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Geophysical Investigation of Selected Sites in Burial Grounds 218-W-3A, -4B, and -4C

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Key Words: Ground-penetrating radar, Geophysical, Electromagnetic induction, Burial grounds

Abstract:

Ground-penetrating radar (GPR) and electro-magnetic induction (EMI) were successfully used to delineate buried wastes in Trenches 218-W-3A, -4B, and -4C and determine the amount of soil cover of the buried wastes.

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1.0 INTRODUCTION

This report contains the results of several geophysical investigations conducted in support of the Pilot Retrieval characterization of selected samples of the transuranic waste (TRU) at the Hanford Site (Figure 1). TRU waste that was generated by national defense programs was stored in a form that was retrievable, pending decisions on its permanent disposal. In general, Pilot Retrieval is the retrieving of selected samples of waste and examining the containers to determine their integrity and analyze their contents. A detailed description of the TRU characterization program at Hanford is described in Anderson (1989a).

The TRU waste at Hanford has been stored in 25 trenches and three buildings in the 200 Areas. Nineteen sites were selected for retrieval and sampling. The first five retrieval sites are presented in Bergstrom and others (1994). The remaining sites, with the exception of two, are presented in this report. The sites investigated were:

Burial Ground 218-W-3A:	Trench 6S, Site 18
	Trench 8, Sites 7,13 & 14
	Trench 9S, Site 17
	Trench 17, Sites 12,15 & 16
218-W-4B:	Trench 7, Sites 6 & 10
218-W-4C:	Trench 7, Site 19

Site #7, 218-W-4B, Trench TV-7, was not investigated due to the steepness of the slope on top of the trench. Site #11, 218-W-4B, Trench 11, was not investigated due to difficulties in site access and termination of project funding for the fiscal year. A geophysical investigation using Ground-Penetrating Radar (GPR) and/or Electromagnetic Induction (EMI) was conducted at each of these sites.

2.0 OBJECTIVES

The objectives of these geophysical investigations were to verify locations of buried materials within the selected sites and to determine the thickness of the fill over the buried materials. GPR and EMI were the methods selected for the investigation.

3.0 METHODOLOGY

3.1 GROUND-PENETRATING RADAR

The GPR system used for this work utilized a 300-megahertz (mHz) transducer. The transducer transmits electromagnetic energy into the ground. Buried objects such as pipes, barrels, foundations, and buried wires can cause all, or a portion of, the transmitted energy to be reflected back to a receiving antenna. Geologic features such as crossbedding, caliche horizons, paleosols, and clays can also cause reflections of the transmitted energy. The reflected energy provides the means for mapping the subsurface features of interest whether man-made or geologic.

The maximum depth of investigation varies from site to site and is a function of the transmit power, receiver sensitivity, frequency of the antenna, and attenuation of the transmitted energy. The attenuation of the energy is primarily a function of the local soil conditions. The depth of investigation is also affected by highly conductive material, such as metal drums and pipes, which essentially reflect all the energy. Since all the energy is reflected, the method cannot "see" below such objects. Maximum depths of penetration for these surveys ranged from 10 to 15 ft.

Display and interpretation of GPR data are similar to that of seismic reflection data (i.e., data are displayed as horizontal distance versus time, depicting pseudo cross-sections of the earth). The approach to an interpretation is quite variable and influenced by the objectives of the survey and the experience of the interpreter. There are also numerous data processing techniques available that may or may not aid in the interpretation process. In some areas, interpretations can be straight forward, but often a highly variable subsurface yields complex data that are difficult to interpret. A common end-product is a plan-view map showing the locations and depths of the features that were detected within the survey area.

GPR data in these surveys were collected with a Geophysical Survey Systems Inc. (GSSI) Subsurface Interface Radar (SIR 10)[1TM]. Recording windows of 100 nanoseconds (*n*sec), 108 *n*sec and simultaneous channels with 37.5 *n*sec and 75 *n*sec were employed at the onset, however 108-*n*sec, two-way travel time was settled on as it was judged to assure maximum depth of investigation without sacrificing the shallow data.

3.2 ELECTROMAGNETIC INDUCTION

The EMI techniques are used to determine the electrical conductivity of the subsurface soil, rock, and groundwater. They are generally used for shallow investigations. The method is based on a transmitting coil radiating an electromagnetic field which induces eddy currents in the earth. A resulting secondary electromagnetic field is measured at a receiving coil as a voltage which is linearly related to the subsurface conductivity. Terrain or ground conductivity is a function of the natural soil matrix and pore fluid electrical conductivity. The depth of investigation is dependent upon the electrical conductivity of the subsurface, the distance between the transmitting and receiving coils, and the sensitivity of

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[TM1] A trademark of Geophysical Systems Inc. (GSSI) equipment and power of the source. The conductivity value resulting from a measurement is a composite, and represents the combined effects of the thickness of the stratigraphic layers, their depths, their specific conductivities and any man-made conductive objects that may be present, such as metal objects. Metallic objects generally overwhelm the natural conductivity of the ground.

A Geonics' EM-31D[2TM] ground conductivity meter was used for the survey and has a maximum depth of penetration of approximately 18 ft. EMI is an effective reconnaissance method used to locate buried metallic objects. The interpretation of EMI data does not yield reliable quantitative information such as depths and the shapes and sizes of objects. However, in areas where the effectiveness of GPR is limited by the surrounding terrain, EMI yields valuable information. The most reliable interpretations are a result of the integration of GPR and EMI data.

3.3 ACCURACY/UNCERTAINTY OF THE METHODS

EMI and GPR investigations are based on an interpretation of very accurate measurements. Interpretations usually include a map showing locations and estimated depths to anomalous features in the survey area. Some interpretations are taken a step further and include a discussion on the source of the anomalies. There are no clear methods to quantify the accuracy/error or uncertainty of an interpretation, essentially the end-product. Interpretations are subjective and significantly influenced by such factors as the density of the data and the experience of the interpreter(s). Other factors that effect the uncertainty of an interpretation are soil conditions, topography, availability of drawings and photographs, geologic knowledge, and accessibility to the area which is to be investigated. "Ground-truthing" is the only available method that can measure the accuracy of an interpretation. The best estimate of the uncertainty in an interpretation comes from the confidence of the interpreters in the interpretation. Confidence in an interpretation reflects the objectives, available supporting data (i.e., photographs, drawings, etc.), experience, and numerous other factors. To further complicate the issue of uncertainty within a given survey area, the confidence may vary considerably from profile to profile. Some areas may be straight forward while others are very complex and puzzling.

Interpreters must communicate clearly with the end-users. Taking an interpretation map only at face-value should be avoided.

4.0 SURVEY GRID

A grid was established for each site following common techniques, dependent on site size, with the grid always extended beyond given site coordinates. The grid boundaries are typically rectangular with northing and easting lines designated by footage values preceded by either an "N" or an "E" with the origin at the southwest grid corner designated N100,E100. The letters "N" or "E" refer to a direction that trends generally north or east, respectively. The grid lines define a 5-ft by 5-ft grid with the exterior corners marked with blue stakes and their survey addresses. Grid intersections were marked by paint dots

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[TM2] A trademark of Geonics Limited

on the ground. Grids are further tied to the Hanford/Plant coordinate system via orange survey stakes established by Kaiser Engineering Hanford (KEH). The number refers to a distance in feet. For example, grid point E135/N120 lies 35 ft "east" and 20 ft "north" of grid point E100/N100. Geophysical surveys such as antenna traverses are obtained on the south or east edge of the grid line to minimize grid disruption. GPR profiles were collected in both east-west and north-south directions. EMI data were also collected along east-west profiles. The profiles were 5 ft apart with data readings taken every 2.5 ft. Each point was not precisely surveyed, but instead was "chained" in. However, all known survey points are believed to be within 1 ft of an accurately surveyed location.

5.0 GEOLOGIC SETTING

The 200 West Area vadose zone is about 200 ft thick. The upper geologic unit, the Hanford formation, is approximately 100 ft thick and consists of two stratigraphic sequences. The first is a coarse-grained sequence of interstratified gravel, sand, and some silt. The second sequence is much finer grained, consisting of silt, silty sand, and sand interbedded with coarse sand. The sediments that were a factor for this investigation were primarily the upper sands and gravels that were "reworked" during the excavation and subsequent back filling of the trenches.

6.0 RESULTS: 218-W-4B BURIAL GROUND

6.1 RETRIEVAL SITE #6. MODULE 5, TRENCH 7, 218-W-4B BURIAL GROUND

The 25-ft by 55-ft grid is located on top of an east-west trending berm approximately 10 ft high that slopes off to an area of level topography over a 12-ft to 13-ft run. The area generally north of an imaginary line from the grid's northeast corner trending southwest to the midpoint then west is a rugose topography with local differentials of 1 to 1.5 ft. The grid area south of the imaginary line is flat and smooth while still on top of the berm.

