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1.0 INTRODUCTION

1.1 BACKGROUND

The Nonradioactive Dangerous Waste Landfill (NRDWL) is located on the Hanford Site approximately 3.5 miles southeast of 200 East Area (Figure 1). The NRDWL is a treatment storage and/or disposal unit and is designated for closure under the *Resource Conservation and Recovery Act of 1976*. The NRDWL has been assigned to the 200-IU-3 operable unit. It was used for dangerous waste disposal from January 1975 through May 1985. The waste was generated from process operations, research and development laboratories, maintenance activities, and transportation functions throughout the Hanford Site.

The NRDWL covers approximately 10 acres and is located at the northern end of the Solid Waste Landfill (Figure 2). It includes 19 unlined trench locations, each approximately 400 ft long and 46 ft wide. Six of the trenches contain chemical waste, nine trenches contain asbestos waste, one trench contains sanitary solid waste, and three trench locations were never used. See *Nonradioactive Dangerous Waste Landfill Closure/Postclosure Plan* (DOE-RL 1990) for detailed descriptions of the wastes contained within each trench.

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Site closure includes placing a cover over the facility to prevent postclosure escape of buried waste. A subsurface site characterization is required to provide information to support final cover design and associated activities. A noninvasive subsurface characterization is also important to the groundwater monitoring program.

This report summarizes the results of the geophysical investigations conducted for site characterization. Ground-penetrating radar (GPR) and electromagnetic induction (EMI) were the two techniques used in the investigation. GPR was specifically identified in DOE-RL (1990). EMI was used to supplement the GPR, particularly in areas where the GPR effectiveness was limited by the terrain.

1.2 OBJECTIVES

The primary objectives of the geophysical investigation were to:

- Define trench boundaries
- Evaluate soil properties
- Assess the presence and extent of voids in the landfill area.

Results of the geophysical surveys were used to assist selection of soil-gas sampling locations and specifically to minimize the risk of penetration of buried hazards during installation of soil-gas probes. The results will be used to: (1) locate monitoring wells, (2) approximate locations of waste containers, and (3) locate and characterize a trench designated J.A. Jones (JAJ) trench, a nonhazardous waste trench immediately to the south of the hazardous trenches (Figure 2).

2.0 GEOLOGIC SETTING

The NRDWL is located within the Cold Creek syncline, an asymmetrical, relatively flat-bottomed structure between the Umtanum Ridge-Gable Mountain uplift and the Yakima Ridge uplift (Figure 3). The site is located on the northern flank of the syncline where bedrock (basalt) is gently dipping, approximately 5°, to the south.

Approximately 600 ft of suprabasalt sediments overlay the layers of basalt that make up the bedrock that defines the Cold Creek syncline. The sediments include the Ringold Formation, early Plio-Pleistocene soils, the Hanford formation, and Holocene surficial deposits (Figure 4). The focus of the geophysical investigations were on the Holocene and upper Hanford formation (Figure 4). Figure 5 is an east-west geologic cross section depicting the sediments at the NRDWL.

The Holocene sediments are primarily eolian sands and silts interspersed with lenses of sands mixed with gravel. The Hanford formation, which are cataclysmic Missoula flood deposits, contains primarily gravely sand to sandy gravel in the study area.

Clastic dikes have been observed in the vicinity of the NRDWL. Clastic dikes are commonly associated with, but not restricted to, the cataclysmic flood deposits.

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3.0 METHODOLOGY

The closure/postclosure plan designated GPR as the geophysical method to be used for characterization. But due to the unfavorable GPR conditions in parts of NRDWL, caused by the mounds of sand around open trenches, EMI data were collected to supplement the GPR. The terrain also adversely affects the EMI, but not to the extent it has on GPR.

3.1 GROUND-PENETRATING RADAR

The GPR system used for this work utilized a 300-megahertz antenna to transmit the electromagnetic (EM) energy into the ground. The transmitted energy is reflected back to a receiving antenna where variations in the return signal are recorded. Common reflectors include natural geologic conditions such as bedding, cementation, moisture, and clay, or man-made objects such as pipes, barrels, foundations, and buried wires.

Depth of penetration at NRDWL was generally 5 to 15 ft. The method is limited in depth by transmit power, receiver sensitivity, and attenuation of the transmitted energy. Depth of investigation is also influenced by highly conductive material, such as metal drums, which reflect all the energy; therefore, the method cannot "see" below such objects.

Display and interpretation of the data are similar to seismic reflection data. In some areas interpretations can be straight forward, but often unknown parameters with a highly variable subsurface yields complex data.

Data for these surveys were collected with a Geophysical Survey Systems Inc. (GSSI) Subsurface Interface Radar (SIR) System 8, model 4800 and digitally stored on a GSSI DT6000A tape drive. A recording window of 100 nanoseconds, two-way travel time, was used, yielding a maximum depth of investigation of about 16 ft.

3.2 ELECTROMAGNETIC INDUCTION

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 that induces eddy currents in the earth. A resulting secondary electromagnetic field is measured at a receiving coil as a voltage that 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 depends on the: (1) electrical conductivity of the subsurface, (2) distance between the transmitting and receiving coils, and (3) sensitivity of 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, depths, specific conductivities, and any man-made conductive objects that may be present such as metal objects. Metallic objects generally overwhelm the natural conductivity.

An EM-31D (a trademark of Geonics Company) was used for the survey and has a maximum depth of penetration of approximately 20 ft. Two measurements were collected, the quadrature and in-phase components. The in-phase component is more sensitive to highly conductive material such as metals.

3.3 GRID/TRENCH PARAMETERS

The survey boundary is rectangular, measuring 550 ft by 920 ft. The long axis of the survey strikes N68° W. Within the survey boundary are 19 parallel, hazardous waste trenches, and a J.A. Jones (JAJ) nonhazardous waste trench that is perpendicular to and south of the other trenches (Figure 6). The boundary line separating the NRDWL from the Solid Waste Landfill is halfway between the JAJ trench and the southern boundary of the NRDWL trenches (DOE-RL 1990).

All trenches were designed to be approximately 400 ft long, 16 ft wide at the base, 15 ft deep, with 46 ft from center to center. Trenches were designed to be separated by a triangular column of undisturbed soil with approximately 1:1 side slopes. The final design profile of the trenches varied depending on the type of waste the trench received. Typical trench design is shown in Figure 7.

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The initial grid lines were designed to be parallel and orthogonal to the strike of the trench centerlines as predicted from engineering drawings. Additionally, the north-south grid lines were spaced at 11.5-ft intervals so the grid lines would theoretically fall on trench centerlines every 46 ft. The data collection was centered around a 20 by 11.5-ft surveyed grid of the NRDWL site. All distances were measured and posted in feet. The southeast corner of the grid is designated E100/N00. The letters "N" or "E" refers to a direction that trends generally north or east, respectively. The number refers to a distance in feet. For example, E200/N300 is 100 ft east and 300 ft north of E100/N00.

The survey was divided into seven sections (Figures 6). Section boundaries were based on topography and changes in the predicted scope of the survey as the data collection and interpretation progressed.

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4.0 RESULTS

The following discussion presents the results of the geophysical investigation. The discussion focuses on interpreted trench boundaries and locating the major concentrations of waste within the trenches. The integrated interpretation (Plate 2) divides the NRDWL into three interpretive categories: (1) undisturbed areas outside the excavated trench boundaries, (2) areas of concentrated anomalies, and (3) scattered, isolated anomalies within the interpreted trench boundaries. In most cases, the anomalies detected are interpreted as buried debris from within the trenches. However, not all anomalies are located within the interpreted trench boundaries.

A pervasive reflecting horizon, interpreted as a calcified zone, proved very significant when interpreting trenches and trench boundaries (Figure 8). The zone is generally found 3 to 5 ft below the surface. A second, similar reflector, is found 3 to 5 ft below the upper calcified layer, but is not reliable as a marker horizon. The caliche horizons are assumed to be relatively flat. Variations in depth to these horizons are interpreted to be a function of the thickness of the overlying eolian deposits (i.e., surface elevation). The upper caliche zone is exposed on the eastern slope of both trench 26 and trench 19N, the two open trenches. In general, if the upper caliche zone was present in the data, it was interpreted as an area outside of the excavated trenches and noted as "undisturbed." It is assumed that during the excavation of the NRDWL trenches, the caliche zone was broken up and removed since the trenches are approximately 15 ft deep and the caliche zone is 3 to 5 ft below the surface. Figure 8 is a GPR profile that shows this relationship.

Generally, the amount of fill overlying the buried waste varied in thickness from 1 to 8 ft. Some trenches had high concentrations of anomalies and in others, the anomalies were relatively spread out. Figure 9 is an example of a section of a GPR profile down the middle of a trench. Note the variation of depths to the debris and the scattered distribution of the anomalies.

EMI data (Plate I) proved very useful, especially when mapping concentrations of anomalies and in areas where the topography limited GPR data acquisition. Plate 2 shows the integrated interpretation and should be referred to during the following discussions. All of the data is included in Mitchell and Bergstrom (1993).

4.1 SECTION A

Section A is the western-most portion of NRDWL, from E100 to E399 (Figure 6). It contains one Sanitary trench (1N), and five asbestos trenches (2N, 20,21,22, and 23). The terrain is relatively flat in the southern half, but in the northern half the terrain drops roughly 8 ft in elevation between N310 to N530.

Subsidence (due to caving in) was observed in three locations; E190/N140, E340/N450, and E340/N300. The subsidence appears to be a result of settling of the overlying fill into voids within buried waste.

Between N100 and N550 the GPR data were collected on a 11.5 by 20-ft grid with east-west profiles every 20 ft and north-south profiles every 11.5 ft. EMI data were collected along north-south profiles 11.5 ft apart with data recorded at 5-ft intervals (Figure 10). Data from Section E west and Section E west extension were also significant to the interpretation of these trenches. Refer to Plate 2, which shows the integrated interpretation for the following trenches.

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4.1.1 Sanitary Trench 1N

Trench 1N contains sanitary waste, which is not considered a dangerous waste but is included as part of NRDWL because of its proximity to the chemical waste trenches and its impact on the design of a postclosure cover (DOE-RL 1990). Generally, this type of waste would be a part of the Solid Waste Landfill. Trench 1N was opened in January 1976 and closed in September 1976.

The trench appears to extend the entire length of the surveyed area, N00 to N550 (Plate 2). The northern extent of the trench was not unequivocally determined. A scattering of GPR anomalies were detected along GPR profile N550. If these anomalies are in the trench, then the northern boundary of the trench was not determined. However, these anomalies are shallow (less than 2 ft below the surface) and could be scattered debris (i.e., cables, pipes, etc.) such as that observed on the surface throughout the site; very little buried debris north of N470 is observed. Because of the lack of debris detected in the northern part of the trench, the preferred interpretation is that the trench actually ends between N530 and N550.

The trench continues beyond the southern survey boundary N00. The western edge of the trench is approximately E123 and the eastern edge, when detectable, is around E169. The center of the trench is approximately E146.

Along its eastern boarder, trench 1N appears to merge with the asbestos trench 2N between N110 to N130 and N330 to N365. A concentration of anomalies was detected in these zones with no indication of a trench boundary between

them. The northern zone appears to be buried debris. It was not possible to determine in which trench the debris was originally buried. The southern zone, N110 to N130, is more ambiguous. The anomalies found in this zone could represent geologic features rather than debris.

The depth to the top of the anomalies varied from 2 ft to over 10 ft below the surface. Most of the anomalies within the trench are covered with a minimum of 4 to 5 ft of fill.

Generally, the heaviest concentration of buried anomalies are south of N270. The average depth to the uppermost anomalies is around 4 ft. Other relatively high concentrations of anomalies are between N310 and N370 and between N410 and N470. The later zone having a considerable number of anomalies in the 1 to 3-ft range.

4.1.2 Asbestos Trench 2N

Trench 2N is the western-most asbestos trench. It was opened in May 1985 and closed in October 1986. The center of trench 2N is essentially E192 (see Plate 2). The southern termination is near N50 with the northern termination near N530. The western edge is generally E169 with the exception of N110 to N130 and from N330 to N370 as discussed previously in Section 4.1.1. The eastern trench boundary undulates around E210 with no apparent breaches with trench 20 to the east.

The detectable anomalies appear to be relatively scattered throughout the trench with major concentrations centered around N100 and between N390 to N419. Thickness of the fill overlying the anomalies varies from 1 to 10 ft with most anomalies in the 2 to 4-ft depth range.

4.1.3 Asbestos Trench 20

Asbestos trench 20 was opened in July 1979 and closed in July 1981. The center of the trench is roughly E238 (see Plate 2). The trench extends from N150 to approximately N540. The western edge is basically E215 and is relatively intact. The eastern edge is roughly E260 and appears to be intact as well.

The trench has relatively high concentrations of anomalies throughout the entire length. The thickness of the overlying fill varies from 2 to 10 ft, but most areas averaged around 6 ft of fill.

