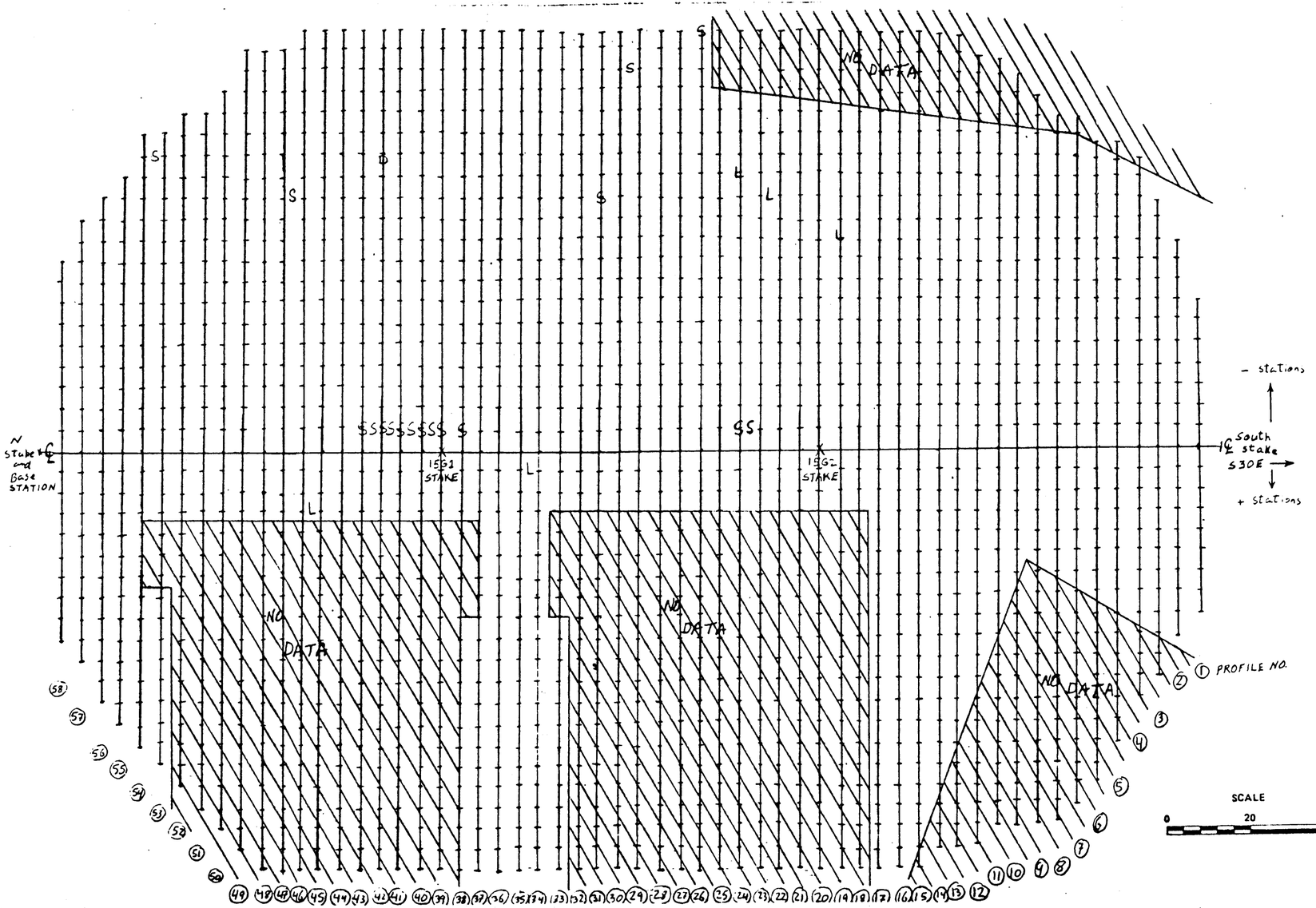
The Earth Technology Corporation

PROJECT NO.: 87-403

KENNEDY/JENKS/CHILTON

SITE 15G1 AND 2
EMI DATA MAP
EAST PANEL.