GPR results (Figure 2) indicate the majority of the area has buried material with 3.5 to 4 ft of cover and a small area in the northwest with slightly more cover. The north and south extent of the reflector(s) coincide closely with the break in slope in their respective directions. The east and west extensions exceed their respective site boundaries. EMI data are presented as ground conductivity and the inphase component in Figure 3 is consistent with the GPR interpretation.

6.2 RETRIEVAL SITE #8. TRENCH TV-7, 218-W-4B BURIAL GROUND

Site 8 is delineated by the west coordinates W77,553 and W77,573 and its steep slope combined with a rough surface precluded the acquisition of definitive data with the methods utilized.

6.3 RETRIEVAL SITE #10. MODULE 18, TRENCH 7, 218-W-4B BURIAL GROUND

The eastern coordinates of Site 10 (W78,003) are 7 ft west of the western coordinates of Site 5 (W77,996). The grid and surveys established at Site 5 (Bergstrom and others., 1994) were extended to the west of Site 5 at the time of that investigation to include what was interpreted as the westernmost extent of anomalies which ended just east of Site 10 for Trench 7. There were no indicated reflectors in Site 10.

7.0 RESULTS: 218-W-4C BURIAL GROUND

7.1 RETRIEVAL SITE #19. TRENCH 7, 218-W-4C BURIAL GROUND

A 40-ft by 50-ft grid was established over Site 19, a smooth, level surface. The GPR transducer was pulled on either side of the grid lines which were established 5 ft apart. A general reflector indicated at approximately 3.5 ft in depth is represented by the hatch zone on Figure 4. This reflective horizon is irregular and has from 1 ft or less to 4 ft of cover. In addition more than a dozen individual anomalies having from less than 1 ft to more than 4 ft of cover occurred throughout the grid area. The EMI data presented in Figure 5 indicate no definable metallic objects, thus the GPR reflectors contain minimal metal or for reasons unknown have little of no effect on the EMI.

8.0 RESULTS: 218-W-3A BURIAL GROUND

8.1 RETRIEVAL SITE #9. TRENCH 6, 218-W-3A BURIAL GROUND

GPR data were not available at the time of this report. EMI results (Figure 6) indicate an anomaly to the west-central portion of the grid area. We are unable to tie the grid directly into survey coordinates at this time as access to the site is limited.

8.2 RETRIEVAL SITE #18. TRENCH 6S, 218-W-3A BURIAL GROUND

A 50-ft by 70-ft grid was established over the site coordinates and offset to the west in order to include that end of the trench. The site is level and relatively smooth. The GPR interpretation (Figure 7) shows a few small reflectors with 1 to 2 ft of cover. The EMI ground conductivity and inphase component (Figure 8) are nondescript over the area defined by the site coordinates, however both indicate an anomaly building to the east of the grid area.

8.3 RETRIEVAL SITE #7. TRENCH 8, 218-W-3A BURIAL GROUND

GPR data interpreted in Figure 9 indicate a reflective area 6 to 10 ft wide (north-south) and approximately 35 ft long (east-west) located slightly to the north of the site's center. Depth of burial is interpreted to be 9.5 to 10 ft. A PVC pipe "vent" is located just south of the reflector's center. In addition, several individual reflectors are indicated ranging from near-surface to 7 ft in depth. The EMI data are presented in Figure 10 and closely support the GPR interpretation.

8.4 RETRIEVAL SITE #13. TRENCH 8, 218-W-3A BURIAL GROUND

The GPR interpretation (Figure 11) shows a reflective zone approximately 10 ft wide (north-south) and 15 ft long (east-west) located north of the site center. Depth of burial ranges from 4.5 ft towards its western end to 6.5 ft to the east. EMI results (Figure 12) show an anomaly towards the eastern end of the GPR reflector, indicating more metal towards that end.

8.5 RETRIEVAL SITE #14. TRENCH 8, 218-W-3A BURIAL GROUND

A 50-ft by 280-ft grid was established over the relatively flat, smooth surface. The interpretation of the GPR data (Figure 13) indicates eleven reflective concentrations, most of which are located along the site centerline running eastwest. These zones have cover ranging from 4 ft to greater than 8 ft. There are also numerous individual reflectors, ranging from less than 1 ft to more 8 ft in depth, scattered over the site. The EMI data (Figure 14) substantiate the GPR reflective zones, plus indicate a subtle anomaly in the eastern quarter of the grid that was not interpreted from the GPR data.

8.6 RETRIEVAL SITE #17. TRENCH 9S, 218-W-3A BURIAL GROUND

The GPR interpretation (Figure 15) indicates a reflective zone approximately 10 ft by 10 ft with 8 to 9 ft of cover centered in the site's coordinates. EMI results in Figure 16 are in close agreement with the GPR interpretation.

8.7 RETRIEVAL SITE #12. TRENCH 17, 218-W-3A BURIAL GROUND

The GPR interpretation (Figure 17) shows a zone of reflections approximately 10 ft wide at the center and tapering to 5 ft towards the north and south ends. The zone extends 20 ft north-south and is centered just north of the site's center. It is interpreted to have 4 to 4.5 ft of fill covering the reflective material. A second, larger reflective zone starts 5 ft off the site's eastern coordinates and extends eastward off the grid with 3 to 4 ft of cover. EMI results (Figure 18) show weak evidence of the zone actually within the site's coordinates; however, they show a strong anomaly coinciding with the eastern zone off the actual site and extending off the grid.

8.8 RETRIEVAL SITE #15. TRENCH 17, 218-W-3A BURIAL GROUND

The GPR interpretation (Figure 19) depicts 7 zones with concentrations of reflectors. Six primary zones ranging from 15 to 30 ft wide (north-south) are located along an east-west trending centerline. The eastern and western most zones extend beyond their respective grid boundaries. The zones are separated by 1 to 3 ft with cover ranging from 2 to 6 ft. The EMI results (Figure 20) indicate multiple anomalies with a pattern similar to the GPR interpretation. Anomaly boundaries differ slightly from GPR picks, which is attributed to the close proximity of the anomalies and variability of buried materials.

8.9 RETRIEVAL SITE #16, TRENCH 17, 218-W-3A BURIAL GROUND

The GPR interpretation (Figure 21) presents a predominant zone of reflection and three lesser zones. The predominant zone is approximately 25 by 50 ft, elongated in the eastwest direction while generally centered in the site and having 1 to 7 ft of cover, suggesting an irregular reflective horizon. Three smaller zones, one to the northwest of approximately 50 sq.ft. and with 2 ft of cover, a second to the south center being lenticular approximating 3 by 20 ft with the long axis east-west and 3 to 5 ft of cover and the third zone to the northeast 15 ft wide and extending off the grid with 1 to 5 ft of fill. The EMI results (Figure 22) support the major zones defined by GPR but add little to the interpretation.

9.0 REFERENCES

Anderson, B. C., J. D. Anderson, J. A. Demiter, D. R. Duncan, and D. C. McCann, 1989, *Contact-Handled Transuranic Waste Characterization Based on Existing Records*, WHC-EP-0225, Westinghouse Hanford Company, Richland, Washington.

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Figure 1: General Site Location Map