4.1.4 Asbestos Trench 21

Asbestos trench 21 was opened in January 1984 and closed in May 1985. Trench 21 is centered at approximately E284 and extends from roughly N90 to N540 (see Plate 2). Its western edge is quite variable, ranging from approximately E255 to E275. However, the trench does not have any obvious breaches between its western neighbor, trench 20. North of N310 the eastern edge is roughly at E307. South of N310 the eastern edge is not clearly defined. From N265 to N310, trench 21 and trench 22 appear to coalesce.

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The same is true between N195 and N230. South of N195 the eastern edge of the trench varies from roughly E290 to E305.

The largest concentration of anomalies is between N130 and N340. North of N340, the anomalies are either more scattered and not as concentrated and/or they are covered with a thicker cover of fill. The anomalies that were identified are generally 8 to 10 ft below the surface in the north end of the trench and 3 to 10 ft in the south end.

4.1.5 Asbestos Trench 22

Asbestos trench 22 was opened in October 1986 and closed in May 1988. Trench 22 is centered around E330 (see Plate 2). The northern end terminates near N530 but the southern end merges with the east-west trending JAJ trench. The western boundary is fairly distinct north of N310 and south of N190. However, between N190 and N310, a boundary separating trench 21 and trench 22 is not apparent, as discussed previously.

The largest concentration of anomalies lies between N390 and N490. Other relatively major concentrations of anomalies are in the proximity of E330/N330, E318/N270, E307/N210, E330/N170, and E318/N150. Most of the anomalies have 4 to 6 ft of fill over them. One exception is at E318/N150, where as little as 1 to 2 ft of fill is present.

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4.1.6 Asbestos Trench 23

Documentation indicates that an asbestos trench should be centered around E376 (see Plate 2). According to DOE-RL (1990), the trench was opened in July 1981 and closed in September 1982. However, the data shows no indication of a trench in this area and there are no anomalies indicative of buried debris.

4.2 SECTION B

Section B extends from E399 to E629 and is centered around an open trench that extends from N110 to N490. The trench is approximately 15 ft deep and 15 ft wide at its base. It appears to be much deeper because it is paralleled by two north-south trending berms. The berms are up to 8 ft higher than the normal ground elevation and are a consequence of the spoils created during the excavation of the open trench. The berms cover several trenches, complicating their characterization.

The induced topography caused by the open trench and surrounding berms severely limited the GPR data acquisition. Those data that were collected were of mixed quality. GPR data collection was limited to north-south profiles every 23 ft. East-west profiles south of N150 and north of the open trench (Figure 11) were also collected.

North-south EMI profiles were spaced every 11.5 ft with readings at 5-ft intervals. However, the additional thickness of soil from the berm prevented the tool from reaching the desired depth of investigation. Given the above limitations, EMI was the more effective of the two methods north of N150,

primarily because EMI data acquisition was possible in places where GPR was not. Because of the limitations described previously, Section B was not characterized nearly to the degree as Sections A and C. These limitations should be considered in the following discussion of the trenches within Section B. Refer to Plates 1 and 2, as they are an integral part of the following trench discussions.

4.2.1 Unused Trench 24

DOE-RL (1990) states that trench 24 apparently was never opened or used. The trench, if it were to be opened, would be centered along profile E422 (see Plate 2). Good GPR data were collected east of E422. West of E422, the data were limited by the terrain. The data that were collected were of poor quality because of the topography. EMI was the more effective of the two methods used east of E422.

The data, though limited, gave no indication that a trench was ever opened or used at this location.

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4.2.2 Asbestos Trench 25

Asbestos trench 25 was opened in September 1982 and closed in March 1984. Trench 25 is located beneath the western berm that parallels open trench 26. Because of the topography, specifically the steep western slope of the open trench and the additional 3 to 8 ft of berm that must be penetrated, delineation of many trench characteristics is incomplete.

The southern end of trench 25 merges with the JAJ trench around N80 (see Plate 2). Though the two trenches merge, no buried anomalies appear in the southern end of the trench that could be confused with anomalies from the JAJ trench. The western boundary of the trench appears to vary between E425 and E435. However, the boundary was only traceable as far as N150. The eastern boundary was also traced as far north as N150. It is located in the vicinity of E468. The northern termination of the trench was not determined.

Anomalies were detected between N100 and N270 at a depth averaging around 9 ft. However, anomalies at N155 and N230 are relatively shallow, 4 ft below the surface, suggesting they are within the berm and quite possibly above the excavated portion of the trench (i.e., normal ground level).

Additional higher quality data, after berm removal, are required to more completely assess trench 25.

4.2.3 Corrosive Trench 26 (Open)

Corrosive trench 26 is the open trench, opened in January 1985, which dominates Section B. It was assumed that the southern and eastern boundary are still relatively intact as observed at the surface. The original western edge of the trench, which is downwind of the prevailing winds, has been hidden under an unknown thickness of windblown sand deposits. The northern end extends beyond the open portion of the trench to approximately N530 (see Plate 2).

A high concentration of GPR and EMI anomalies, approximately 35 ft wide (E505 to E540), extend from N480 to N510. Most of the anomalies originate from a depth 3 to 5 ft below the surface. These anomalies are interpreted to represent buried waste within the northern end of the trench. Three anomalous sections from the GPR data, N170 to N210, N265 to N290, and N360 to N380, were detected along profile E514. These were not noticeable in the EMI data. The GPR data were collected on the relatively steep western slope of the trench such that the radar signal was propagating into the "side" of the hill as much as vertically. Therefore, the depth estimates of 5 to 7 ft below the surface are questionable. It is not known whether these anomalies are within the confines of the original trench boundaries.

Clastic dikes, which have been observed in the vicinity of the NRDWL, can give a signature similar to these enigmatic anomalies. There is also a relatively continuous reflective horizon over each of the anomalous zones. Anomalies with these characteristics are usually geologic in origin, which is the preferred interpretation. However, the possibility that the anomalies are a consequence of buried debris cannot be discounted without further investigation.

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4.2.4 Asbestos Trench 27

Asbestos trench 27, located beneath the eastern berm that parallels open trench 26, was opened in January 1975 and closed in July 1976. Because of the topography, specifically the steep eastern slope of the open trench and the additional 3 to 8 ft of berm that the signal must penetrate, GPR data collection and use were limited. Consequently, detailed trench characterization was not possible.

The southern end of the trench is at approximately N120 and the northern end is in the vicinity of N530 (see Plate 2). The eastern and western boundaries of the trench were not determined because of data limitations.

A relatively high concentration of GPR anomalies was detected along profile E560 between N160 and N410. Most were in the depth range of 8 to 11 ft. The east-west extent of these anomalies were not determined due to the lack of data. It is speculated that these anomalies represent buried debris within the trench. Also detected along profile E560 was an anomaly at N520, possibly buried debris. A moderate concentration of anomalies was found along profile E583 between N135 and N120.

4.2.5 Corrosive Trench 28

This trench was opened February 1984 and closed in January 1985. It is centered at about E615 along the south end and at about E620 at the north end of the trench. The north boundary is at about N540 and the south trench boundary is at about N80 (see Plate 2).

The primary data used to delineate the trench boundaries and location of concentrated anomalies were EMI data. The trench lies beneath a berm of soil from open trench 26. This additional cover and associated relief make GPR difficult or impossible to reliably collect and interpret along some profiles. Additionally, the "extra" soil cover reduces the effectiveness of shallow-

penetration, high-resolution tools such as GPR and EMI. These factors need to be considered in the following discussion on corrosive trench 28.

Neither the east or west edges of the trench are distinctly defined. Asbestos trench 27 and corrosive trench 28 may merge at N220. Trench 28 and asbestos trench 29 appear to merge at several locations; N130, around N290 to N330, and around N470 (see Plate 2).

Anomalies are concentrated in several zones along the entire length (see Plates 1 and 2). Depths to anomalies vary from 5 to 10 ft below the surface (i.e., from the berm level) where present.

4.3 SECTION C

Section C extends from E629 to E905 and covers six trench zones; asbestos trenches 29 and 30, chemical trenches 31, 33, and 34, and unused trench 32. This section is relatively flat with a gentle lowering in elevation of 4 to 5 ft along the northern portion of the section. Section C is bounded on the east and west by berms from open trenches 19N and 26, respectively.

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GPR and EMI data were collected over the entire section. Between N100 and N550 the GPR data were collected on an 11.5 by 20-ft grid with east-west profiles every 20 ft and north-south profiles every 11.5 ft. A 10 by 11.5-ft grid between N00 and N100 with east-west profiles every 10 ft and north-south profiles every 11.5 ft. EMI data were collected along north-south profiles, 11.5 ft apart, with data collected at 5-ft intervals (Figure 12).

The integrated interpretation of Section C is shown on Plate 2. Refer to Plates 1 and 2 as they are an integral part of the following trench discussions.

4.3.1 Asbestos Trench 29

This trench was opened in September 1976 and closed in June 1979. The entire trench is centered at about E652 (see Plate 2). The edges of the trench are not obvious from the data. The trench appears to merge with asbestos trench 30 to the east and corrosive trench 28 to the west.

This trench contains three major areas of concentrated anomalies. The first is between N100 and N195. The top of the anomalies range from 2 to 5 ft below the surface. The next zone is between N230 and N290 with the depth to anomalies ranging from 2 to 7 ft below the surface. The most northern zone is between N310 and N350 and the anomalies range from 4 to 8 ft below the surface. Several isolated anomalies at about an 8-ft depth are located between N460 and N500. These anomalies are not distinctly separate from strong anomalies to the west in chemical trench 28.

The presence of the interpreted caliche horizon at about N520 marks the maximum northern extent of this trench. The southern end of the trench appears to be at about N80.

4.3.2 Asbestos Trench 30

This trench was open for only 1 month, from August 1976 to September 1976. The entire trench is centered on about E698. The northern extent of the trench is at about N540. The southern boundary is at about N90. An interpreted caliche horizon, roughly along the E721 line, marks the eastern extent of this trench (see Plate 2).

The western edge of the trench is not marked by the presence of the caliche horizon except south of N190. North of N190, this trench blends into asbestos trench 29. Three zones of concentrated anomalies are centered at N100, N370, and N540. These zones are shallow with anomalies starting at 2 to 5 ft below the surface.

4.3.3 Chemical Trench 31

This trench was opened in September 1982 and closed in April 1984. The trench centerline strikes about 5° more east than the other trenches in the NRDWL. The southern trench center is at E750. The northern trench center is at E785 (see Plate 2). The trench also appears to be significantly wider, approximately 75 ft, at the north end.

Three large areas of concentrated anomalies exist in this trench. The northern area begins at about N520, extends to about N325, and is about 35 ft wide. Anomalies are about 2 to 4 ft below the surface at the north end and become deeper towards N325, buried 5 to 8 ft below the surface with more gaps between individual anomalies.

The second concentrated zone of anomalies is centered at N290/E767. These anomalies begin at about 5 ft below the surface.

The southern third major area of concentrated anomalies ranges from about N40 to N210. This anomalous zone appears continuous into the JAJ trench (Section 4.5). Additionally, no shallow caliche horizon is present between the JAJ trench and trench 31, adding more evidence that the trenches are connected.

4.3.4 Unused Trench 32

Geophysical data (DOE-RL 1990) indicates that this unused trench location is underlain by a zone of undisturbed, shallow (1 to 3 ft deep), interpreted caliche horizon. The "undisturbed" zone is about 45 ft wide and centered on E790 along the N100 line (see Plate 2). The undisturbed zone narrows to 10 to 15 ft wide toward the north end of the trench location and centered at about E813. This orientation is skewed to the east similar to chemical trench 31.

4.3.5 Chemical Trench 33

This trench opened in November 1980 and closed in September 1982 and is centered at about E836 for its entire length. The north trench boundary is at about N525 (see Plate 2). No southern trench boundary is observed. The

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caliche horizon, typically observed a few feet below the surface in undisturbed areas, is not present between chemical trench 33 and the JAJ trench. But as observed on Plate 2, anomalies, associated with possible debris, from the JAJ trench and trench 33 do not overlap.

The trench is about 30 ft wide with the major concentrations of anomalies near the centerline of the trench, located in three zones. The southern zone of anomalies extends from N90 to N170 with the anomalies beginning from 2 to 4 ft below the surface. Another zone is located between N340 to N440. The depth to the anomalies in this zone ranges from 3 to 9 ft. The third major area of anomalies ranges from N490 to N520.

4.3.6 Chemical Trench 34

This trench was opened in January 1975 and closed in November 1980. The western edge of the trench is between E865 and E870 (see Plate 2). The eastern boundary of the trench was not detected. This eastern boundary is below a berm created from the material removed from open trench 19N. Due to the berm, data are limited along the eastern boundary and into study area Section D.

The northern trench boundary is N530. No clear southern boundary exists in terms of an observable shallow caliche horizon. The trench itself appears to connect with the JAJ trench, although the most southern buried anomalies from chemical trench 34 are at about N90.