1-88



EXPLANATION

RADAR SURVEY

S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET

SCALE

0 20 40 feet

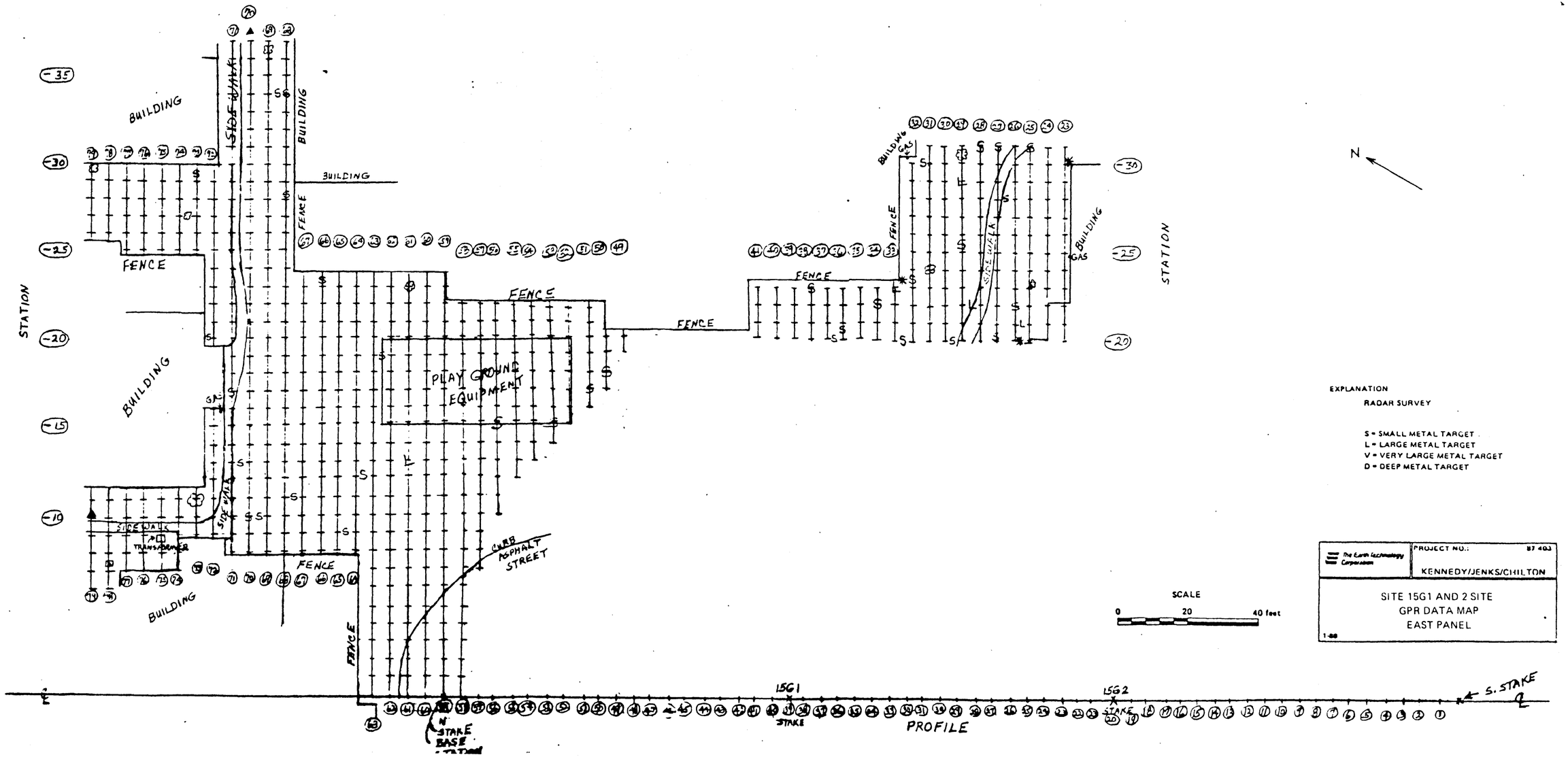
The Earth Technology Corporation

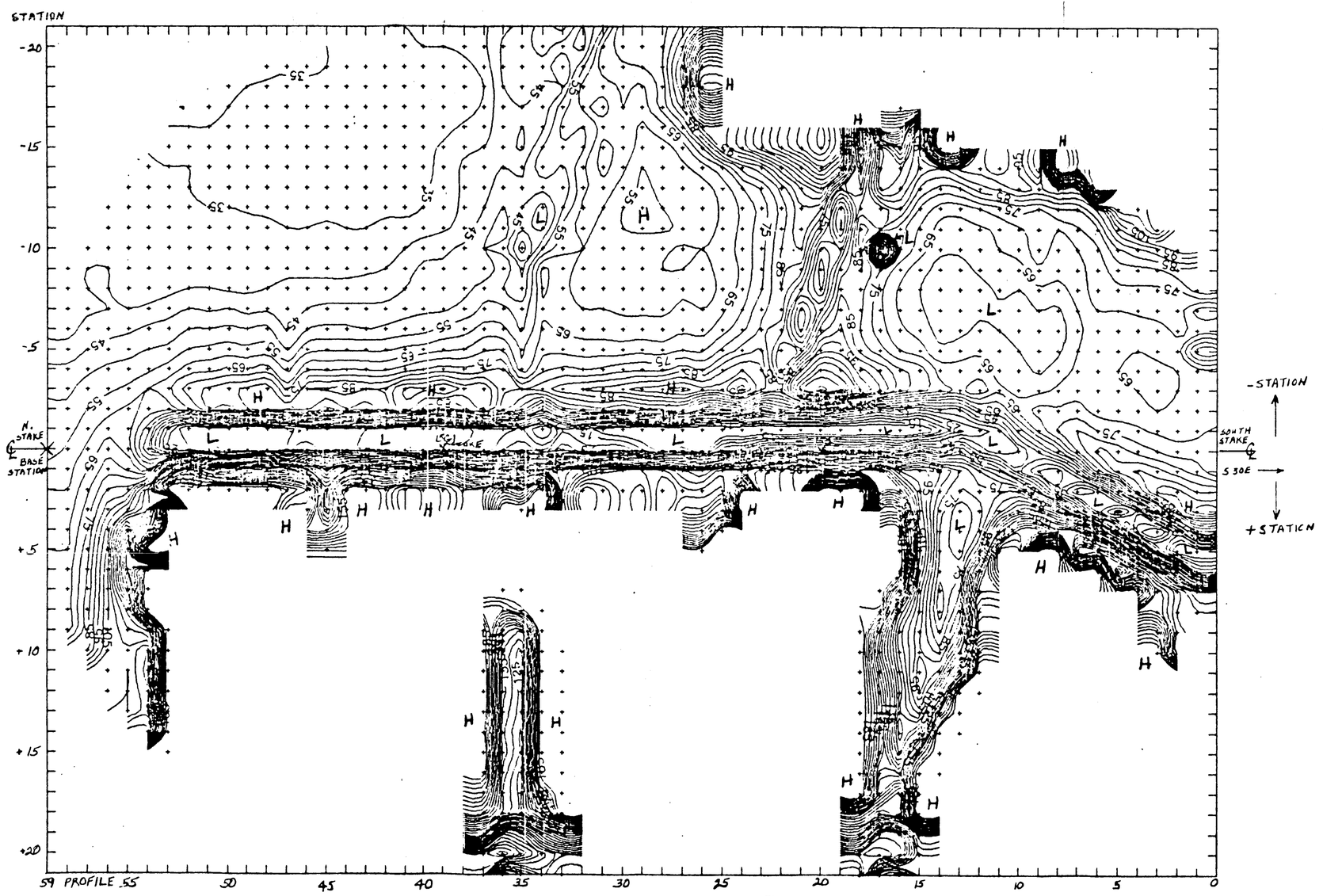
PROJECT NO.: 87 403

KENNEDY/JENKS/CHILTON

SITE 15G1 AND 2
GPR DATA MAP
WEST PANEL

1-88


STATION
-35
-30
-25
-20
-15
-10
BUILDING
STOP SIGN
BUILDING
BUILDING
FENCE
FENCE
FENCE
BUILDING
PLAY GROUND EQUIPMENT
GAS
SIDE WALK
SIDE WALK
SIDE WALK
TRANSFORMER
FENCE
BUILDING
FENCE
CURB
ASPHALT STREET
FENCE
BUILDING
GAS
FENCE
SIDE WALK
BUILDING
GAS
-35
-25
-20
STATION
N
EXPLANATION
RADAR SURVEY
S = SMALL METAL TARGET
L = LARGE METAL TARGET
V = VERY LARGE METAL TARGET
D = DEEP METAL TARGET
SCALE
0
20
40 feet
PROJECT NO.: 87 403
KENNEDY/JENKS/CHILTON
SITE 15G1 AND 2 SITE
GPR DATA MAP
EAST PANEL
1-88
15G1
STAKE
15G2
STAKE
S. STAKE
N STAKE
BASE
PROFILE