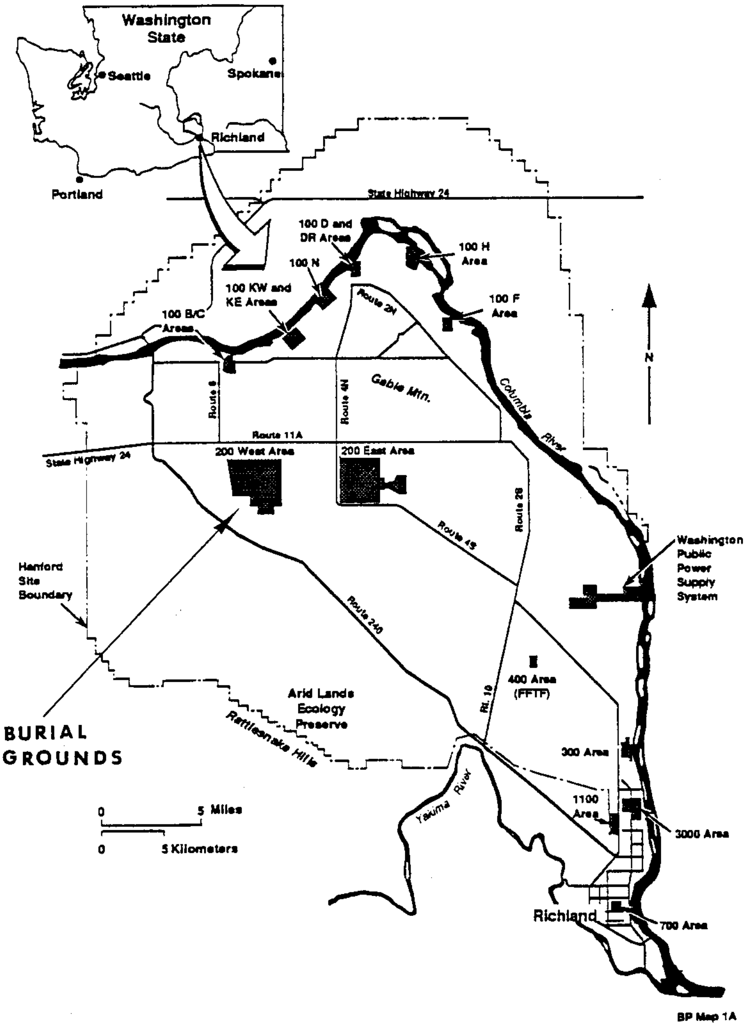


Figure 2: Ground-Penetrating Radar Interpretation Site 6

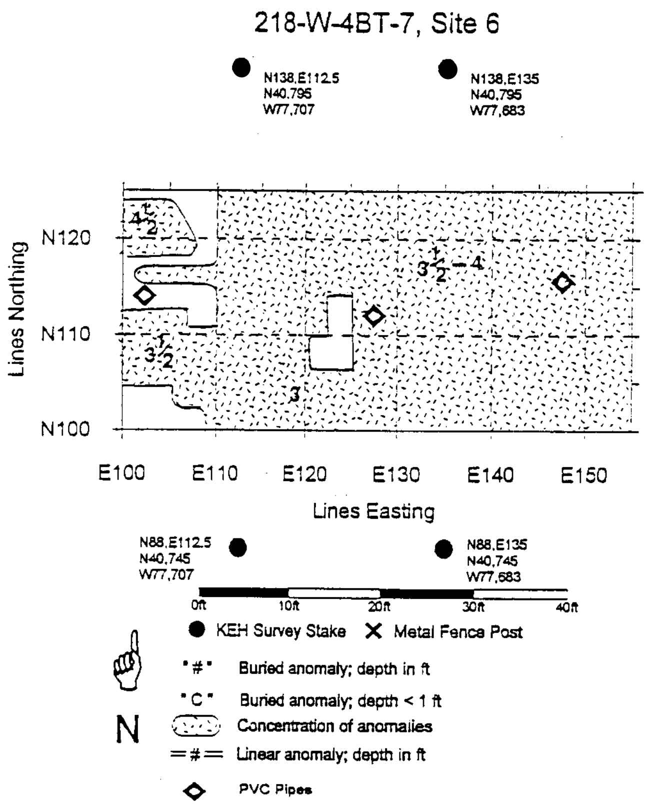


Figure 3: Electromagnetic Induction Results Site 6

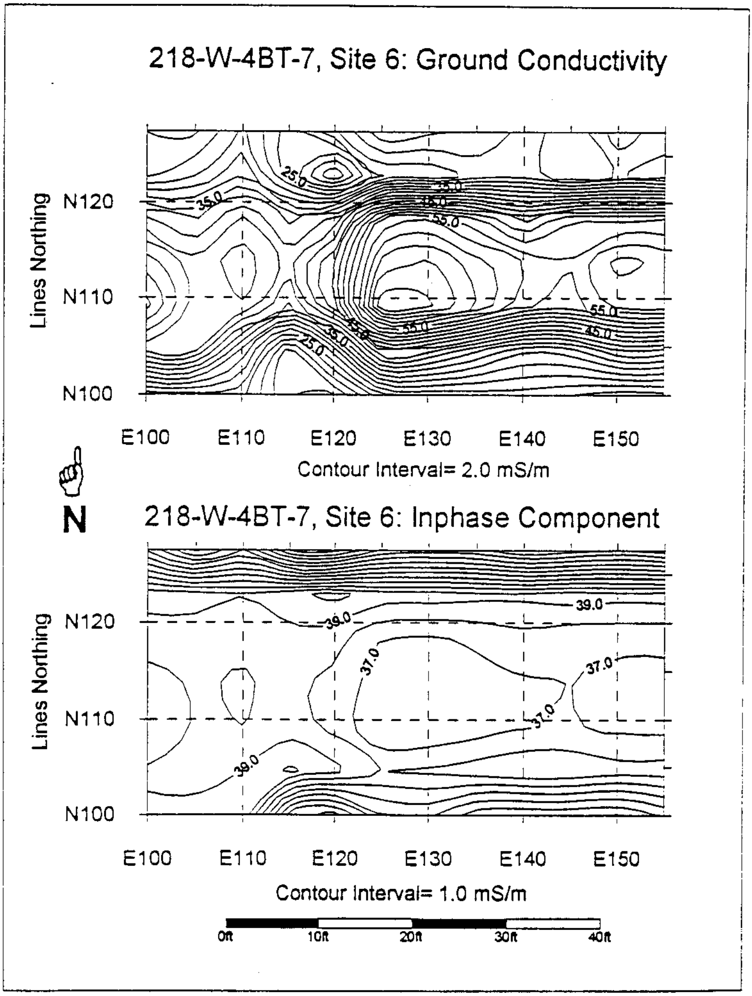


Figure 4: Ground-Penetrating Radar Interpretation Site 19

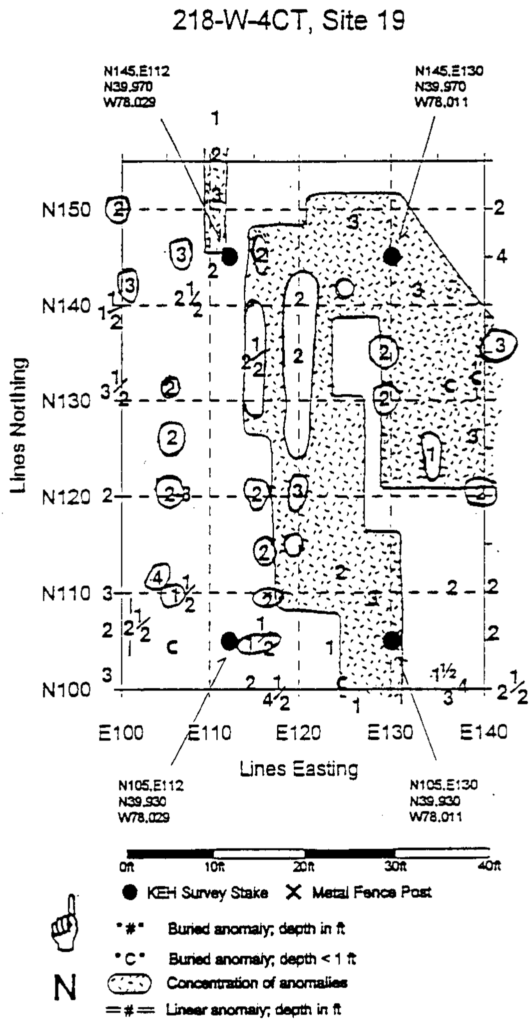


Figure 5: Electromagnetic Induction Results Site 19

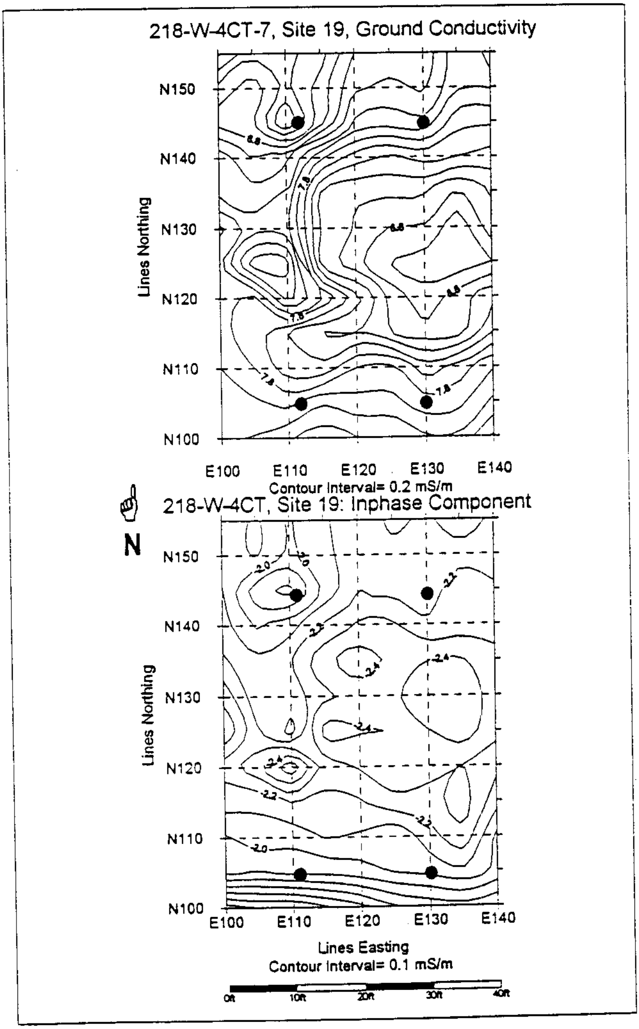


Figure 6: Electromagnetic Induction Results Site 9

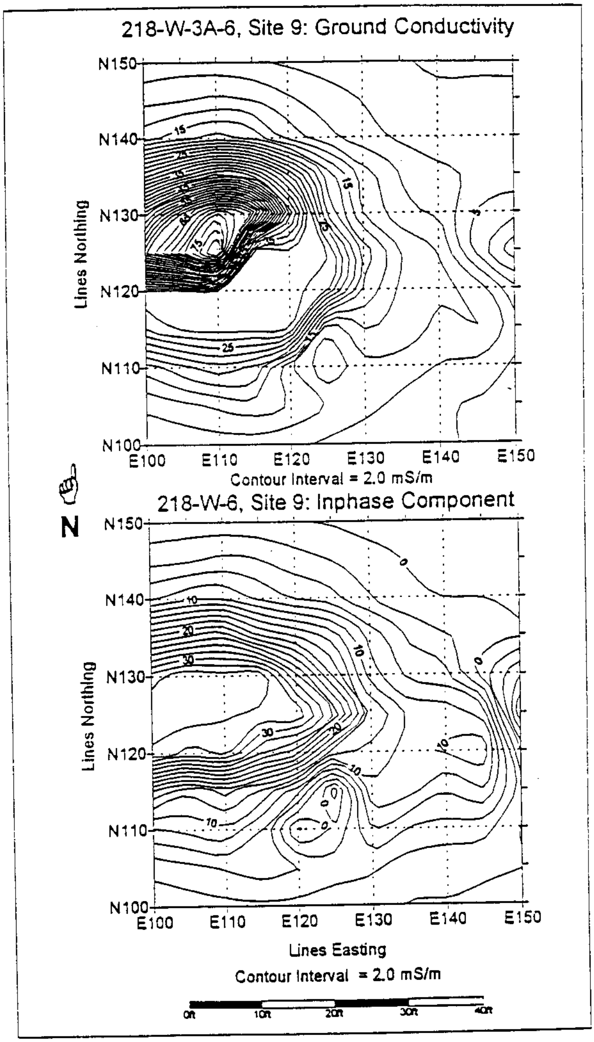


Figure 7: Ground-Penetrating Radar Interpretation Site 18

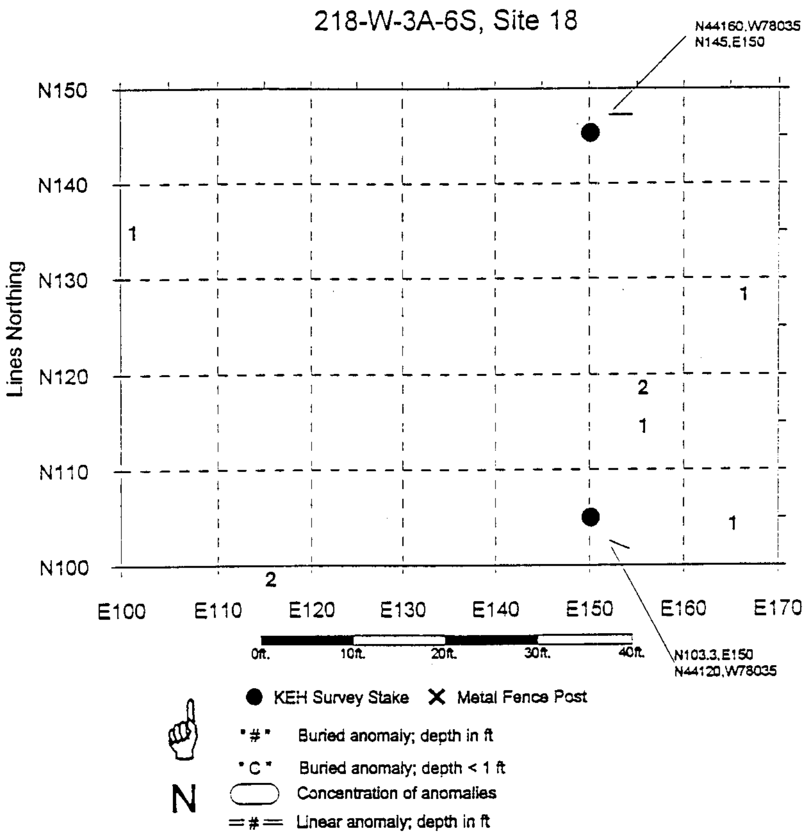