Anomalies are scattered along the entire trench but are concentrated in about five zones (see Plate 2). Anomalies in the zone from N90 to N160 are buried 2 to 6 ft below the surface. The zone from N170 to N240 has anomalies generally 3 to 5 ft below the surface. The third zone is centered at N330 and begins about 3 ft below the surface. From N360 to N490, the anomalies are buried 3 to 8 ft. The most northern observed anomalies occur at N510, about 2 ft below the surface.

4.4 SECTION D

Section D is the eastern portion of NRDWL, from E905 to E1020 (Figure 6). It contains two trench locations: (1) an unused trench location (18N), and (2) an open oxidizer trench (19N). Two berms, up to 8 ft high, parallel and flank open trench 19N. These berms and the associated open trench between, produce topography that severely limits GPR data acquisition. GPR data collection was primarily limited to north-south profiles every 23 ft. East-west GPR profiles were collected south of N190 and north of N530.

North-south EMI profiles were spaced every 11.5 ft with readings at 5-ft intervals. The additional thickness of soil from the berms prevents the signal from reaching desired depths of investigation below the natural surface elevation.

Due to limited data in this section, compared to Sections A and C, characterization was not as detailed. The data limits should be considered when referring to Plate 2 and in the following sections.

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4.4.1 Unused Trench 18N

DOE-RL (1990) states that trench 18N, centered along profile E928, was never opened or used (see Plate 2). Data from both the GPR and EMI surveys support this conclusion. Even though the GPR data are limited both in coverage and in depth of exploration, there are indications that the area beneath the berm is undisturbed. The shallow caliche horizon appears continuous beneath the berm in this trench location.

One anomalous area does exist at N320/E928. The anomalies appear to be at or near the bottom of the berm, not necessarily in an "excavation". Both the GPR and EMI detected this anomalous zone.

4.4.2 Oxidizer Trench 19N (Open)

Oxidizer trench 19N, opened in March 1984, is the eastern-most open trench, dominating Section D. It is assumed that the southern, western, and eastern edges of the trench are relatively intact. The northern end of the trench is at about N530. The trench has been filled in to about N470. The only anomalies in this trench occur in this backfilled area. This anomalous zone extends from N500 to N525 and from E960 to E1000.

The southern end of the trench is at about N250. South of N250, the subsurface appears relatively undisturbed except at N190/E1020. This anomalous zone extends from N170 to N200 and from E1008 to beyond the eastern boundary of this survey. The anomalies are about 2 ft below the surface. They are interpreted as either shallow buried debris located outside of a detected trench or could be related to clastic dikes.

4.5 SECTION E/JAJ TRENCH

GPR data were collected over the entire JAJ trench, from E100 to E1020 and between N00 to N100 (see Plate 2). Data were collected on a 20-ft by 11.5-ft grid spacing from E284 to E698. Grid spacing of 10 ft by 11.5 ft were used from E100 to E307 and from E698 to E1020. EMI data were collected over the central portion of the trench, between E399 and E629. Three areas have no data due to steel tanks on the surface. These "no data" areas are relatively small, approximately 30 ft by 30 ft, and do not significantly impact the overall interpretation.

The JAJ trench strikes N68°W, parallel to the "E-W" survey grid lines. The trench is 725 ft long by 50 ft wide. The north, south, east, and west trench boundaries are located roughly at grid lines N75, N25, E985, and E260, respectively. The trench "boundaries" are inferred primarily from mapped boundaries of a shallow caliche horizon.

Concentrated anomalies within this trench are located between N30 and N70 and between E270 and E928. Depths to the top of major concentrations of anomalies are typically about 5 ft. Depths to specific anomalies are as little as 2 ft in several places (see Plate 2).

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The JAJ trench is not clearly separated from the NRDWL trenches, chemical 34 and 31 and asbestos 25 and 22. This interconnection of trenches is inferred by the absence of the shallow (2 to 5 ft) caliche horizon. The absence of the interpreted caliche horizon is likely due to excavation. Anomalies from chemical trench 31 are continuous into the JAJ trench anomalies at E755 (Plate 2).

West of E260, numerous anomalies are located above the shallow caliche horizon. This indicates some shallow disposal, perhaps in 1 to 3-ft deep trenches, or at/near the surface and then covered by a 1 or 2 ft of fill. In particular, the area between about E175 to E200, and N00 to N40, the caliche horizon (paleosol) seems intact at about a 3 ft depth with metallic anomalies above.

5.0 CONCLUSIONS/RECOMMENDATIONS

The interpreted trench boundaries and major areas of concentrated anomalies were identified by a combination of GPR and EMI. Most of the trench centers are close to those predicted by documentation, but some vary by as much as 15 ft. An exception is asbestos trench 23 where a shallow reflector, interpreted to be a calcified geologic horizon, is still intact, which suggests that the trench was never opened or used. This calcified horizon is prevalent throughout most of the NRDWL except in the used trenches where it was removed during trench excavation.

The depths to the top of the debris within the trenches were determined. However, the depth to the bottom of the anomalies must be inferred from expected trench depths. Most debris appears to be covered with less fill material than the documented 4 ft in asbestos trenches and 10 ft in chemical trenches. The geophysical surveys indicate the buried debris is covered by as little as 2 ft of fill in many places.

Several NRDWL trenches appear to merge laterally. In addition, four NRDWL trenches merge with the east-west trending JAJ trench. Chemical trench 31 has anomalies continuous into the JAJ trench. This trench also is wider than documented and trends into the location of unused trench 32.

The berms of sand, that parallel open trenches 26 and 19N in Sections B and D, adversely affected the data quality and reduced profile coverage. This limited the subsequent interpretation to a few isolated areas within the sections. The open trenches need to be backfilled with the berm material, and the site roughly leveled, if more detailed data and interpretations are needed in Sections B and D.

A closely spaced grid would improve the delineation of trench boundaries and more accurately locate concentrations of debris within the NRDWL. Other geophysical methods such as magnetic gradiometer and deeper looking EMI, such as an EM-34, could enhance the interpretation if required.

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6.0 REFERENCES

DOE-RL, 1990, *Nonradioactive Dangerous Waste Landfill Closure/Postclosure Plan*, DOE/RL-90-17, U.S. Department of Energy, Richland Field Office, Richland, Washington.

Mitchell, T. H. and K. A. Bergstrom, 1993, *Data Package for Geophysical Investigation of Nonradioactive Dangerous Waste Landfill (NRDWL)*, WHC-SD-EN-DP-064, Westinghouse Hanford Company, Richland, Washington.

Weekes, D. C., S. P. Luttrell, and M. R. Fuchs, 1987, *Interim Hydrogeologic Characterization Report and Groundwater Monitoring System for the Nonradioactive Dangerous Waste Landfill, Hanford Site, Washington*, WHC-EP-0021, Westinghouse Hanford Company, Richland, Washington.

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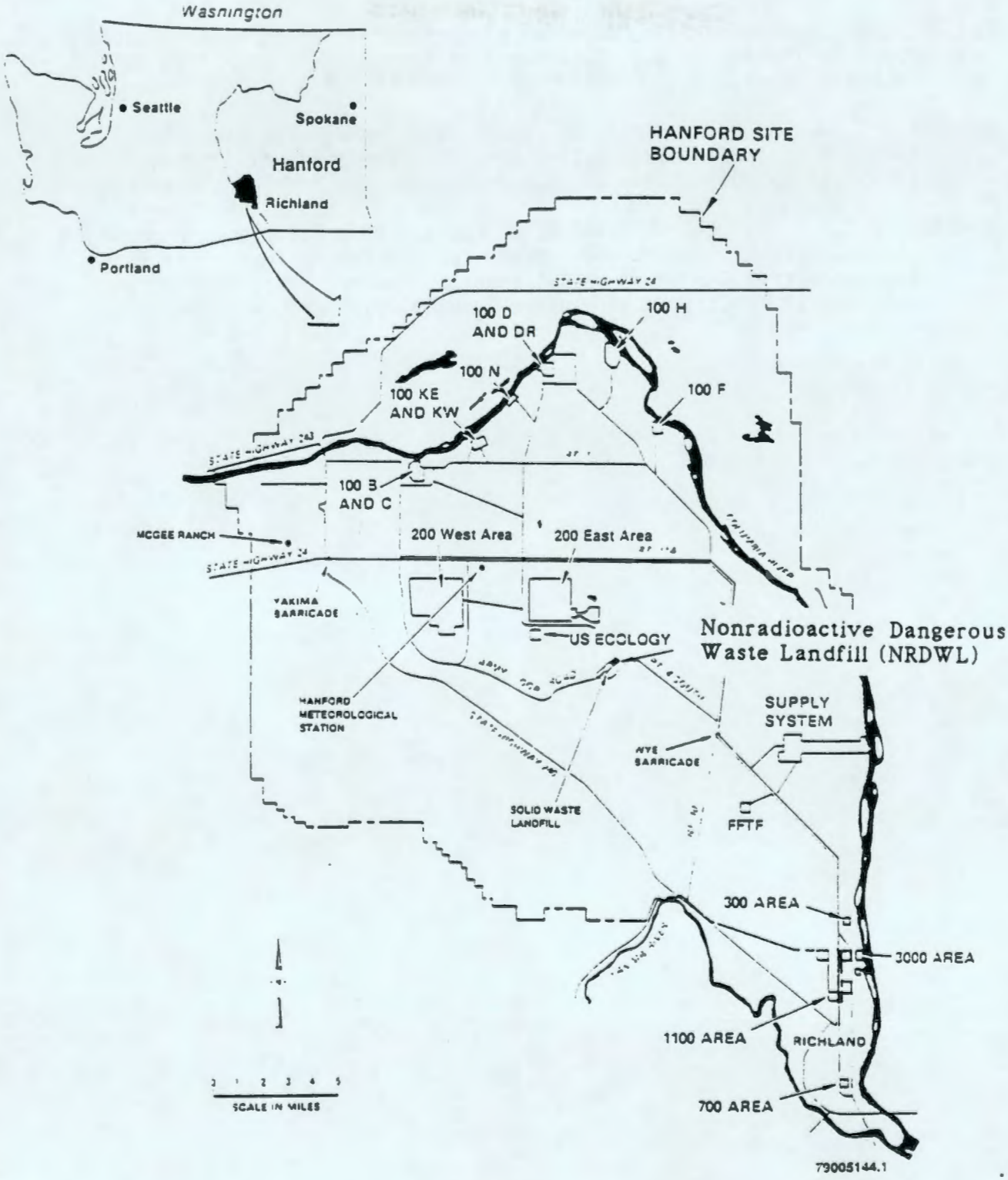

Figure 1. NRDWL Location Map.

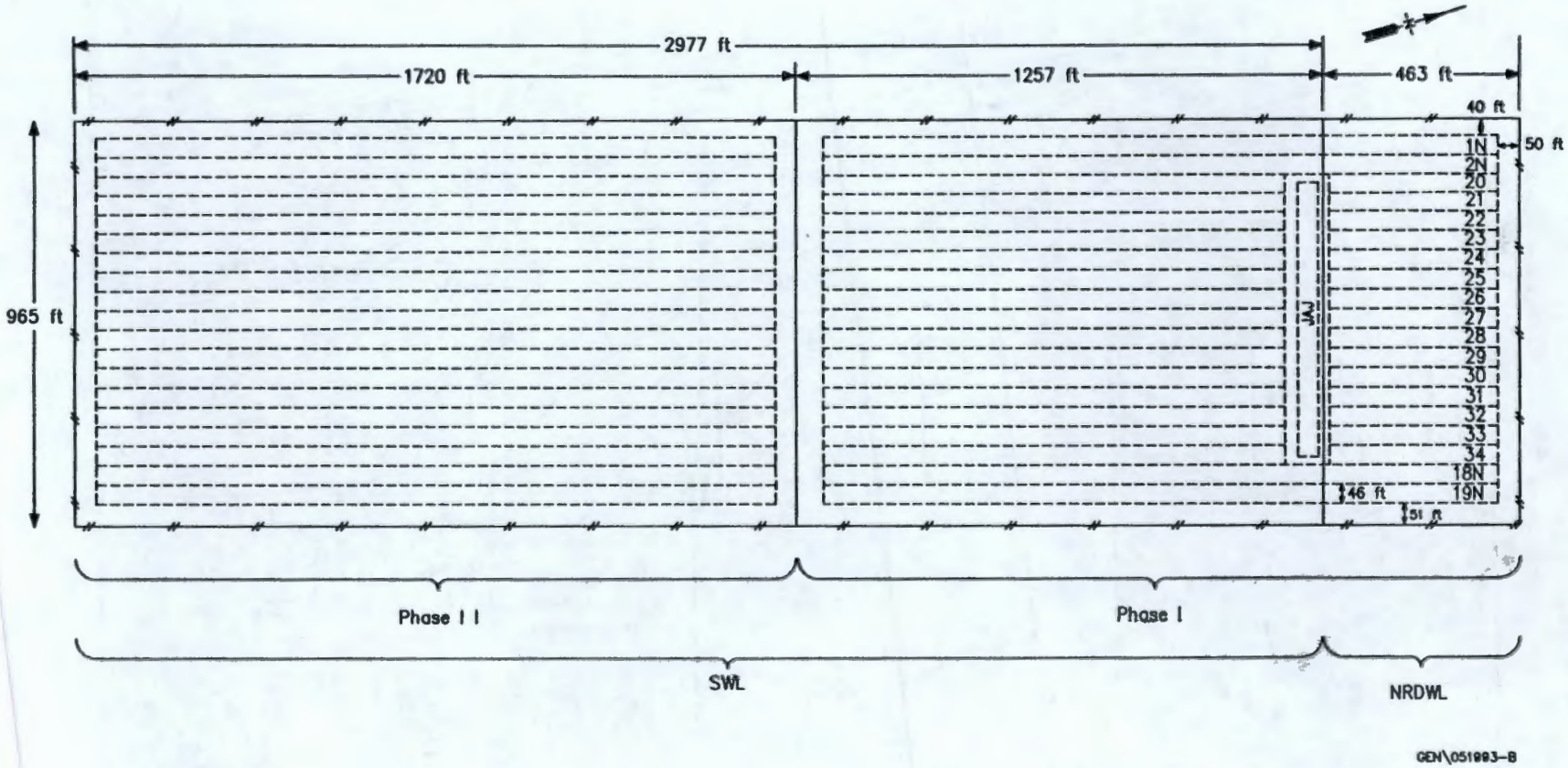

Figure 2. NRDWL at the Northern End of the Solid Waste Landfill.

