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Environmental Geophysics at Kings Creek Disposal Site and 30th Street Landfill, Aberdeen Proving Ground, Maryland

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Environmental Geophysics at Kings Creek Disposal Site and 30th Street Landfill, Aberdeen Proving Ground, Maryland

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Preface

This report provides administrative and technical staff, responsible for environmental planning and remediation at Aberdeen Proving Ground, with the final results and conclusions drawn from geophysical studies begun in April 1994. Three technologies, not listed in the work plan, were added to the study to improve diagnostic interpretations, and one technology was removed because it was considered redundant. The technologies added were downhole induction logging and downhole gamma logging, which were used to interpret subsurface lithologies, and downhole seismic velocity measurements, used to assist in the interpretation of seismic reflection data. Resistivity sounding was deleted from the study. Staff at Aberdeen Proving Ground, Directorate of Safety, Health, and Environment, and Argonne National Laboratory guided the work scope and its objectives.

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Environmental Geophysics at Kings Creek Disposal Site and 30th Street Landfill, Aberdeen Proving Ground, Maryland

by

B.E. Davies, S.F. Miller, L.D. McGinnis, C.R. Daudt, M.D. Thompson, J.E. Stefanov, M.A. Benson, and C.A. Padar

Abstract

Geophysical studies on the Bush River Peninsula in the Edgewood Area of Aberdeen Proving Ground, Maryland, delineate landfill areas and provide diagnostic signatures of the hydrogeologic framework and possible contaminant pathways. These studies indicate that, during the Pleistocene Epoch, alternating stands of high and low sea levels resulted in a complex pattern of shallow channel-fill deposits in the Kings Creek area. Ground-penetrating radar studies reveal a paleochannel greater than 50 ft deep, with a thalweg trending offshore in a southwest direction into Kings Creek. Onshore, the ground-penetrating radar data indicate a 35-ft-deep branch to the main channel, trending to the north-northwest directly beneath the 30th Street Landfill. Other branches are suspected to meet the offshore paleochannel in the wetlands south and east of the 30th Street Landfill. This paleochannel depositional system is environmentally significant because it may control the shallow groundwater flow regime beneath the site. Electromagnetic surveys have delineated the pre-fill lowland area currently occupied by the 30th Street Landfill. Magnetic and conductive anomalies outline surficial and buried debris throughout the study area. On the basis of geophysical data, large-scale dumping has not occurred north of the Kings Creek Disposal Site or east of the 30th Street Landfill.

1 Introduction

An environmental geophysical study was conducted north of Kings Creek at Aberdeen Proving Ground (APG), Edgewood Area (Figure 1). The study area includes two solid waste management units (SWMUs) identified in the *RCRA Facility Assessment Report, Edgewood Area, Aberdeen Proving Ground, Maryland* (Nemeth 1989). The two SWMUs, referred to as the Kings Creek Disposal Site and the 30th Street Landfill, are located outside the security fence within Cluster 15 (Figure 2).

Open burning of chemical munitions reportedly occurred at the Kings Creek Disposal Site during the 1920s and 1930s. Drummed wastes were also stored on the surface in this area. It is not known whether chemical munitions or wastes were buried at the disposal site.