Figure 8: Electromagnetic Induction Results Site 18

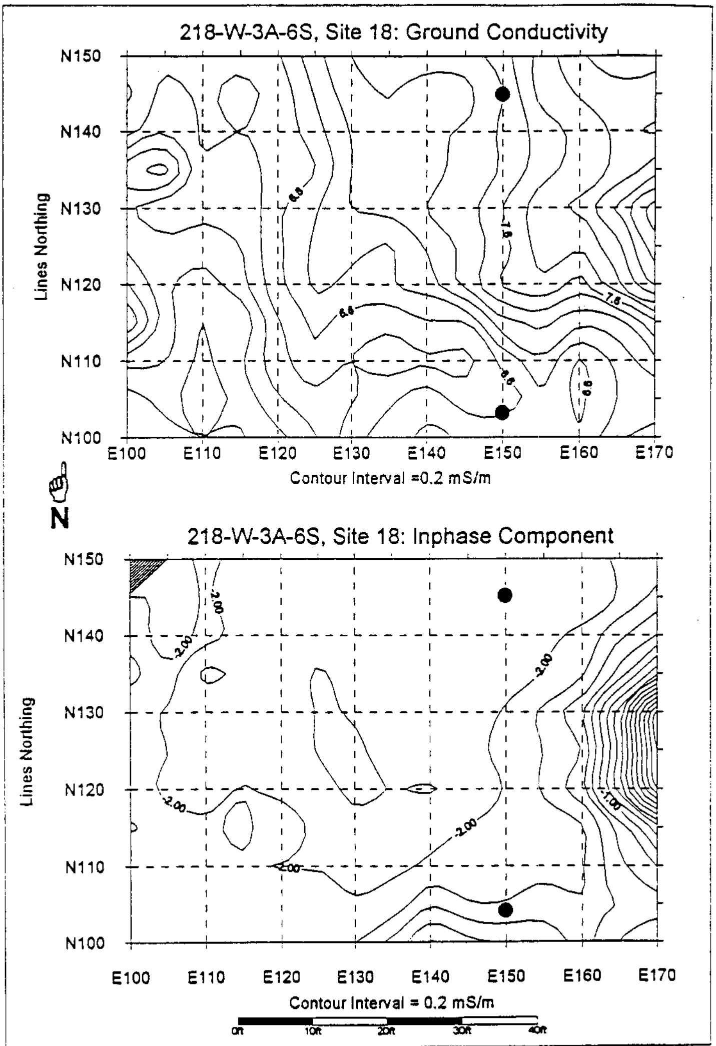


Figure 9: Ground-Penetrating Radar Interpretation Site 7

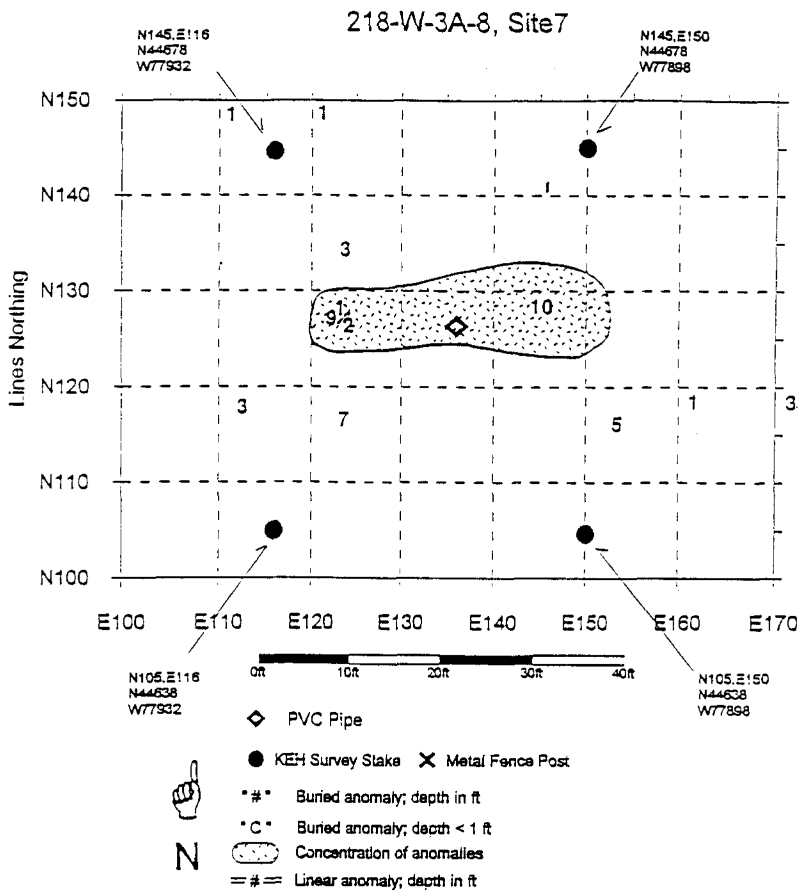


Figure 10: Electromagnetic Induction Results Site7

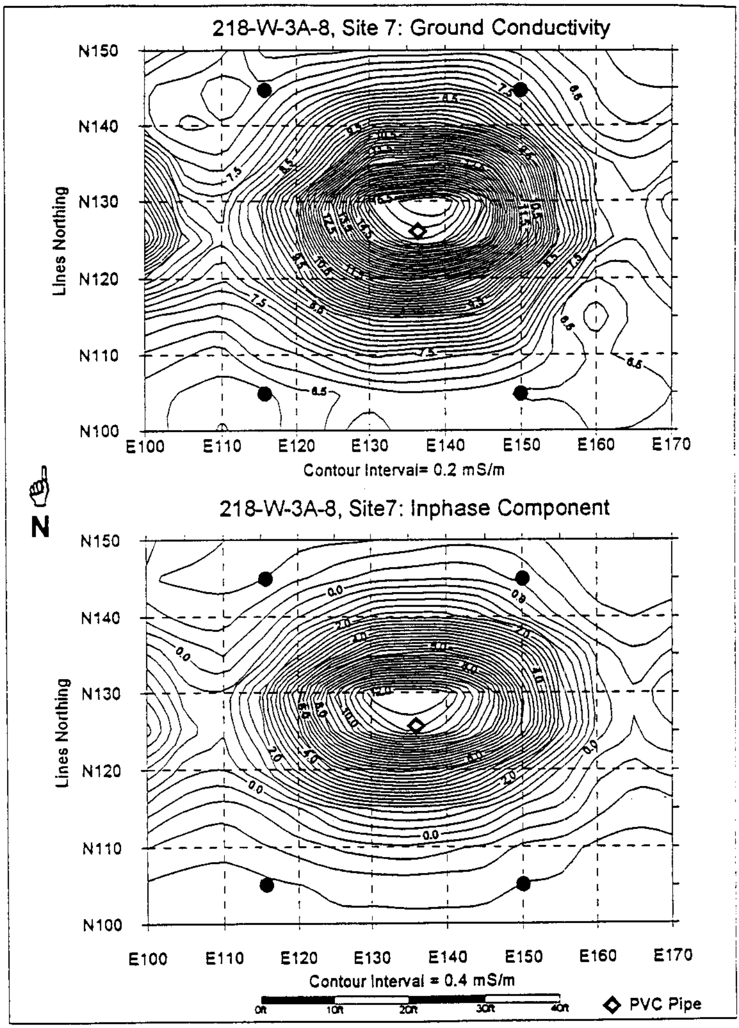


Figure 11: Ground-Penetrating Radar Interpretation Site 13

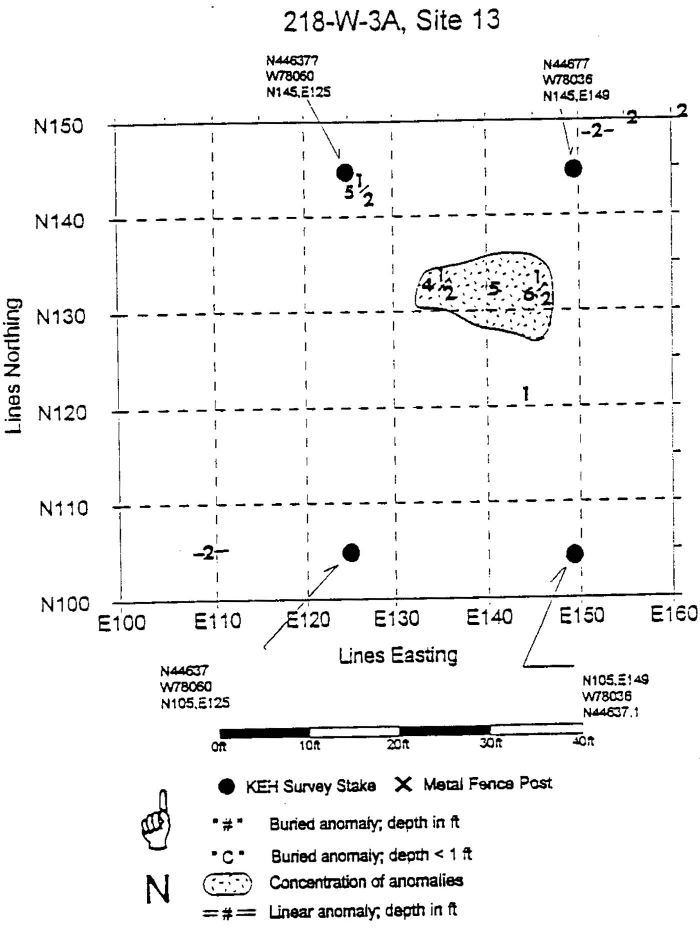


Figure 12: Electromagnetic Induction Results Site 13

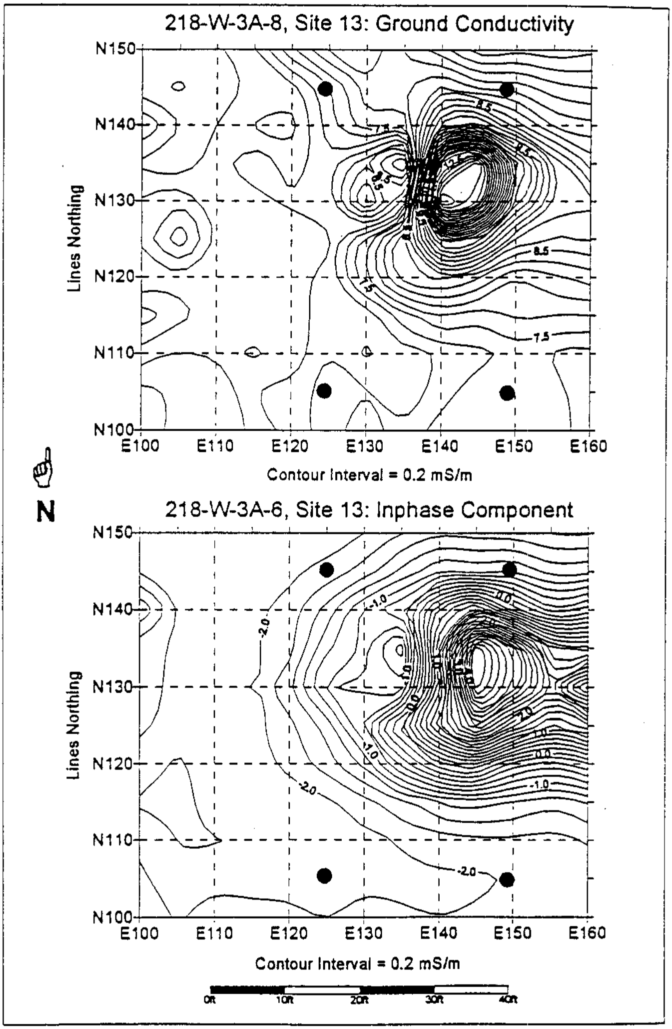


Figure 13: Ground-Penetrating Radar Interpretation Site 14

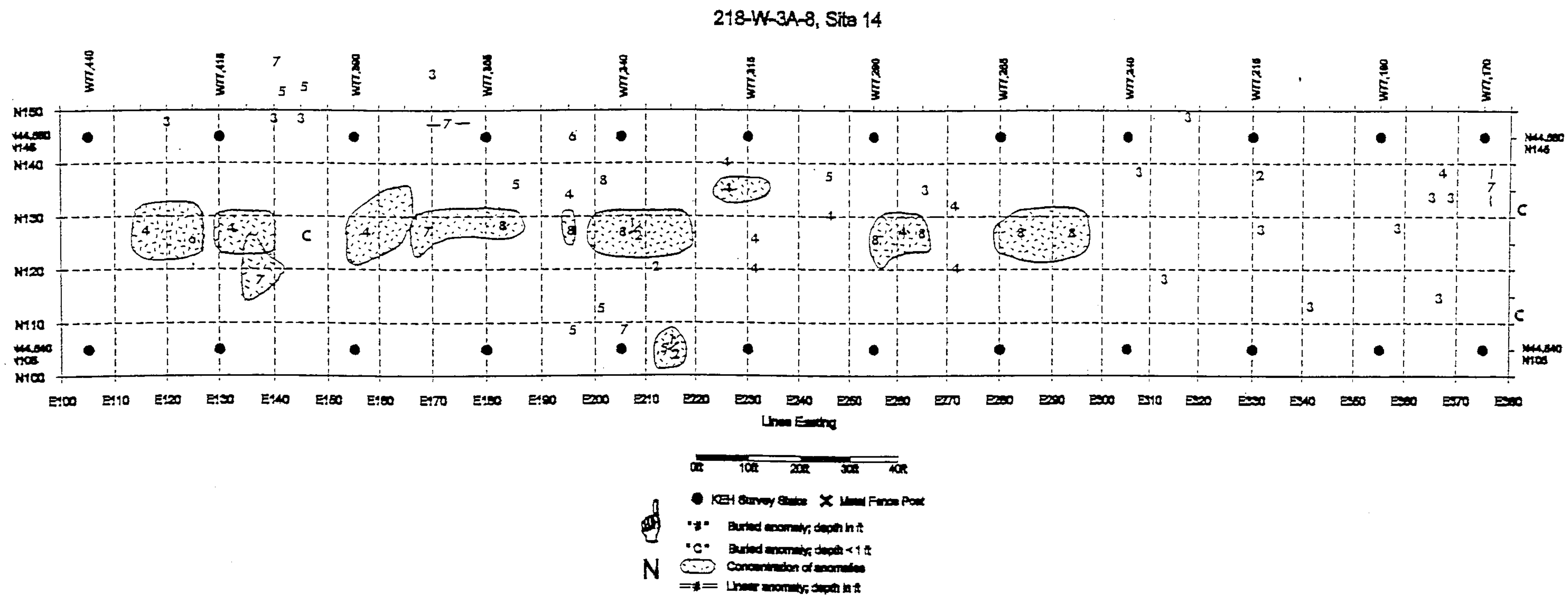