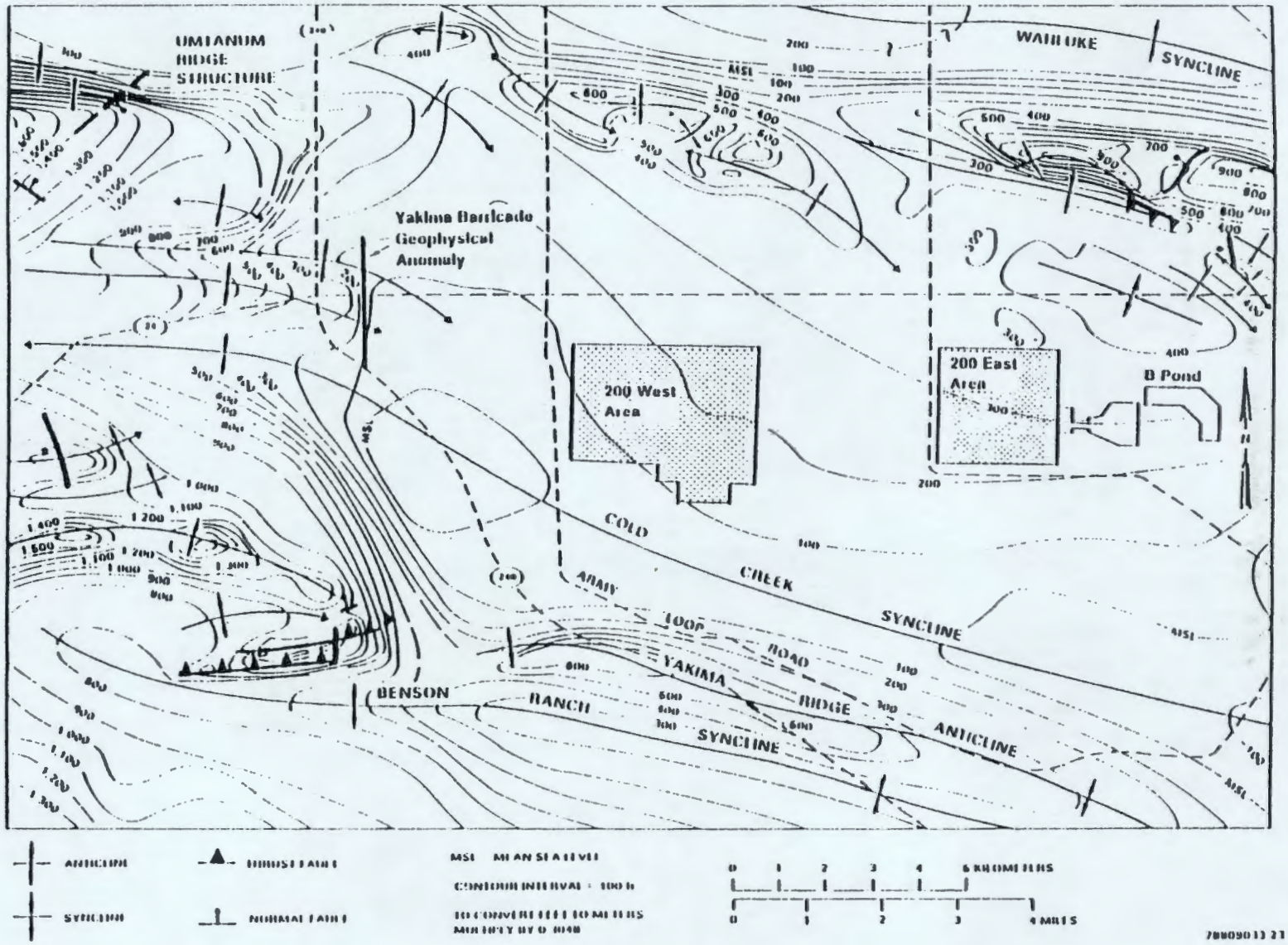

Figure 3. Structure Contour Map of the Top of the Basalt Beneath NRDWL. (Weekes et al. 1987)

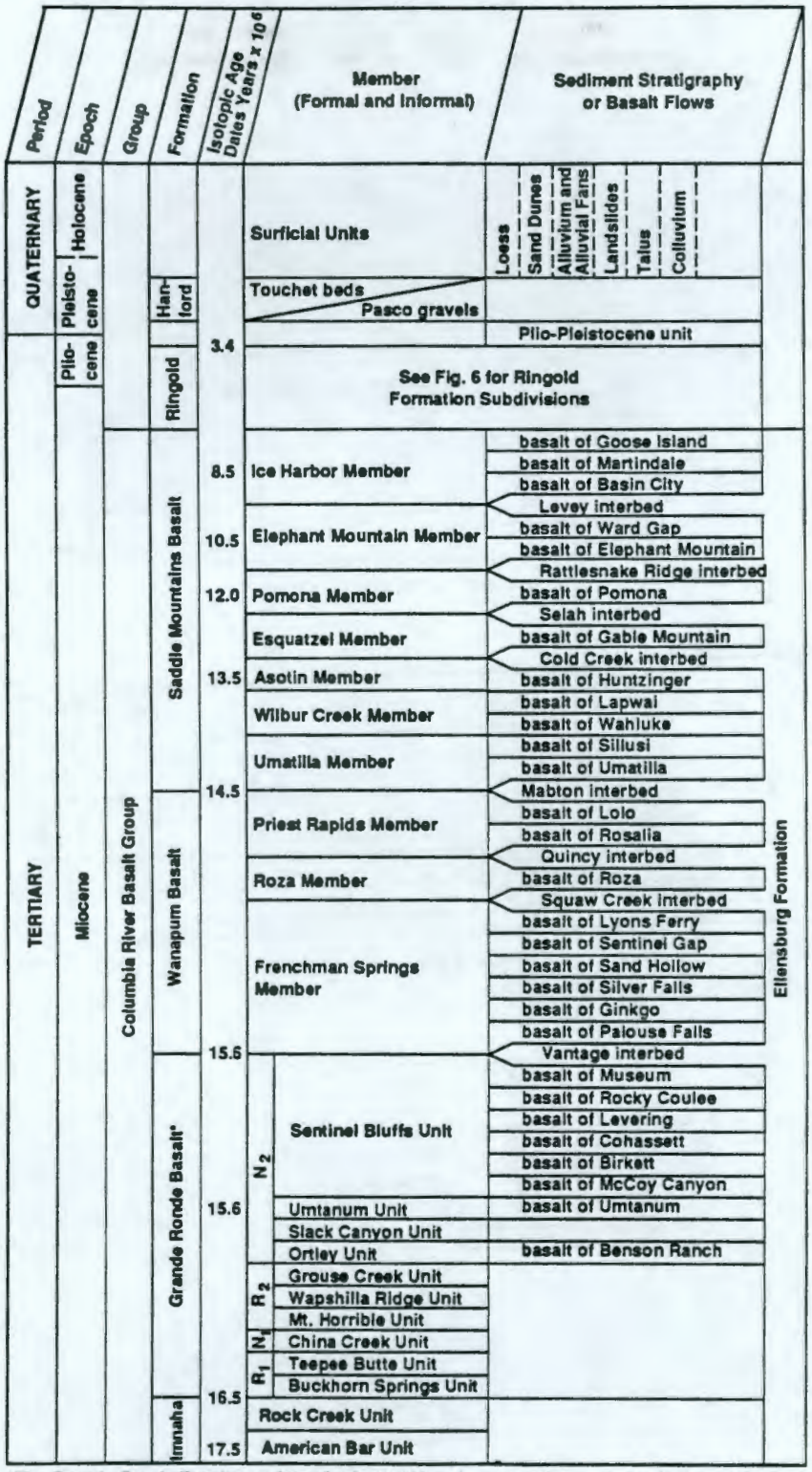

Figure 4. Stratigraphic Nomenclature of Units Penetrated Within the Pasco Basin.

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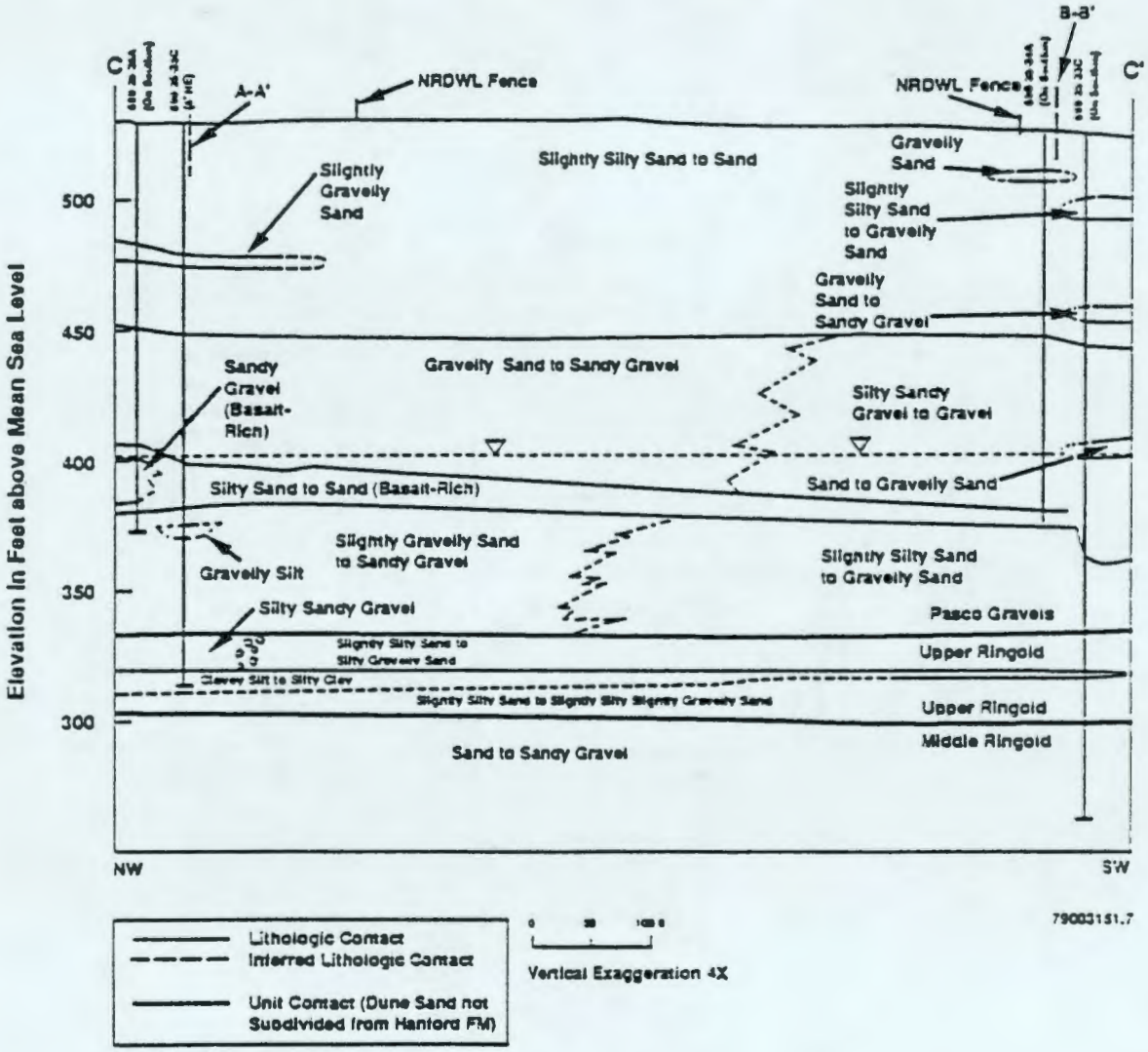

Figure 5. Geologic Cross Section of Sediments at the NRDWL (Weekes et al. 1987).