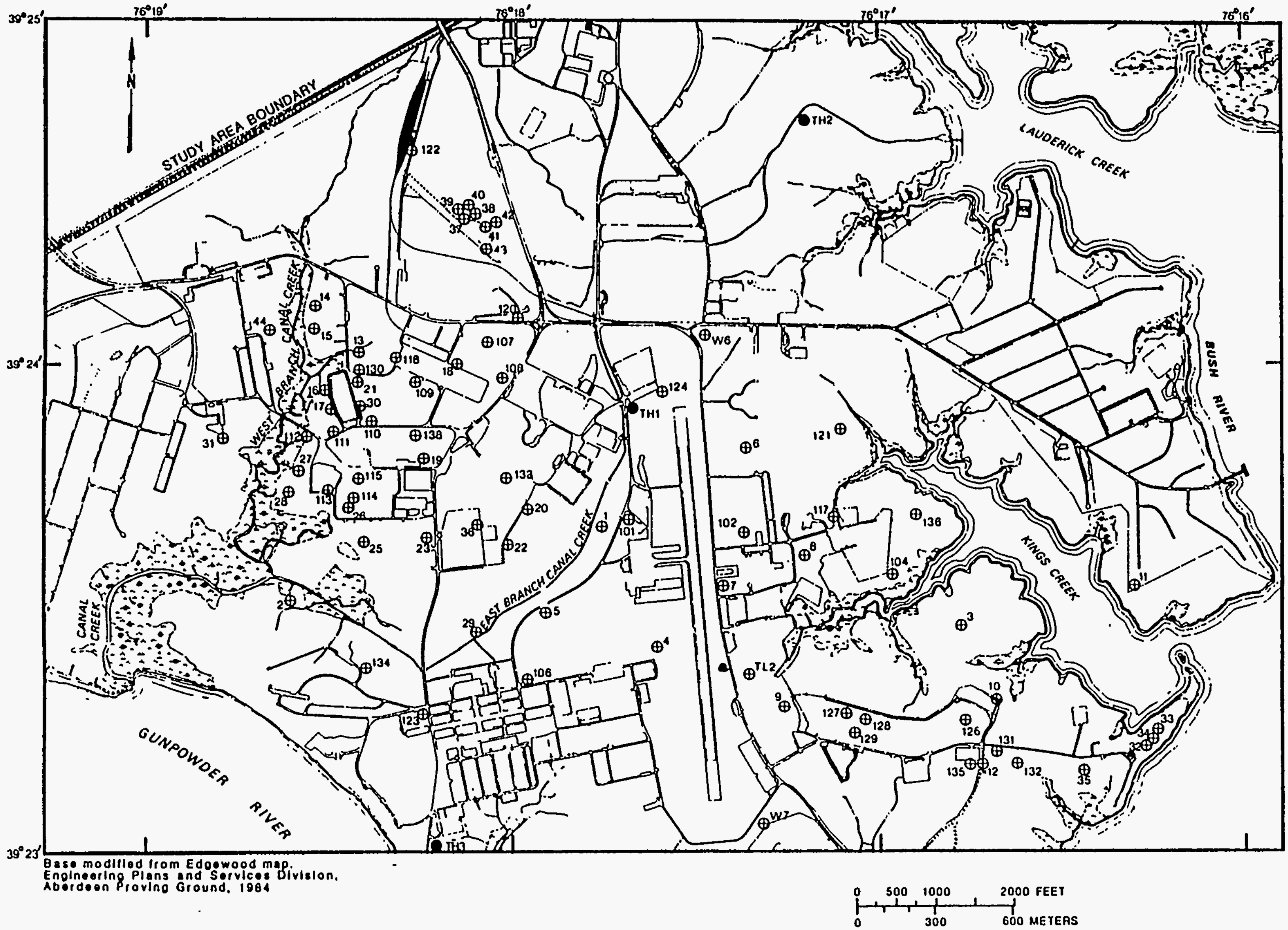


FIGURE 1 Kings Creek Study Area in the Aberdeen Proving Ground, Edgewood Area

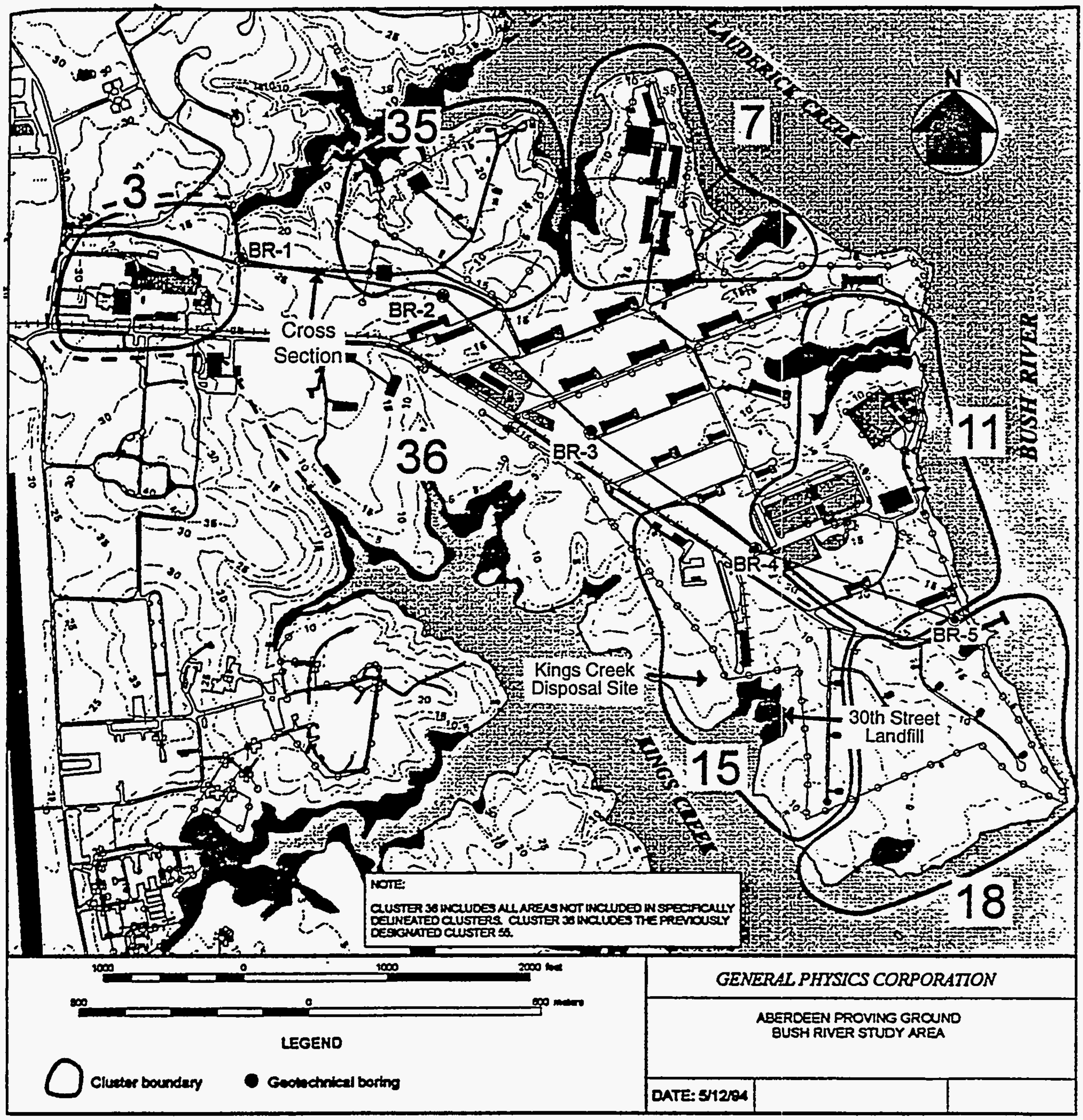


FIGURE 2 Topography and Site Features of the Bush River Peninsula (adapted from U.S. Army Corps of Engineers 1994)

The 30th Street Landfill is located east of and adjacent to the Kings Creek Disposal Site, in a former wetland. Dumping occurred at the landfill in the 1960s and probably into the early 1970s. The area is currently covered with vegetation, and some debris is visible on the surface. Buried munitions were discovered at the landfill during the summer of 1994, but no records of munitions disposal in this area exist (Nemeth 1989).

The objectives of the geophysical investigation (as outlined in the workplan) are as follows:

1. Define the areal extent of the affected sites,

2. Characterize the hydrogeologic framework beneath the sites to provide information to support the current site monitor well installation program, and

3. Provide information on the geologic integrity and continuity of strata underlying the embayment and wetlands adjacent to the sites.