Figure 14: Electromagnetic Induction Results Site 14

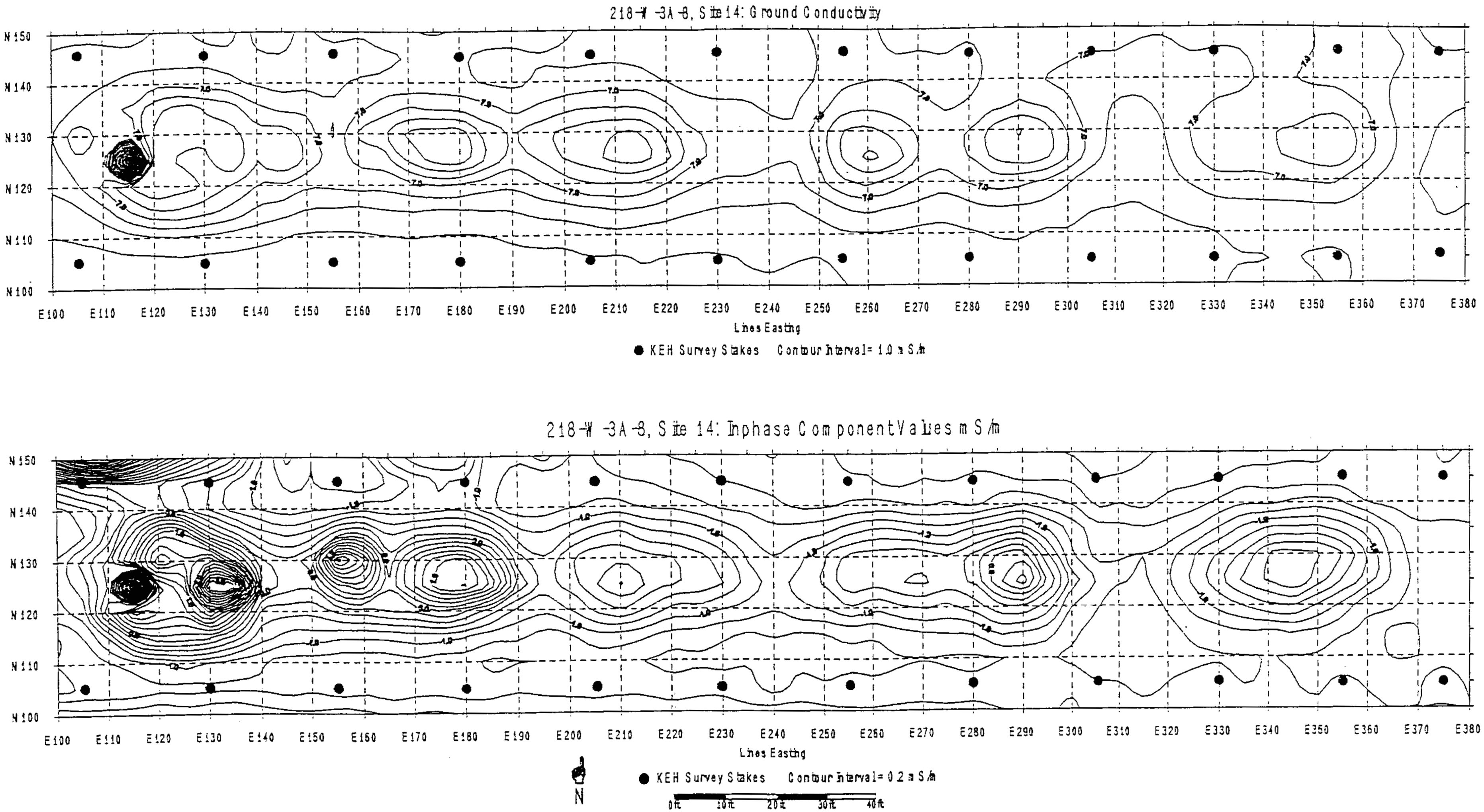


Figure 15: Ground-Penetrating Radar Interpretation Site 17

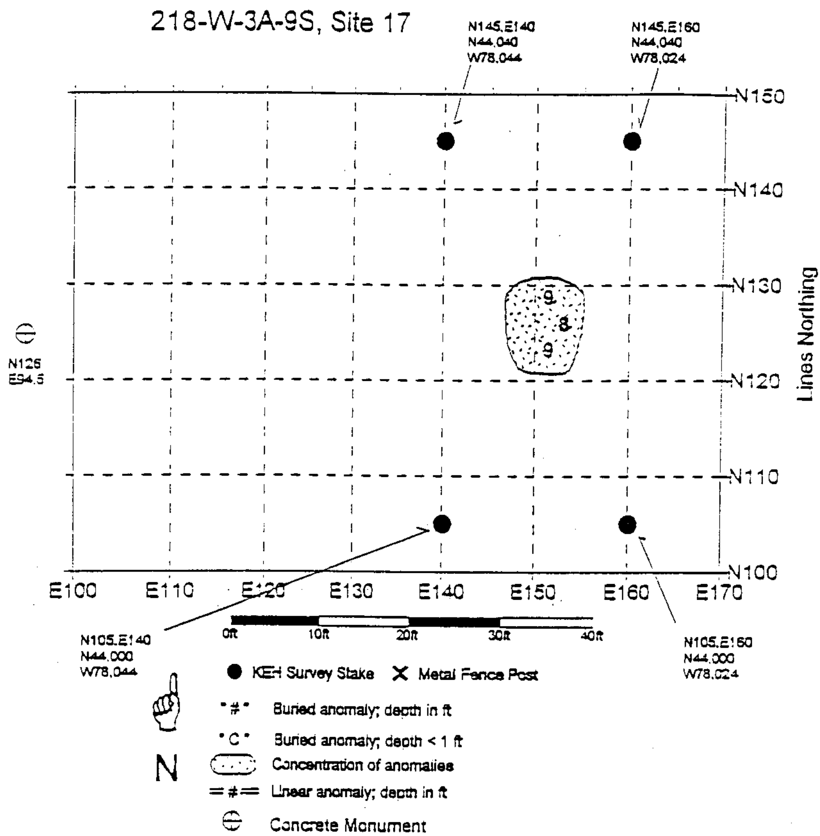


Figure 16: Electromagnetic Induction Results Site 17

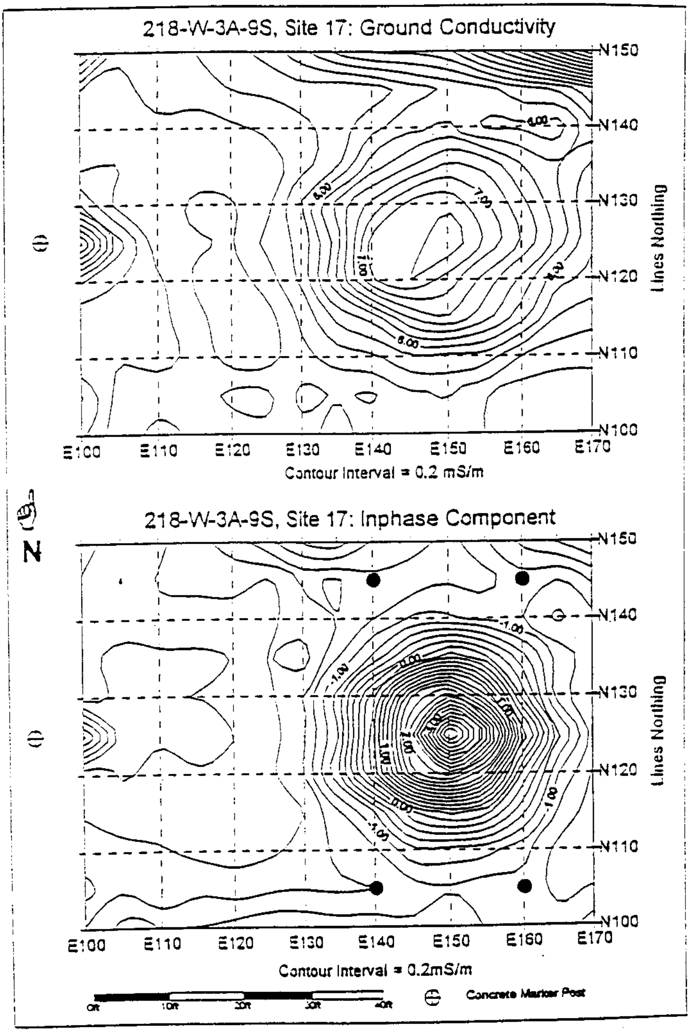


Figure 17: Ground-Penetrating Radar Interpretation Site 12

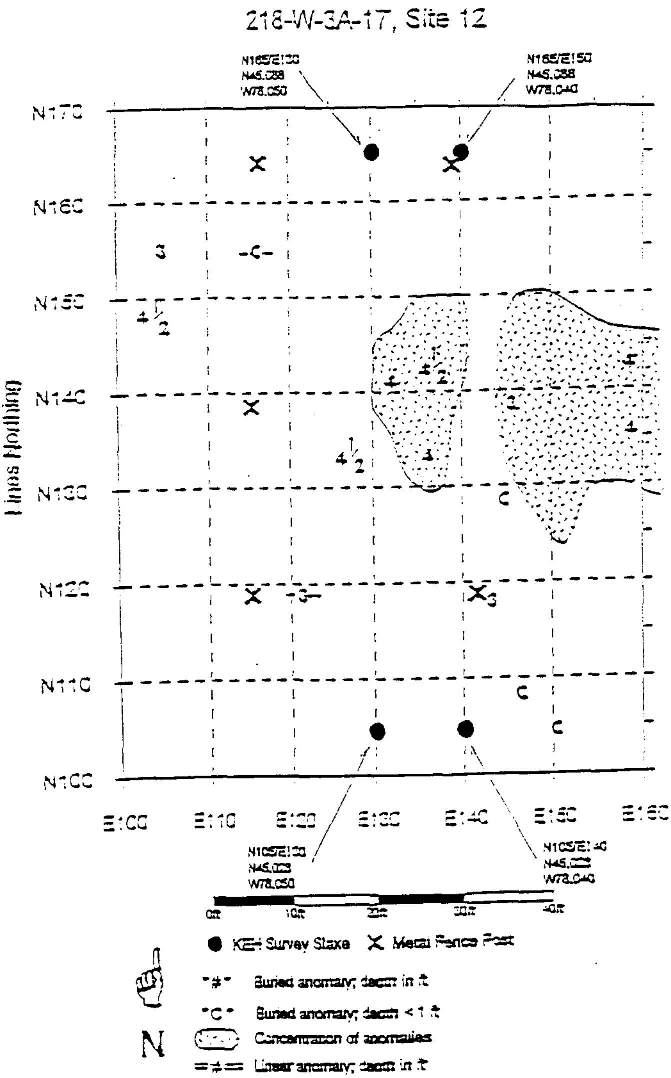


Figure 18: Electromagnetic Induction Results Site 12

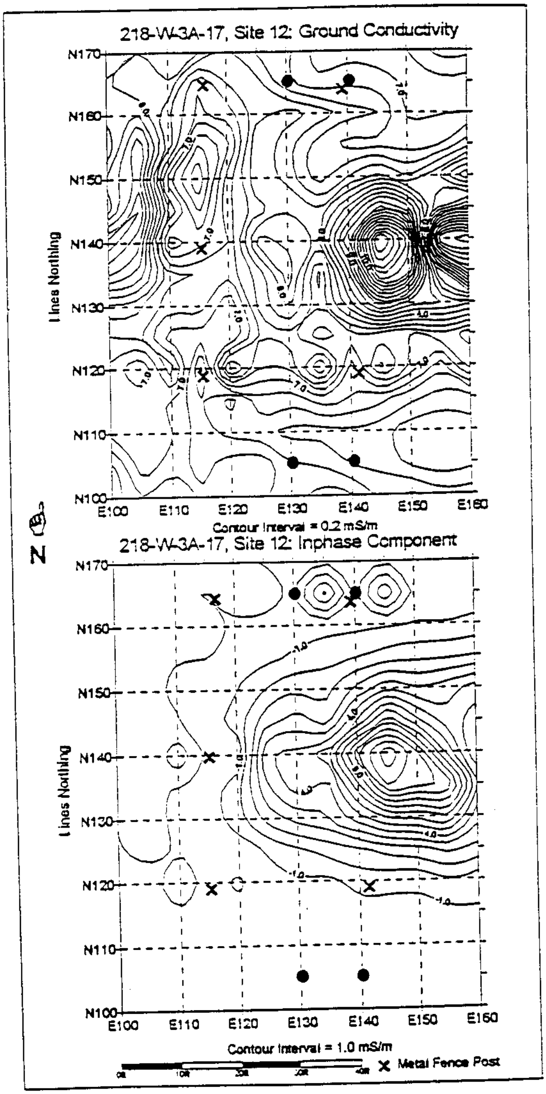


Figure 19: Ground-Penetrating Radar Interpretation Site 15

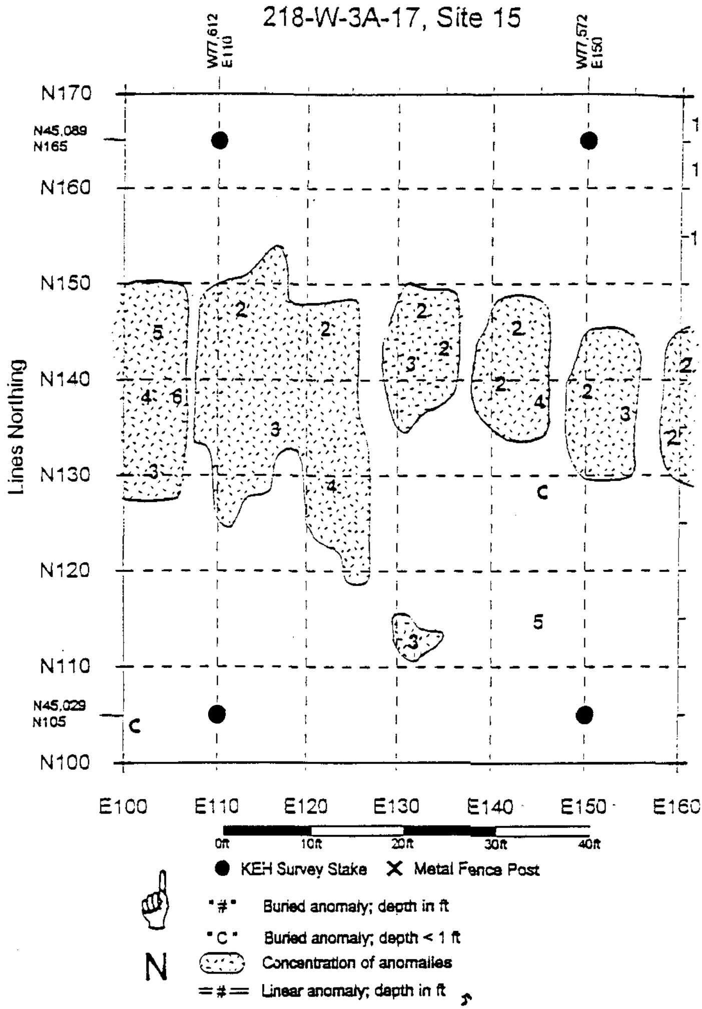


Figure 20: Electromagnetic Induction Results Site 15