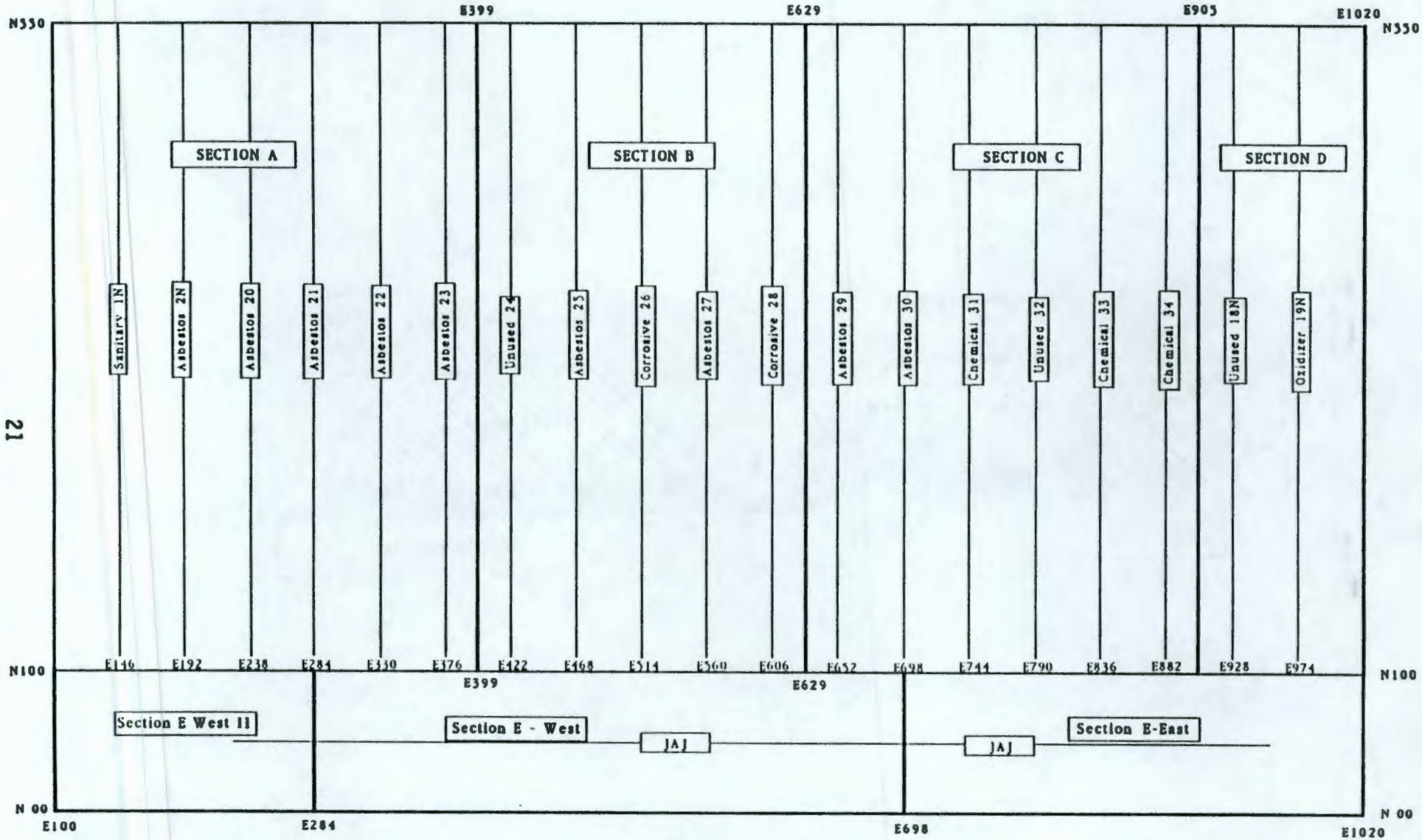

Figure 6. The NRDWL Study Area Divided into Seven Sections.
(The center of the trenches, as predicted from DOE-RL 1990, are shown in relationship to the survey grid.)

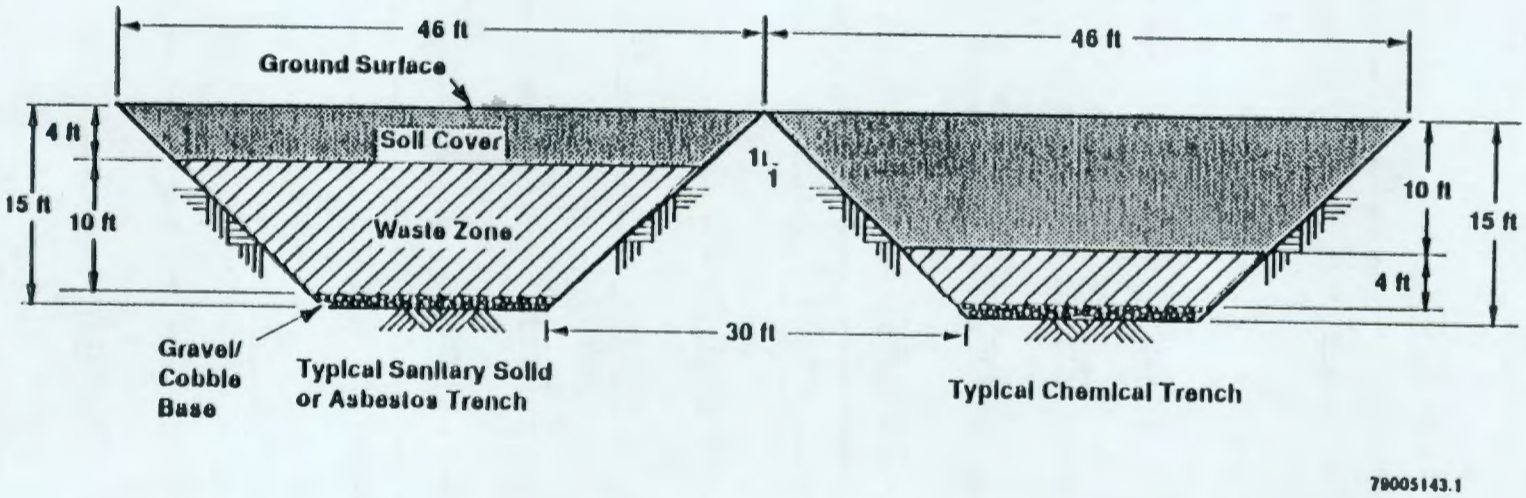

Figure 7. Documented Designs for "Typical" Asbestos and Chemical Trenches.

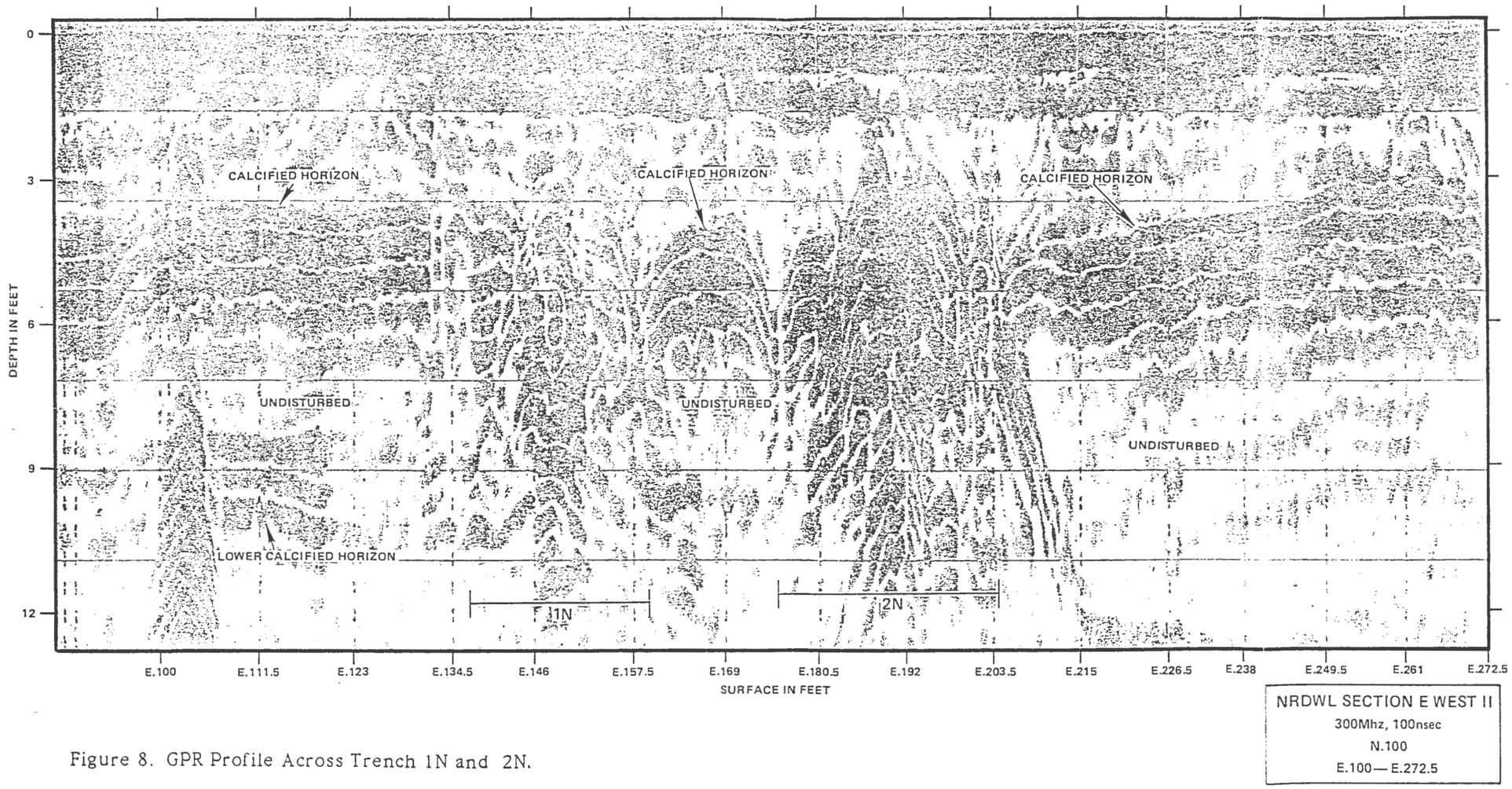

Figure 8. GPR Profile Across Trench 1N and 2N.

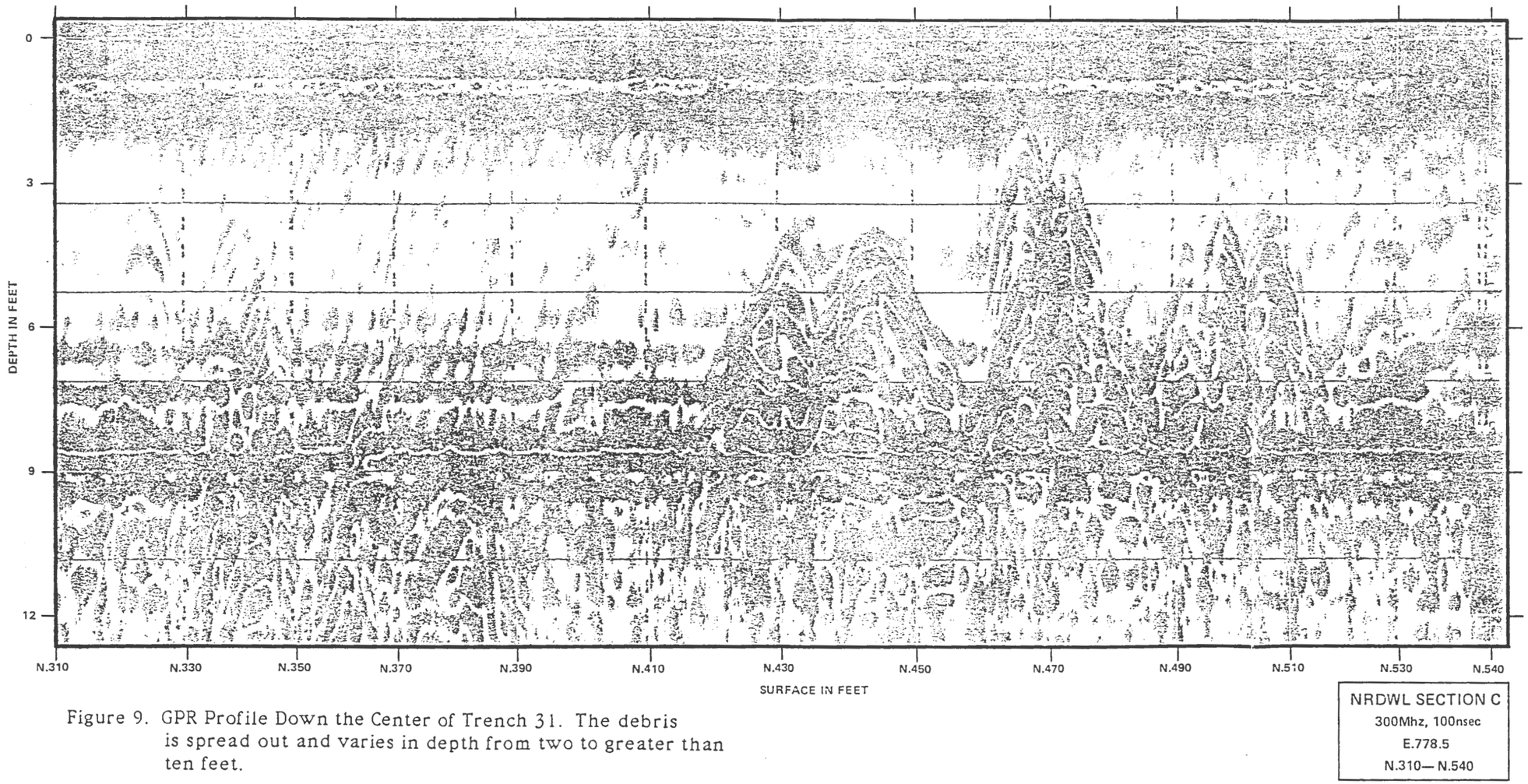

Figure 9. GPR Profile Down the Center of Trench 31. The debris is spread out and varies in depth from two to greater than ten feet.