Field activities were conducted during the spring and summer of 1994. Geophysical techniques used during this study to meet the objectives listed above included seismic reflection and refraction, downhole seismic induction and gamma well logging, magnetics, electromagnetics, and ground-penetrating radar (GPR). Magnetic, electromagnetic, and GPR surveys were performed to define the approximate areal extent of solid (and potentially liquid) wastes.

1.1 Physiographic Setting and Site Survey

The Kings Creek area lies within the Atlantic Coastal Plain physiographic province of Maryland. The study area is located in the south-central portion of the Bush River Peninsula, which is bounded by Lauderick Creek to the north, Bush River to the east, and Kings Creek to the south (Figure 2). The peninsula is a remnant of subareal erosion that occurred during a low-sea-level stand followed by a sea-level rise and estuarine encroachment into Kings Creek and Lauderick Creek, which are tributaries of the Bush River. This river is one of the major tidal estuarine channels on the western shore of Chesapeake Bay. Elevations of the Bush River Peninsula range from greater than 20 ft above mean sea level (msl) in the central portion of the peninsula to sea level at the shoreline (Figure 2). The elevation of the study area ranges from sea level to approximately 14 ft above msl at the northernmost survey point. The average elevation of the site is 5 to 6 ft above msl.

The area surveyed covers approximately 11 acres surrounding a small embayment on the north shore of Kings Creek. The northern and eastern portions of the site are covered by trees and surface obstructions (fallen trees, vines, and brush). The Kings Creek Disposal Site is partially wooded and contains numerous fallen trees. The 30th Street Landfill is covered with low grassy vegetation and is surrounded to the south and southeast by phragmite and cattail marsh.

Geophysical survey coordinate 00N/00E corresponds to control point CP-12 of a survey performed by Gilmore and Associates, Inc., in October 1992 (Figure 3). CP-12 is located at 620823.72 north, 1517457.09 east in the Maryland State Plane Coordinate System. A 50-ft grid was established, using wooden survey stakes, to guide the geophysical surveys (Figure 3). The grid was laid out by using 300-ft surveyor's tapes and a Brunton compass. Geophysical profiles in the eastern section of the survey area are skewed slightly from those in the main survey area to better fit this irregularly shaped section.

1.2 Geology and Hydrogeology

The Precambrian crystalline basement platform lies approximately 450 ft beneath the land surface of the Bush River Peninsula. Basement lithologies are similar to those found at the surface in the Piedmont Province, which is located northwest of the fall line (Oliveros and Vroblesky 1989). The crystalline basement surface dips to the southeast at an angle of less than one degree