N

EXPLANATION

ELECTROMAGNETIC INDUCTION SURVEY
DRIFT CORRECTED

C.I. = 5 mmhos/m

SCALE

0 20 40 feet

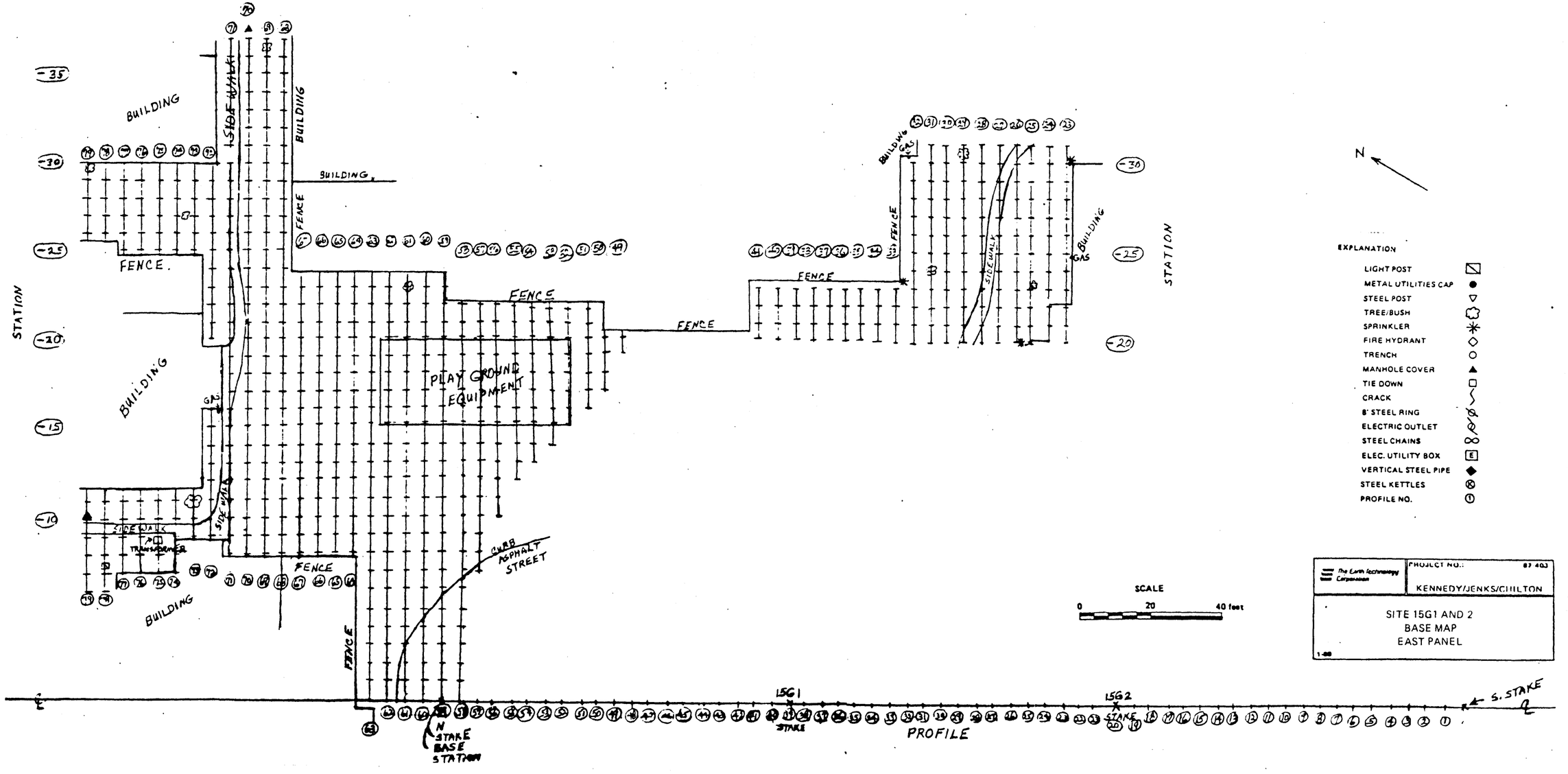
The Earth Technology Corporation

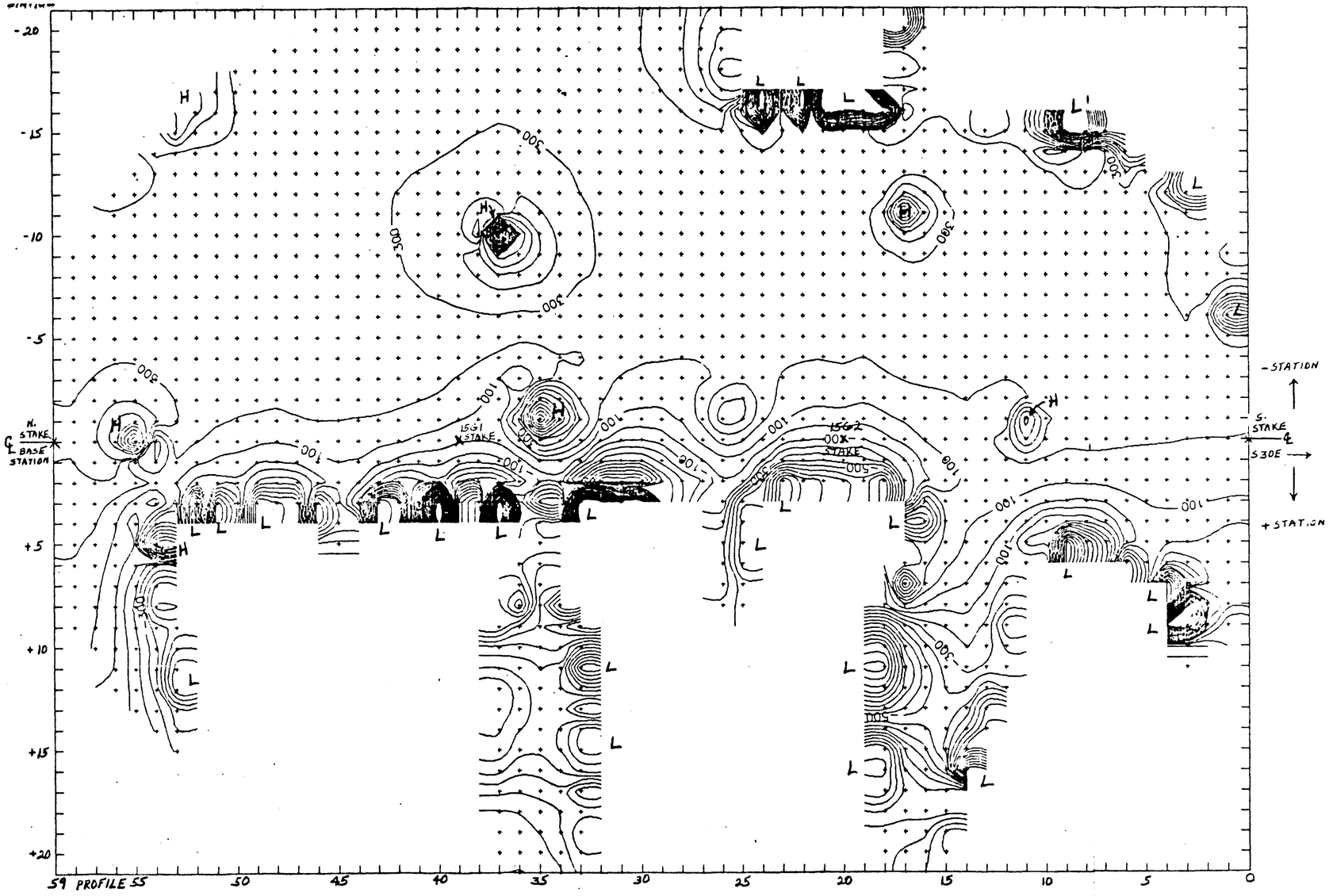
PROJECT NO. 87 403

KENNEDY/JENKS/CHILTON

SITE 15G1 AND 2
EMI DATA MAP
WEST PANEL

1-88


-35
-30
-25
-20
-15
-10
STATION
BUILDING
SIDEWALK
BUILDING
BUILDING
FENCE
FENCE
FENCE
FENCE
FENCE
PLAY GROUND EQUIPMENT
GAS
SIDEWALK
TRANSFORMER
CURB
ASPHALT STREET
BUILDING
FENCE
BUILDING
GAS
FENCE
SIDEWALK
BUILDING
GAS
STATION
N STAKE BASE STATION
15G1 STAKE
15G2 STAKE
S. STAKE
PROFILE
N
EXPLANATION
LIGHT POST
METAL UTILITIES CAP
STEEL POST
TREE/BUSH
SPRINKLER
FIRE HYDRANT
TRENCH
MANHOLE COVER
TIE DOWN
CRACK
8" STEEL RING
ELECTRIC OUTLET
STEEL CHAINS
ELEC. UTILITY BOX
VERTICAL STEEL PIPE
STEEL KETTLES
PROFILE NO.
SCALE
0
20
40 feet
The Earth Technology Corporation
PROJECT NO.: 87 403
KENNEDY/JENKS/CHILTON
SITE 15G1 AND 2
BASE MAP
EAST PANEL
1-88