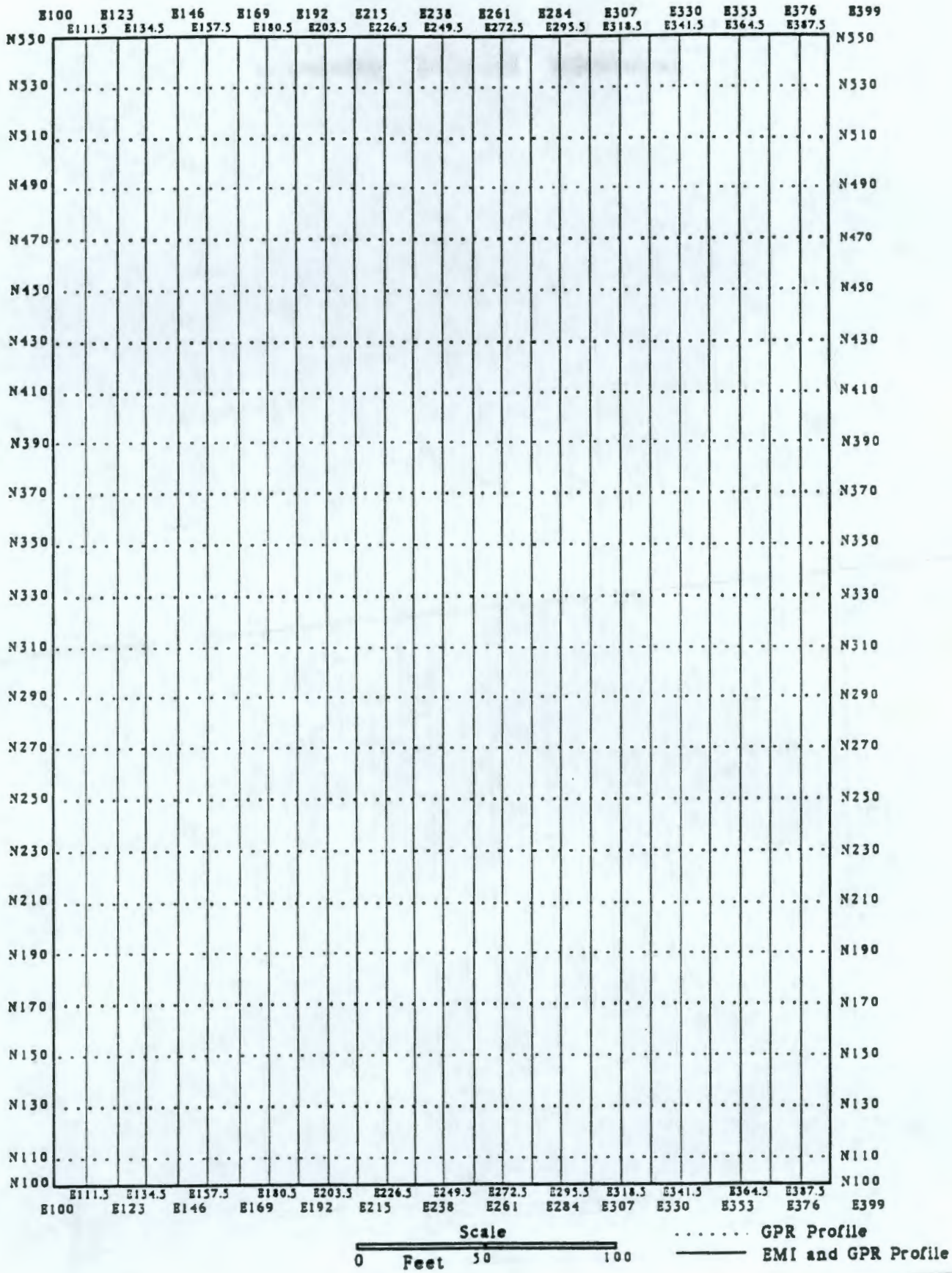

Figure 10. Section A Survey Grid with Locations of EMI and GPR Profiles.

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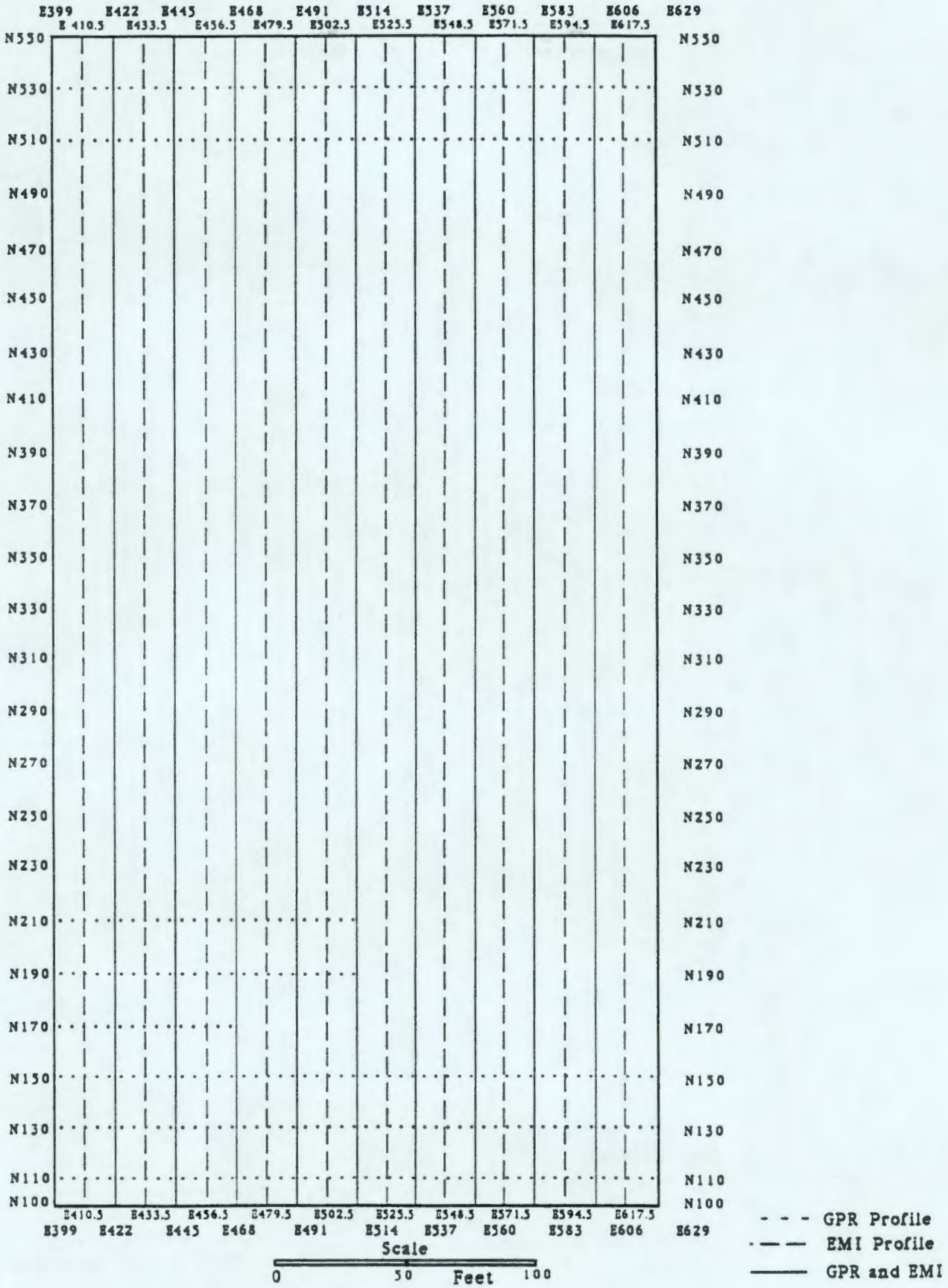

Figure 11. Section B Survey Grid with Locations of EMI and GPR Profiles.

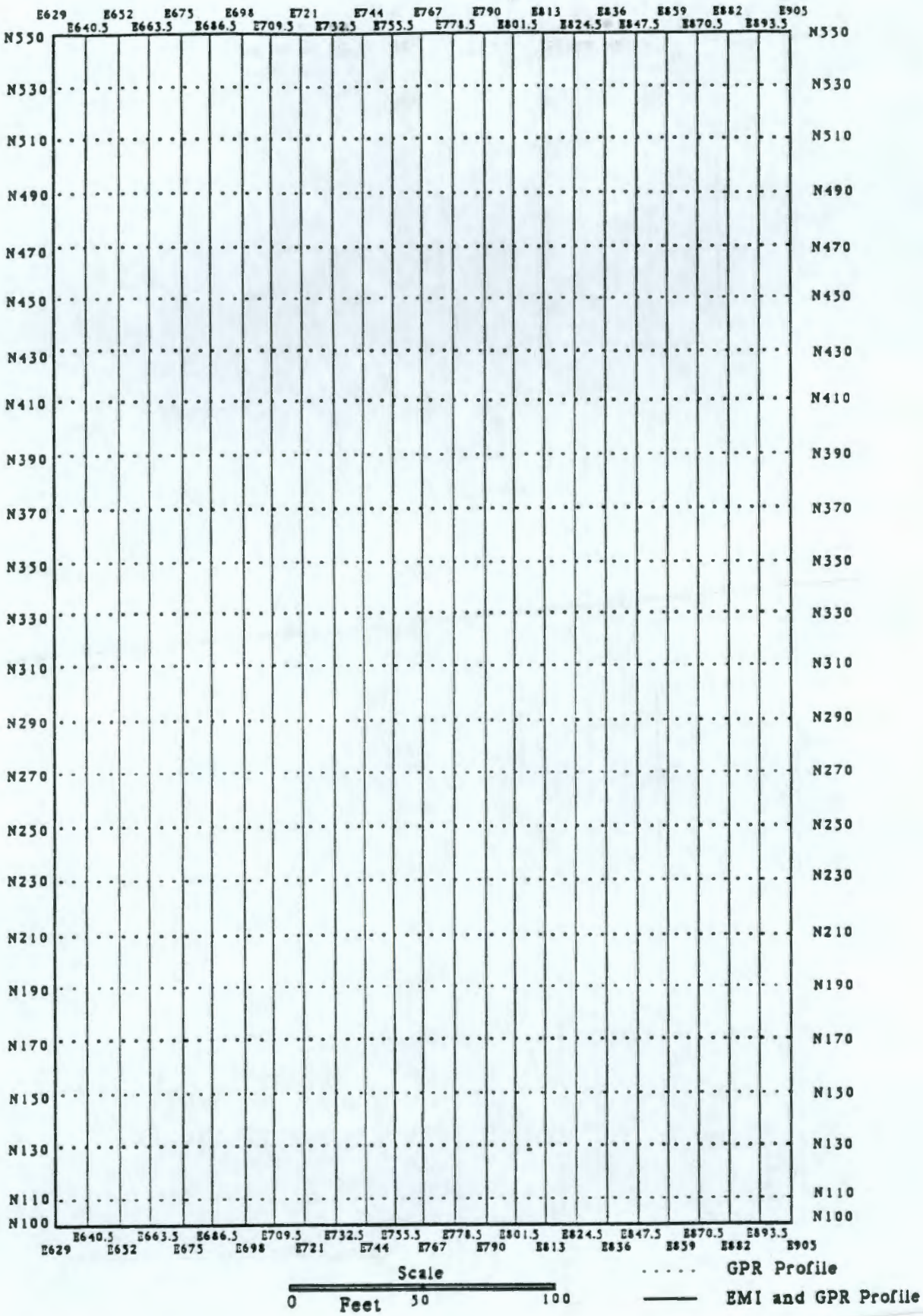

Figure 12. Section C Survey Grid with Locations of EMI and GPR Profiles.