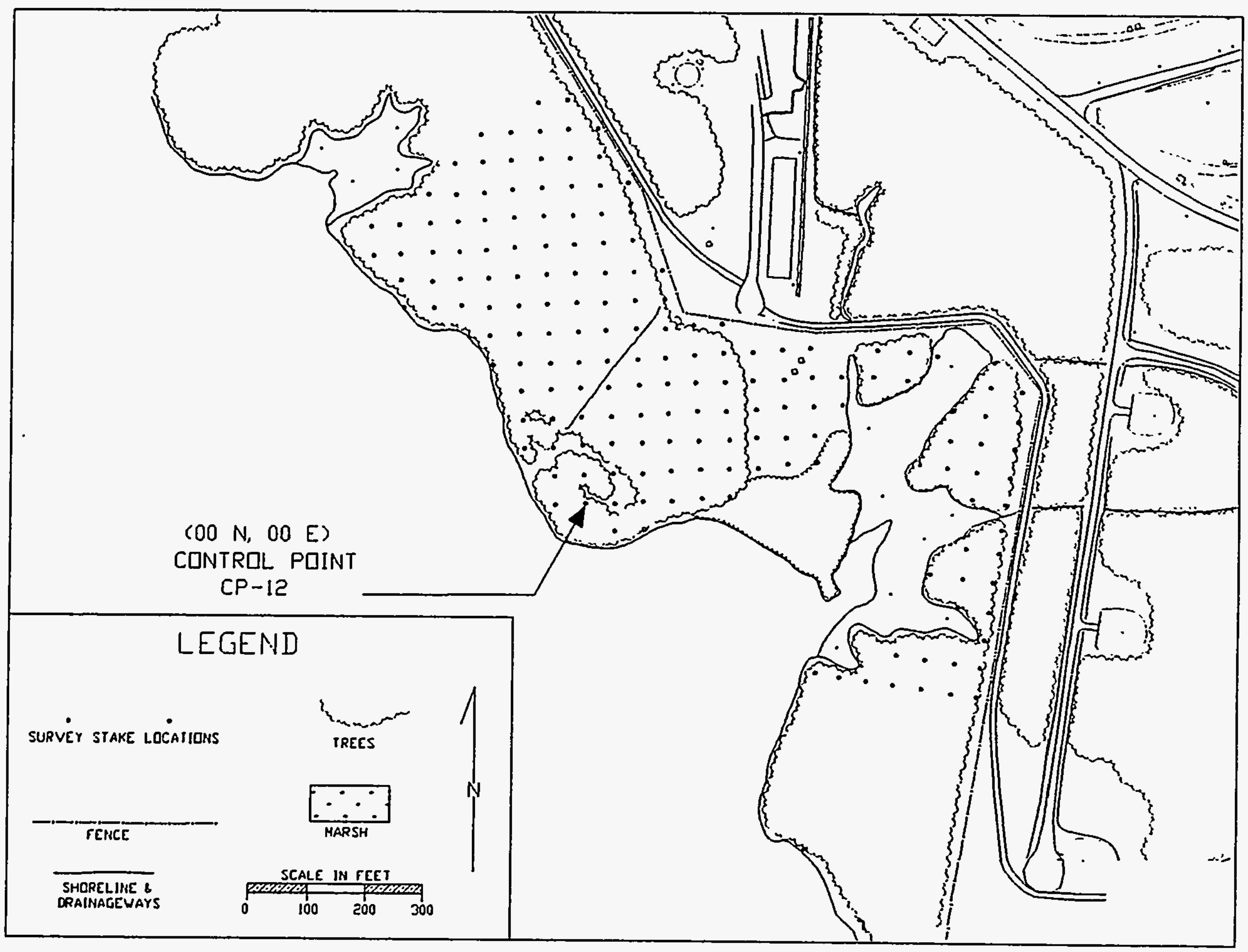


FIGURE 3 Geophysical Survey Grid, Kings Creek Study Area

(Bennett and Meyer 1952; Dingman et al. 1956; Southwick, Owens, and Edwards 1969). Previous geophysical studies at Beach Point, approximately 3,000 ft south, revealed the Precambrian basement approximately 560 ft beneath the land surface (McGinnis et al. 1994a). In areas east of the fall line, including all of the areas discussed in this report, unconsolidated Atlantic Coastal Plain sediments overlie Piedmont basement rocks.

Atlantic Coastal Plain sediments beneath the Edgewood area of APG were deposited during the Cretaceous Period and the Pleistocene Epoch (Oliveros and Vroblesky 1989; Thurmond 1993). A thin layer of Holocene estuarine sediments covers the wetland areas at APG. Most of the unconsolidated sediments, which comprise the Potomac Group, were deposited during the Cretaceous Period. The Potomac Group units are continentally derived and represent several depositional systems: mostly fluvial, channel, and overbank or levee deposits. Cretaceous deposits in the area generally consist of interbedded clays and fine- to medium-grained quartz-sands. These Cretaceous sediments likely belong to the Patapsco Formation of the Potomac Group.

The Pleistocene Talbot Formation, which rests unconformably on the Potomac Group, contains minor amounts of Quaternary alluvium (Oliveros and Vroblesky 1989). The gravelly sand, sand, and silty clay deposits are marginal marine in origin and consist primarily of fluvial and estuarine deposits (Southwick, Owens, and Edwards 1969). During the Pleistocene Epoch, the sea level fluctuated and channels were cut into the Cretaceous sediments. The Talbot Formation is commonly found as paleochannel-fill complexes deposited during subsequent rises in sea level (Kehrin et al. 1988). Beneath the Bush River Peninsula, the Talbot Formation is thickest in these paleochannel-fill complexes.

Figure 4 presents a hydrogeologic cross section running northwest to southeast along the Bush River Peninsula (adapted from Thurmond 1993). The location of the cross section is shown in Figure 2. The sediments beneath the Bush River Peninsula are a complex mix of interfingering clays, silts, sands, and gravels. Lorah and Vroblesky (1989) describe a similar section as follows: "Hydrogeologic units were defined partly on the basis of hydrogeologic characteristics of the units; therefore, the boundaries between the hydrogeologic units do not necessarily correspond with the contacts between geologic units." The surficial aquifer sediments are primarily composed of the Talbot Formation and appear to pinch out in the northwestern end of the cross section (Figure 4).

The Pleistocene disconformity is developed on the clay aquitard, which is a member of the Potomac Group sediments. The disconformity, where the base of the Pleistocene sediments is also clayey, is not readily discernible in drill core or geophysical logs. In the discussions to follow, the term "base of the surficial aquifer" refers to the contact between the sandy sediments and the underlying clay, regardless of the relative ages of the two units.

On the basis of observations at the Kings Creek study area and studies conducted in other portions of the Edgewood Area, including Beach Point (McGinnis et al. 1994a) and Canal Creek (Lorah and Vroblesky 1989 and McGinnis et al. 1994b), it is evident that a well-integrated