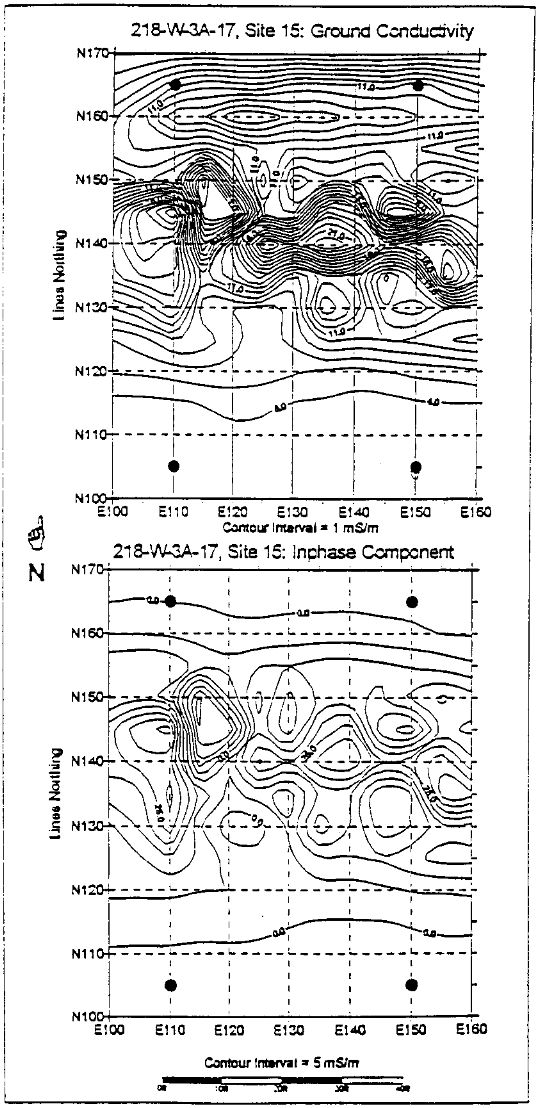


Figure 21: Ground-Penetrating Radar Interpretation Site 16

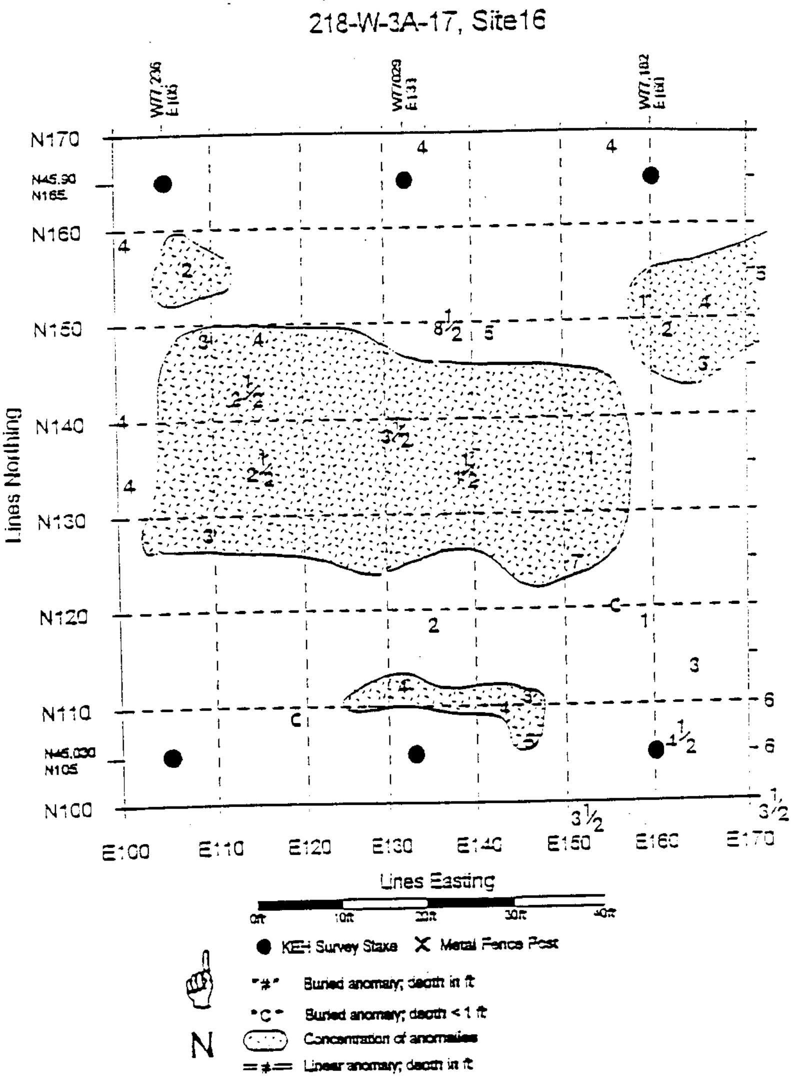
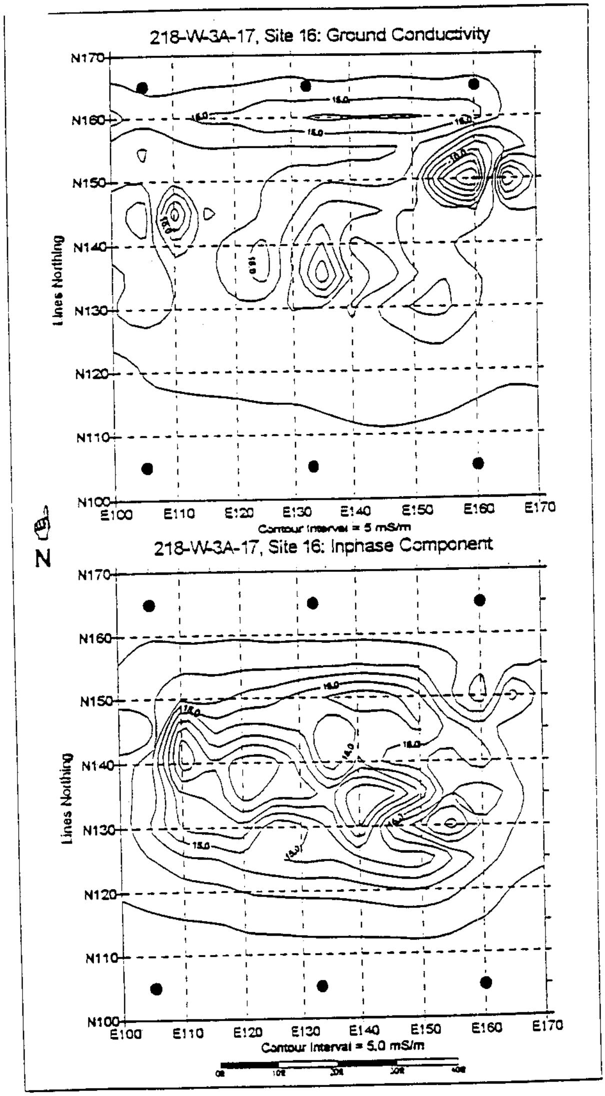


Figure 22: Electromagnetic Induction Results Site 16



APPENDIX A

Metric Conversions

To Convert	Multiply By	To Convert	Multiply By
LINEAR MEASURE (LENGTH)			
inches to millimeters	25.4	millimeters to inches	0.0394
inches to centimeters	2.54	centimeters to inches	0.394
feet to meters	0.305	meters to feet	3.281
yards to meters	0.914	meters to yards	1.094
miles to kilometers	1.609	kilometers to miles	0.621
SQUARE MEASURE (AREA)			