N

EXPLANATION

MAGNETIC SURVEY
DRIFT CORRECTED
-50,000 gammas

C.I. =100 gammas

SCALE

0 20 40 feet

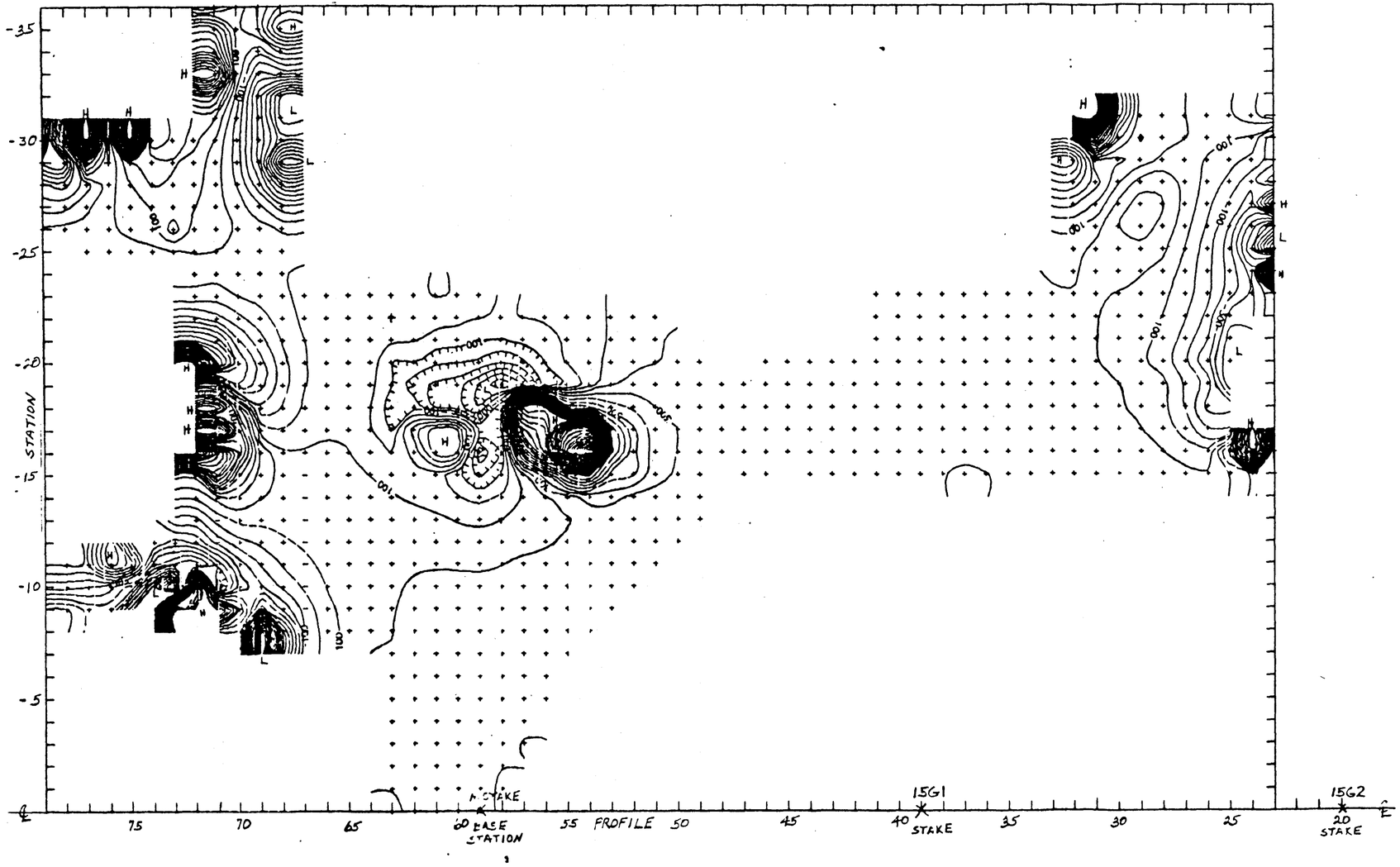
The Earth Technology Corporation

PROJECT NO.: 87 403

KENNEDY/JENKS/CHILTON

SITE 15G1 AND 2
MAGNETIC DATA MAP
WEST PANEL

1-88



EXPLANATION

MAGNETIC SURVEY
DRIFT CORRECTED
−50,000 gammas

C.I. = 20 gammas

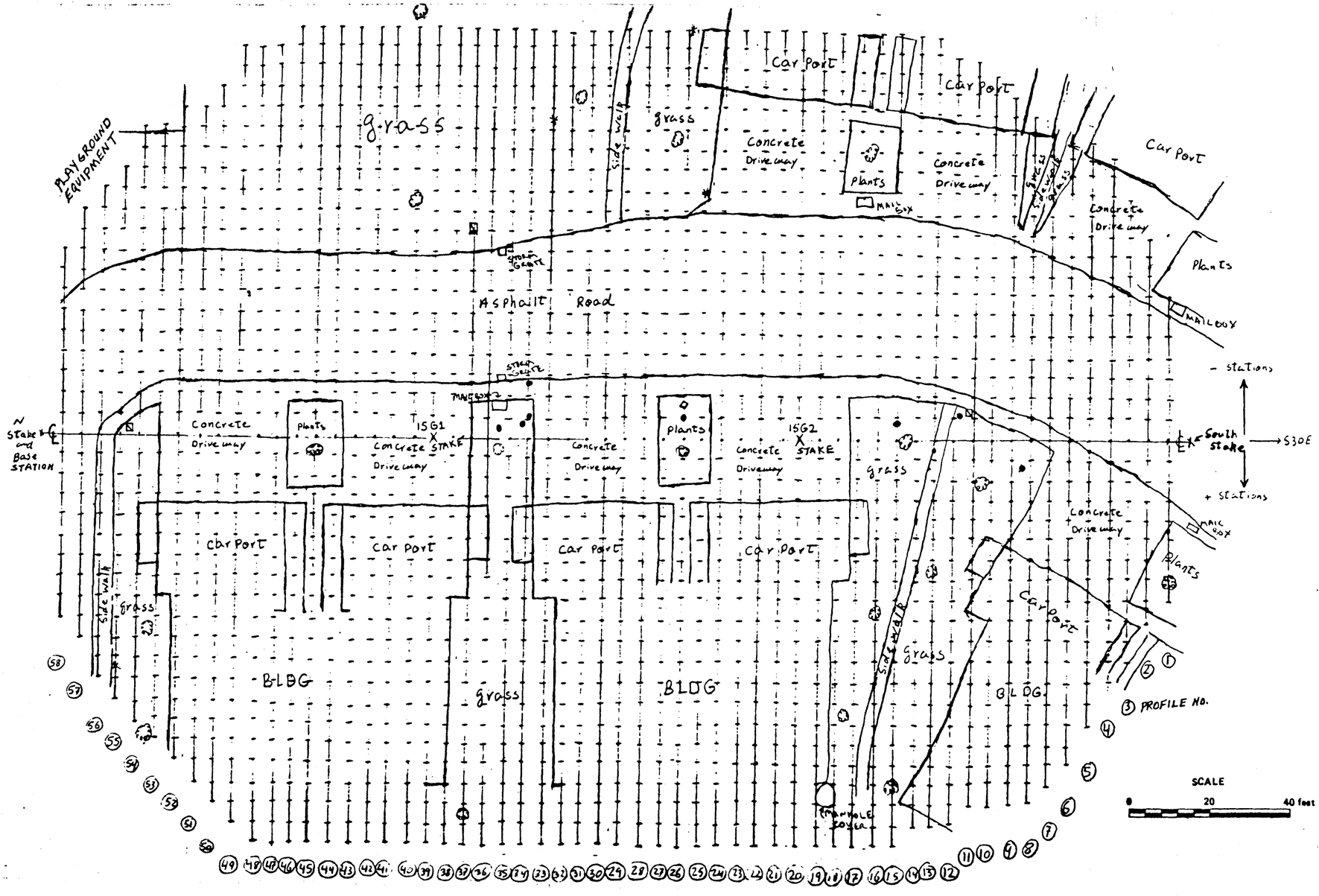
SCALE

0 20 40 feet

Pat Lynn Technology Corporation	PROJECT NO.: 87-403
	KENNEDY/JENKS/CHILTON

SITE 15G1 AND 2 SITE
MAGNETIC DATA MAP
EAST PANEL

1-88



EXPLANATION

LIGHT POST	
METAL UTILITIES CAP	●
STEEL POST	▽
TREE/BUSH	
SPRINKLER	✳
FIRE HYDRANT	◇
TRENCH	○
MANHOLE COVER	▲
TIE DOWN	□
CRACK	⌇
8" STEEL RING	⌀
ELECTRIC OUTLET	⌀
STEEL CHAINS	∞
ELEC. UTILITY BOX	E
VERTICAL STEEL PIPE	◆
STEEL KETTLES	⊗
PROFILE NO.	①

The Earth Technology Corporation	PROJECT NO.: 87-403
	KENNEDY/JENKS/CHILTON

SITE 15G1 AND 2
BASE MAP
WEST PANEL

1-88