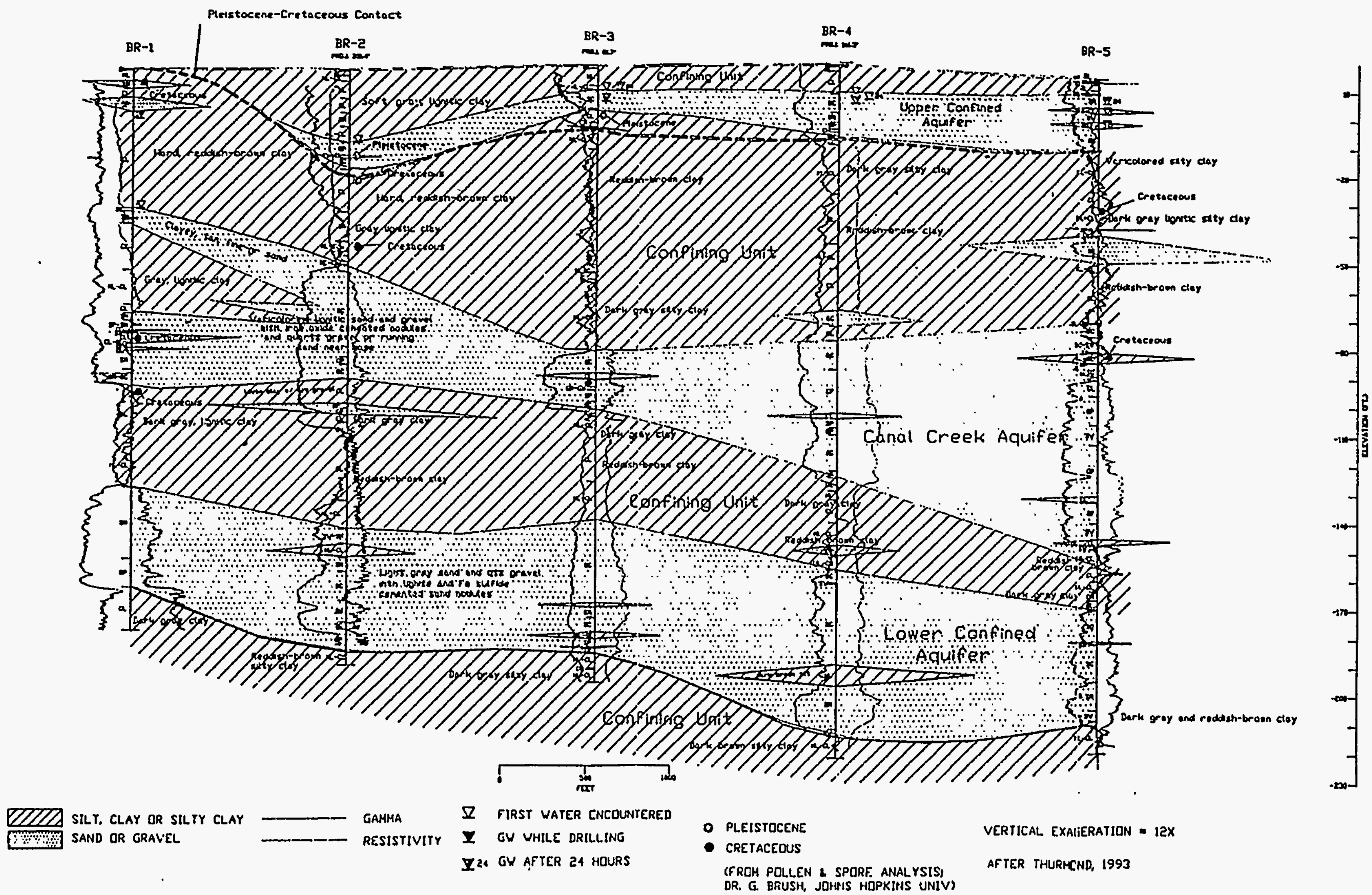


FIGURE 4 Geologic Cross Section of the Bush River Peninsula (Thurmond 1993)

Pleistocene tributary system was deeply incised into the Potomac Group sediments as a result of successive lowering of the sea level. The tributary system provides the framework for shallow groundwater flow and for potential recharge into the Potomac Group aquifers. Mapping the configuration of this system is one of the objectives of the geophysical studies conducted at the Kings Creek Disposal Area/30th Street Landfill.

1.3 Instrumentation and Software

Instruments used to collect geophysical data at the site included the following:

- Magnetic gradiometer,
- Cesium vapor magnetometer,
- Electrical conductivity instrument,
- Induction probe and logging unit,
- Natural gamma probe and logging unit,
- SIR-2 and SIR-3 ground-penetrating radar,
- Engineering seismographs,
- Elastic wave generator, and
- Geophones.

The following paragraphs describe each of these instruments and the software used to reduce the electromagnetic data, process the magnetic data, process the seismic reflection and refraction data, and produce contour maps.

The Model Mac-51B, a magnetic gradiometer and cable locator manufactured by Schonstedt, Inc., is a dual-mode instrument designed to detect shallow buried iron and steel objects and trace underground cables and pipes. The system consists of a transmitter and a dual-function receiver designed to detect anomalous magnetic gradients. The magnetic gradiometer was used during this study to (1) clear survey areas prior to driving the wooden stake grid markers and geophones and (2) perform magnetic surveys.

Total field magnetic data were acquired by using the Model G-822L cesium vapor magnetometer manufactured by EG&G Geometrics. The magnetometer is a continuous-recording (10 readings per second), total-field, microprocessor-based instrument capable of resolution of anomalies to one nanotesla (1 nT).

Electrical conductivity measurements were made with a Model EM-31, an electromagnetic instrument manufactured by Geonics Limited that provides mean values of conductivity, in millisiemens per meter (mS/m), for soils ranging from 0 to approximately 18 ft in depth. Apparent conductivities measured by the EM-31 are weighted mean values measured over the entire depth range, with greater weights applied to shallower depths.

Initial reduction of the electromagnetic and total field magnetic data was completed using DAT 31 software provided by Geonics. The United States Geological Survey (USGS) minimum curvature gridding program MINC (Cordell et al. 1992) was used to plot the data on a grid. Color contour maps presenting the electromagnetic and total field magnetic data were produced by using software developed by Argonne National Laboratory (ANL).

Two geophysical well logging techniques, induction and gamma logging, were employed at selected wells on the Bush River Peninsula. An EM-39 induction probe, manufactured by Geonics Limited and adapted to an MGX model logging unit manufactured by Mount Sopris Instrument Company, was used to produce conductivity logs. A Mount Sopris Instrument Company Model HLP-2375/S was used with the MGX model logging unit to produce gamma logs.

GPR surveying was accomplished by using Geophysical Survey Systems, Inc. (GSSI), models SIR-3 and SIR-2. The SIR-3 was equipped with a Model 38 video display and digital audio tape (DAT) recorder; data were recorded on DAT and downloaded to a personal computer in the field office. Data from the SIR-2 system were downloaded directly to the personal computer. Continuous profiling was performed by using both the 100- and 300-megahertz (MHz)-frequency antennas in the bistatic mode. The control/video display was mounted directly on an all-terrain vehicle, which was used to pull the different antenna arrays through the onshore survey area. For offshore GPR profiles, the antennas rested directly on the bottom of an inflated rubber raft that was towed by a small aluminum bass boat across the survey areas. An IBM-compatible processing computer was located in a field office to download and check the radar profiles and to allow preliminary data processing in the field. Radan III computer software written by GSSI was used for processing the GPR data.

A 24-channel engineering seismograph (EG&G model ES-2401) was employed to determine the depths and seismic velocities of the sediments underlying the Kings Creek study area. Seismic refraction data of the entire sedimentary section were obtained using a trailer-mounted elastic wave generator (EWG) manufactured by Bison Instruments, Inc., for a source and geophones with a natural frequency of 16 hertz (Hz) for receivers. Shallow and deep high-resolution reflection data were obtained by using the EWG and a 16-pound sledgehammer for sources and geophones with a natural frequency of 60 Hz for receivers. The different geophones were manufactured by Mark, Inc. Multiple EWG hits or hammer hits were stacked as needed to increase the signal-to-noise ratio. Full 24-channel reflection data were obtained using a Model RLS-120 roll-along switch with common-depth-point (CDP) cables, manufactured by Input/Output, Inc.