square inches to square centimeters	6.452	square centimeters to square inches	0.155
sq feet to sq meters	0.0929	sq meters to sq feet	10.764
sq yards to sq meters	0.836	sq meters to sq yards	1.196
acres to hectares	0.405	hectares to acres	2.471
CUBIC MEASURE (VOLUME)			
cubic inches to cubic centimeters	16.387	cubic centimeters to cubic inches	0.0610
cu feet to cu meters	0.0283	cu meters to cu feet	35.315
cu yards to cu meters	0.765	cu meters to cu yards	1.308
LIQUID MEASURE (CAPACITY)			
fluid ounces to liters	0.0296	liters to fluid ounces	33.814
quarts to liters	0.946	liters to quarts	1.057
gallons to liters	3.785	liters to gallons	0.264
imperial gallons to liters	4.546	liters to imperial gallons	0.220
WEIGHTS (MASS)			
ounces avoirdupois to grams	28.35	grams to ounces avoirdupois	0.0353
pounds avoirdupois to kilograms	0.454	kilograms to pounds avoirdupois	2.205
tons to metric tons	0.907	metric tons to tons	1.102
TEMPERATURE			
32 °F (freezing point of water)	0 °C		
212 °F (boiling point of water)	100 °C		
98.6 °F (body temperature)	37 °C		
To find degrees Celsius, subtract 32 degrees Fahrenheit and divide by 1.8. To find degrees Fahrenheit, multiply degrees Celsius by 1.8 and add 32.			

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