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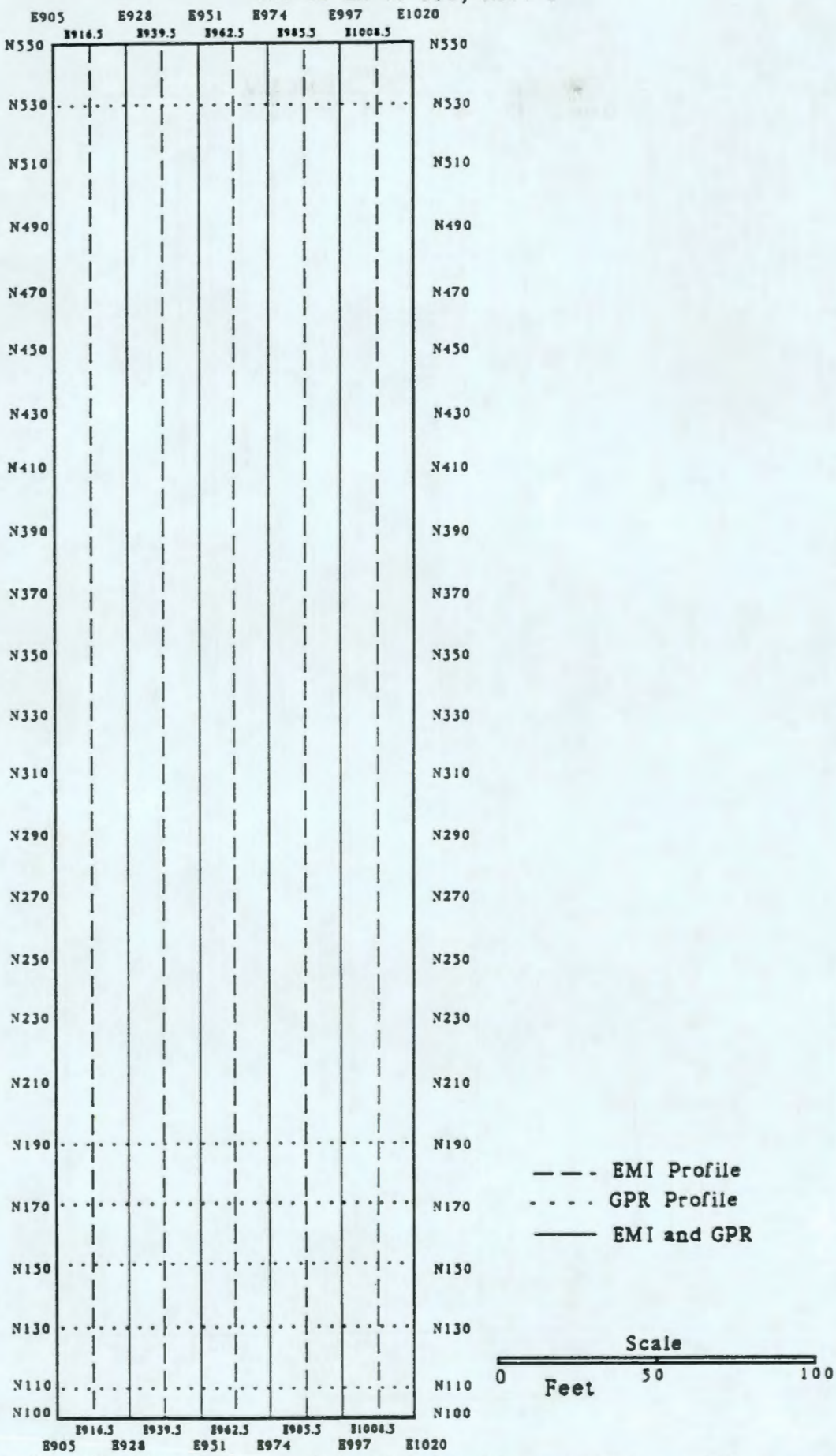

Figure 13. Section D Survey Grid with Locations of EMI and GPR Profiles.

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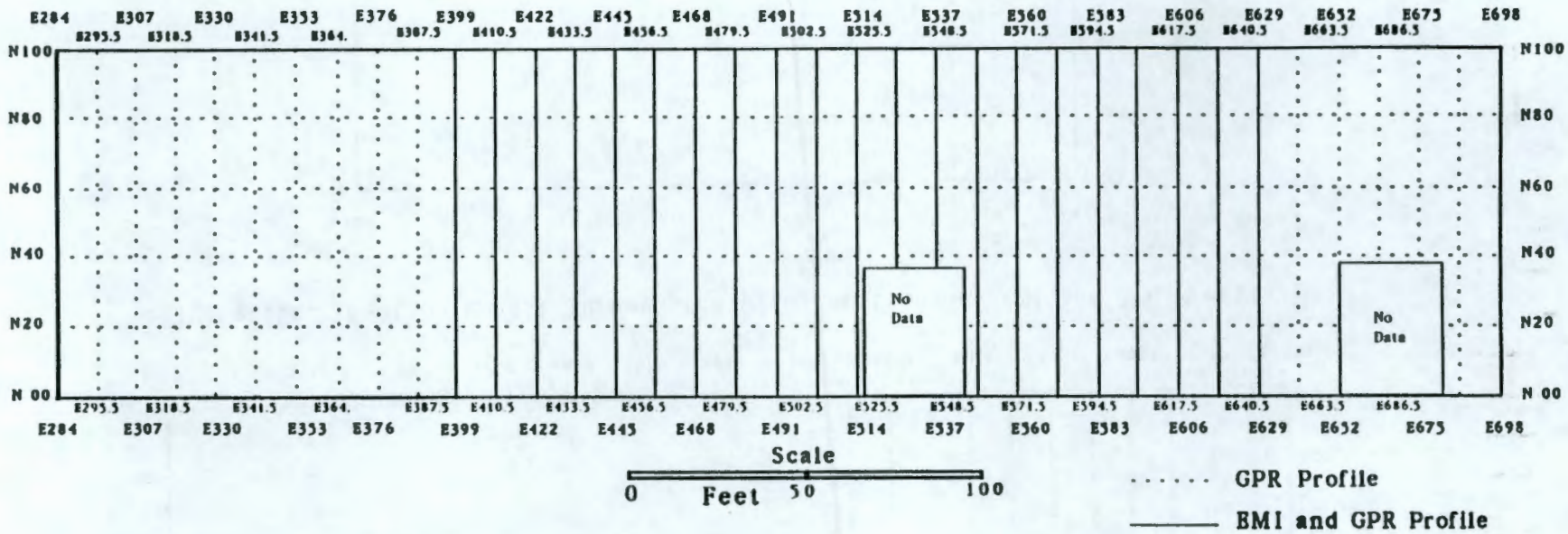


Figure 14. Section E West Survey Grid with Locations of EMI and GPR Profiles.

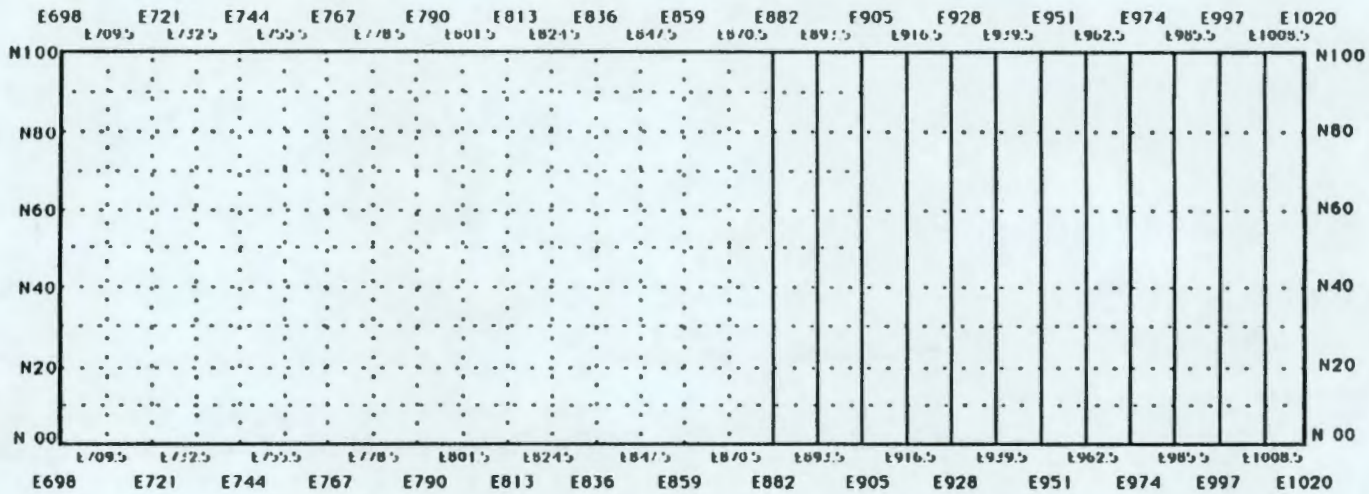


Figure 15A. Section E East Survey Grid with Locations of EMI and GPR Profiles.

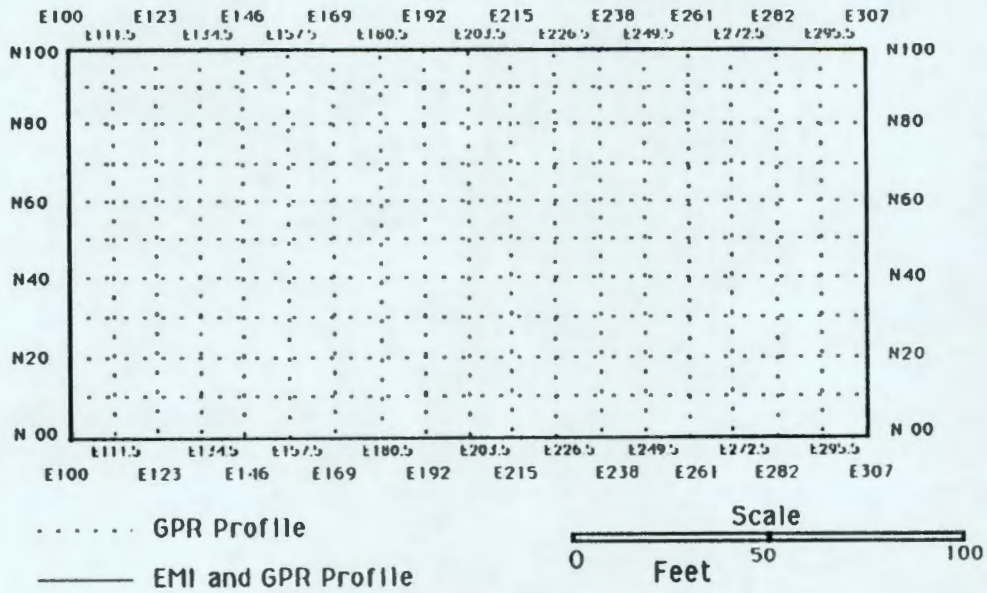
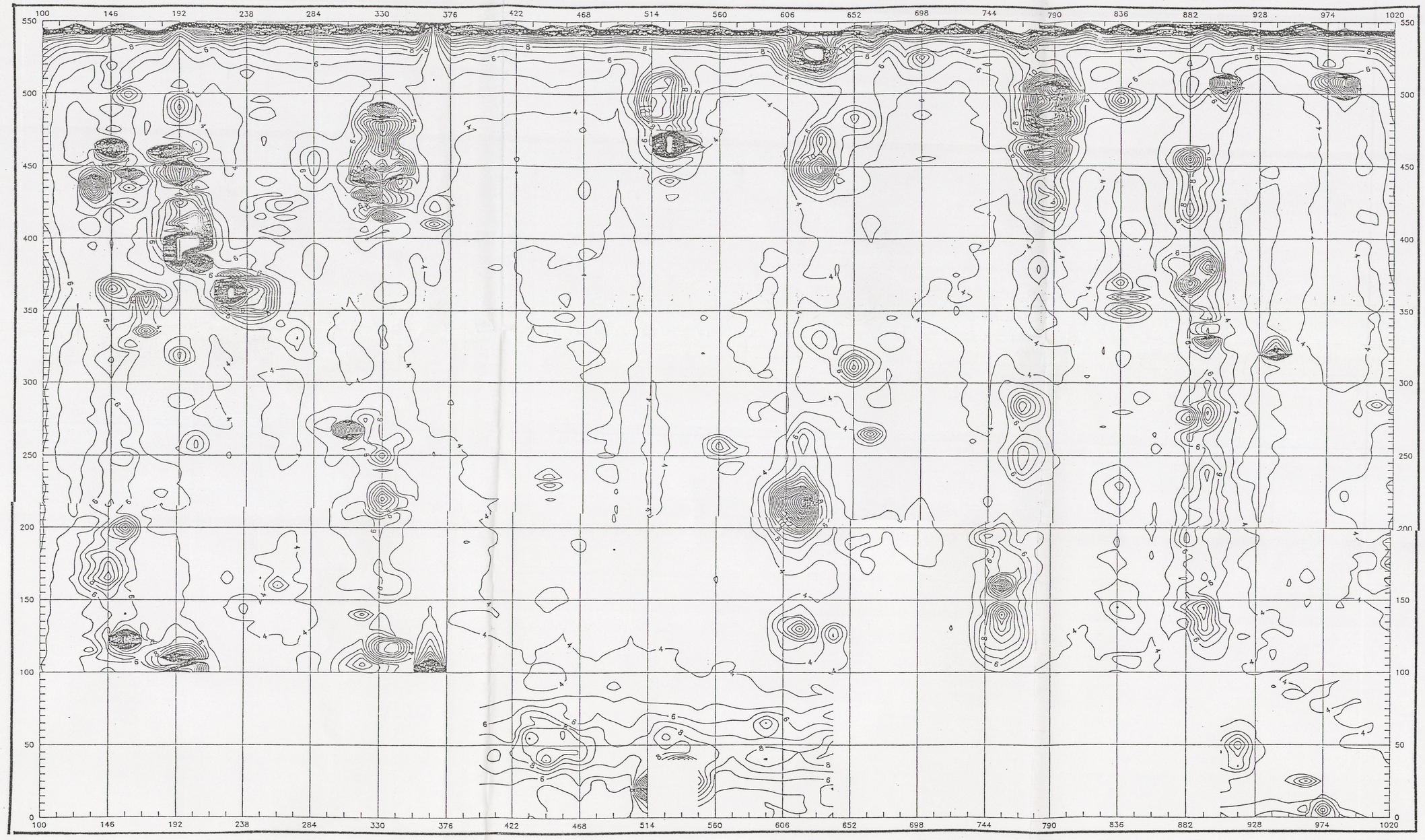
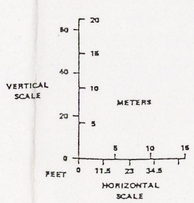