Two shallow seismic refraction lines and downhole seismic data collection techniques were used to further characterize the seismic velocities of the sediments underlying the Bush River Peninsula. A Bison Instruments Model 5012, 12-channel engineering seismograph was utilized to collect these data; a 12-pound sledgehammer served as a sound source. Surveyors used 60-Hz geophones manufactured by Mark, Inc., to collect data from the two shallow refraction lines and a Mark L-10, 8-Hz, three-component geophone to obtain the downhole seismic data.

EAVESDROPPER reflection software, developed by the Kansas Geological Survey (1993), was employed for reflection data processing. The seismic refraction data were processed by using SIPT2 refraction programs, developed by RIMROCK Geophysics, Inc. (1992).

2 Magnetic Surveys

The objectives of the gradiometer and total field magnetic surveys performed at the Kings Creek site were to (1) delineate the boundaries of fill areas containing ferromagnetic debris, and (2) avoid shallow magnetic debris (unexploded ordinance) during the placement of the geophones and survey stakes. The results of these surveys are presented below.

2.1 Continuous Profiling Magnetometry

The study area was divided into four sections (Area 1 through Area 4) to obtain total field magnetometry data. Figure 5 shows the magnetic profile locations and indicates the boundaries of the four subdivisions of the study area. Magnetic maps of the entire study area and the four sections are presented in Figures 6 through 10.

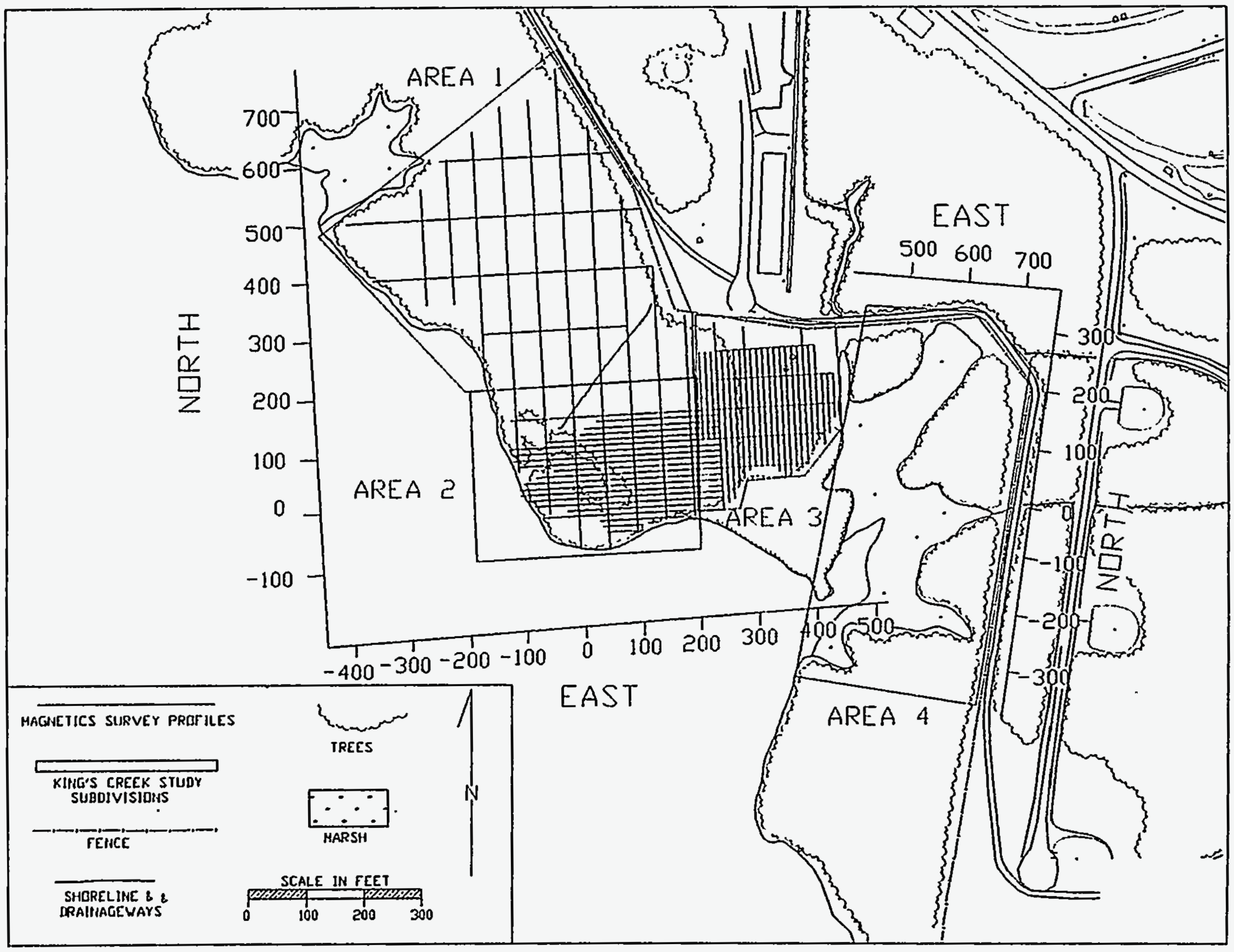


FIGURE 5 Kings Creek Study Area Subdivisions (Areas 1 through 4) and Magnetic Survey Profile Locations

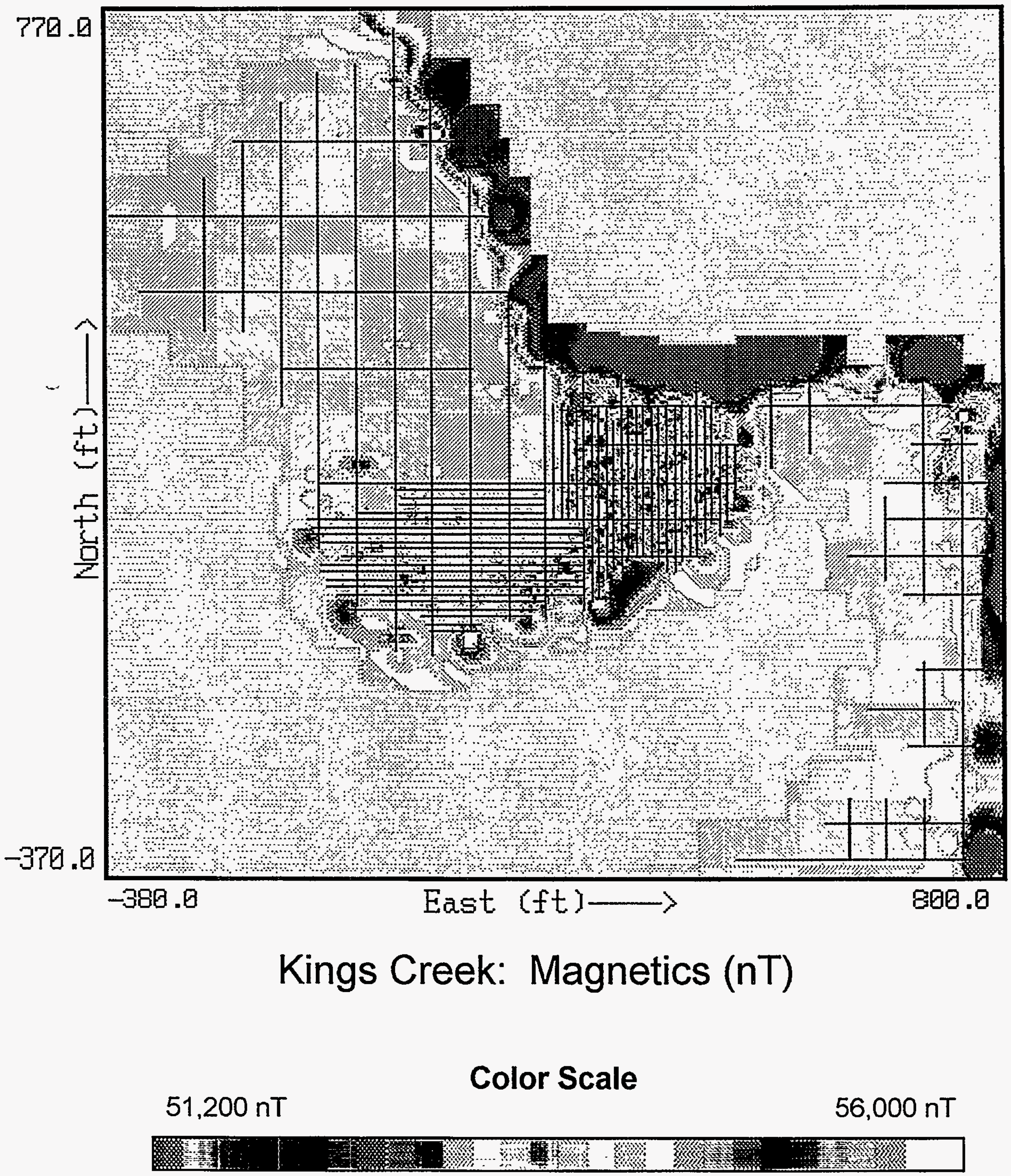
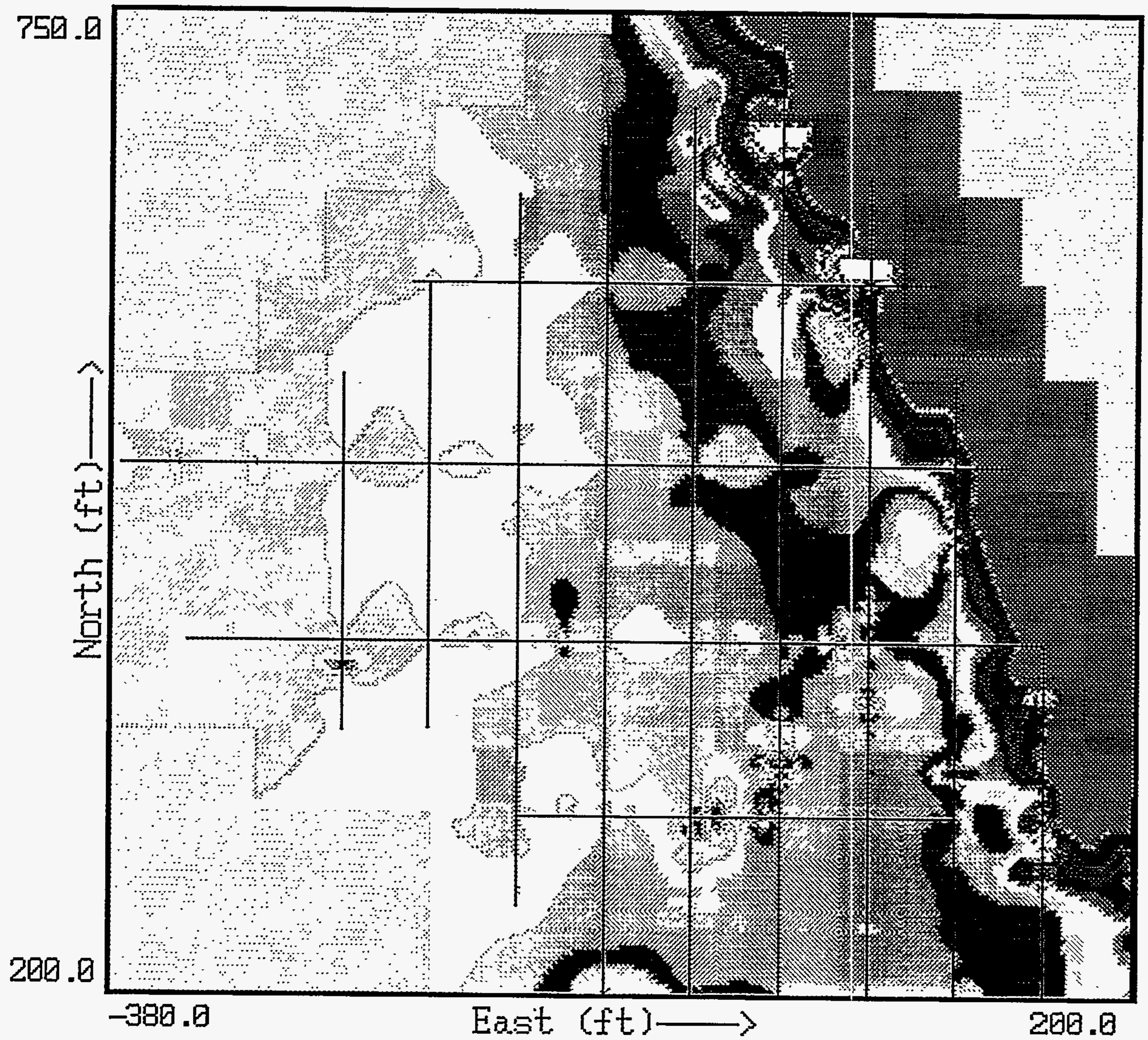