Figure 15B. Section E West II Survey Grid with Locations of EMI and GPR Profiles.



NONRADIOACTIVE DANGEROUSE WASTE LANDFILL (NRDWL) ELECTROMAGNETIC INDUCTION



GEOPHYSICS BY:
T.H.MITCHELL AND K.A.BERGSTROM
DRAWN BY:
W.H CROWLEY JR.

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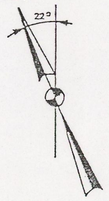

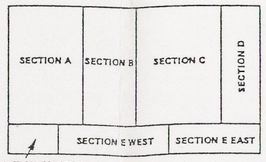

SECTION ARRANGEMENT

HANFORD SITE

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PLATE 1

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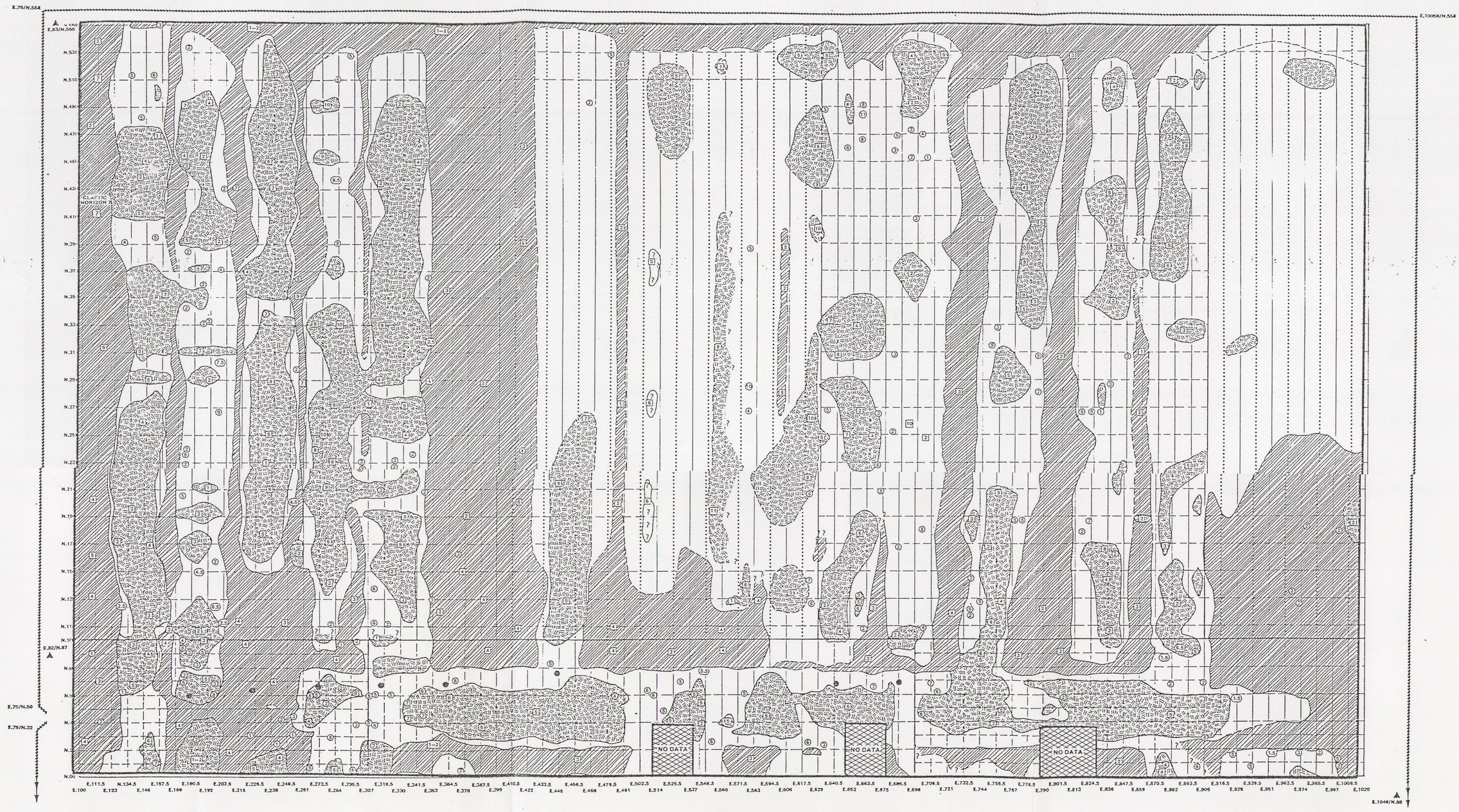
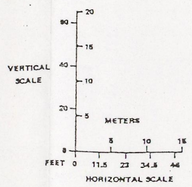


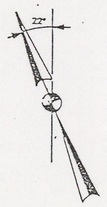
NONRADIOACTIVE DANGEROUSE WASTE LANDFILL (NRDWL)

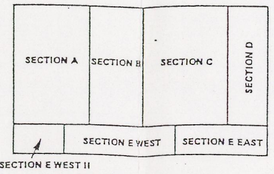
GEOPHYSICS BY
T.H.MITCHELL AND K.A.BERGSTROM
DRAWN BY
W.H.CROWLEY JR.

LEGEND

- AREA OUTSIDE OF TRENCH BOUNDARIES. GENERALY UNDISTURBED BELOW DEPTH OF A FEW FEET.
- CONCENTRATIONS OF ANOMALIES WITHIN INTERPRETED TRENCH BOUNDARIES.
- SCATTERED ANOMALIES WITHIN TRENCH BOUNDARIES.
- 4 AVERAGE DEPTH OF FILL OVER BURIED ANOMALIES (HIGHLY VARIABLE).
- 5 DEPTH TO CALICHE HORIZON OUTSIDE OF TRENCH BOUNDARIES WHERE PRESENT.
- EMI PROFILE
- GPR PROFILE
- EMI AND GPR PROFILE
- ASBESTOS SIGN POSTS
- E.00/N.00 SURVEY HUB
- FENCE







SECTION ARRANGEMENT

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PLATE 2

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APPENDIX A

GPR PROFILES IN SUPPORT OF SOIL-GAS SURVEYS

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APPENDIX A

North-south trending Solid Waste Landfill trenches lie immediately south of the JAJ trench. The northern-most end of several of these trenches were detected during the initial NRDWL investigation (Plate 2). Six east-west GPR profiles and 10 north-south GPR profiles were collected over several of these trenches in support of soil-gas surveys (Figure A-1). The intersections of the north-south and east-west profiles were tentative locations for soil-gas probes. The objective of the surveys were to locate areas where probes could be inserted without undue risk of penetrating buried waste material. These data were not used to characterize the trench locations or their contents. Data is included in Mitchell and Bergstrom (1993).

Status of the southern soil-gas probe locations and recommended location changes, where appropriate, are listed below.

Location	Status
E146/S50	Buried debris 5+ ft below the surface
E238/S50	Buried debris 5+ ft below the surface
E330/S50	Move to E330/S55. Buried debris 5+ ft below the surface
E442/S50	Location is between trenches
E514/S50	Move ~20 ft to the west
E606/S50	No soil probe. The site is in an open trench
E698/S50	Move to E698/S45
E790/S50	Move 10 to 15 ft to the east
E882/S50	Site ok
E974/S50	Site ok
E146/S50	Site ok
E238/S150	Move west ~10 ft
E330/S150	Move site to E330/S145. Buried debris 6 ft below the surface
E442/S150	Site is between trenches
E514/S150	Buried debris 5+ ft below the surface
E606/S150	Site ok

9313041.1162

Location	Status
E698/S150	Buried debris 5+ ft below the surface
E790/S150	Move 10 to 15 ft to the west
E882/S150	Buried debris 6+ ft below the surface
E974/S150	Buried debris 6+ ft below the surface

9313041.1163

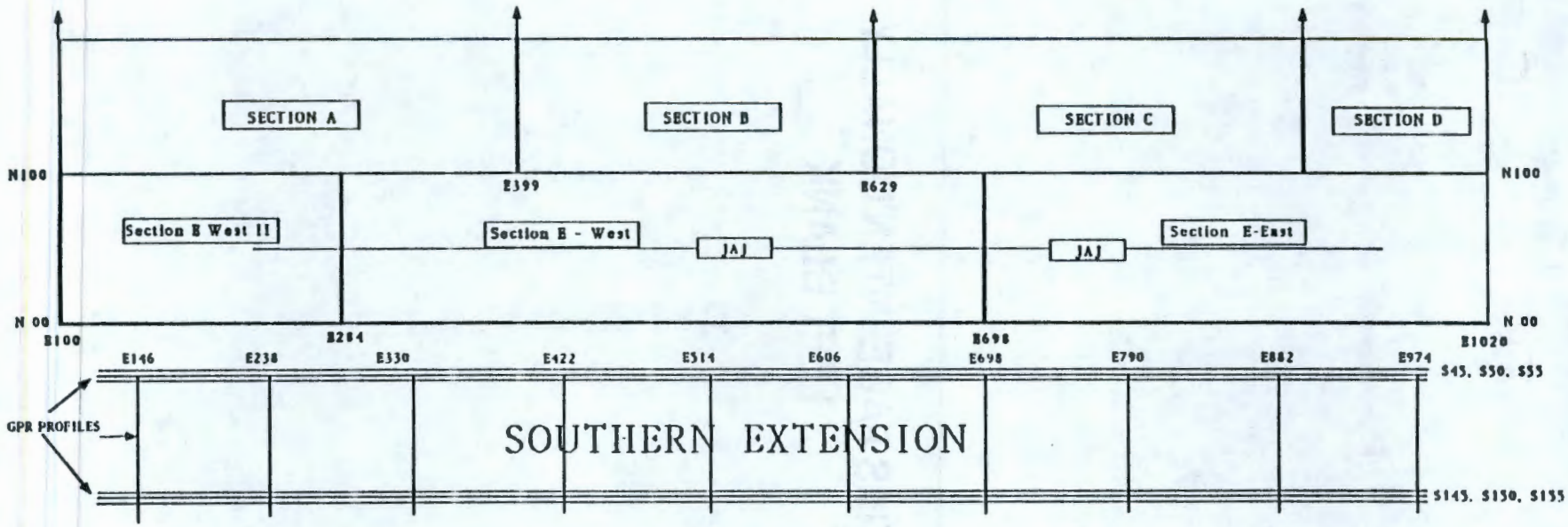

Figure A-1. The Southern Extension of the NRDWL Geophysical Survey.

(The southern extension consisted of several east-west GPR profiles and isolated north-south profiles to assist in locating soil-gas probes).

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