FIGURE 6 Kings Creek Study Area Total Field Magnetics Map



Kings Creek: Area 1 Magnetics (nT)

FIGURE 7 Area 1, Total Field Magnetics Map

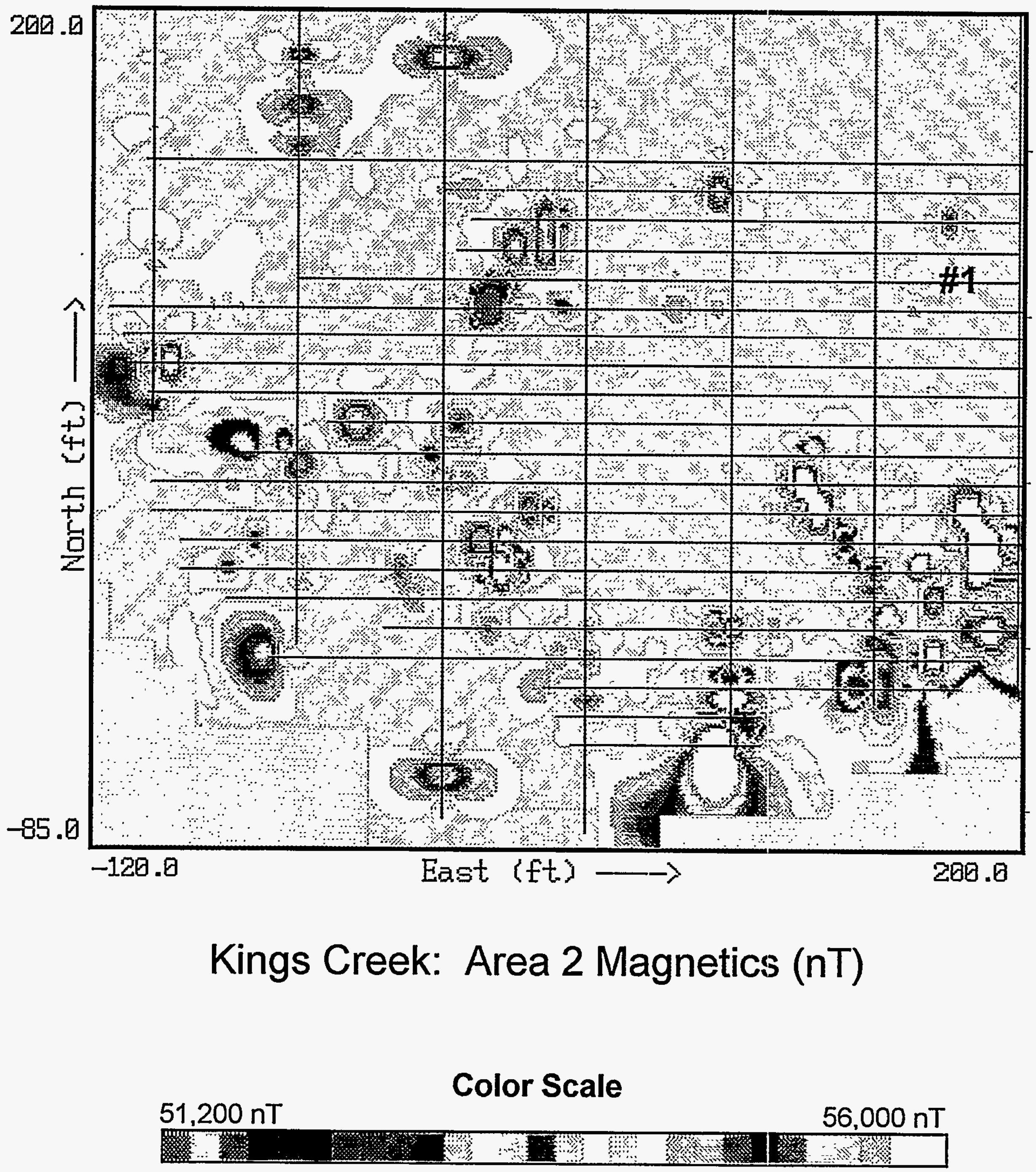


FIGURE 8 Area 2, Total Field Magnetics Map

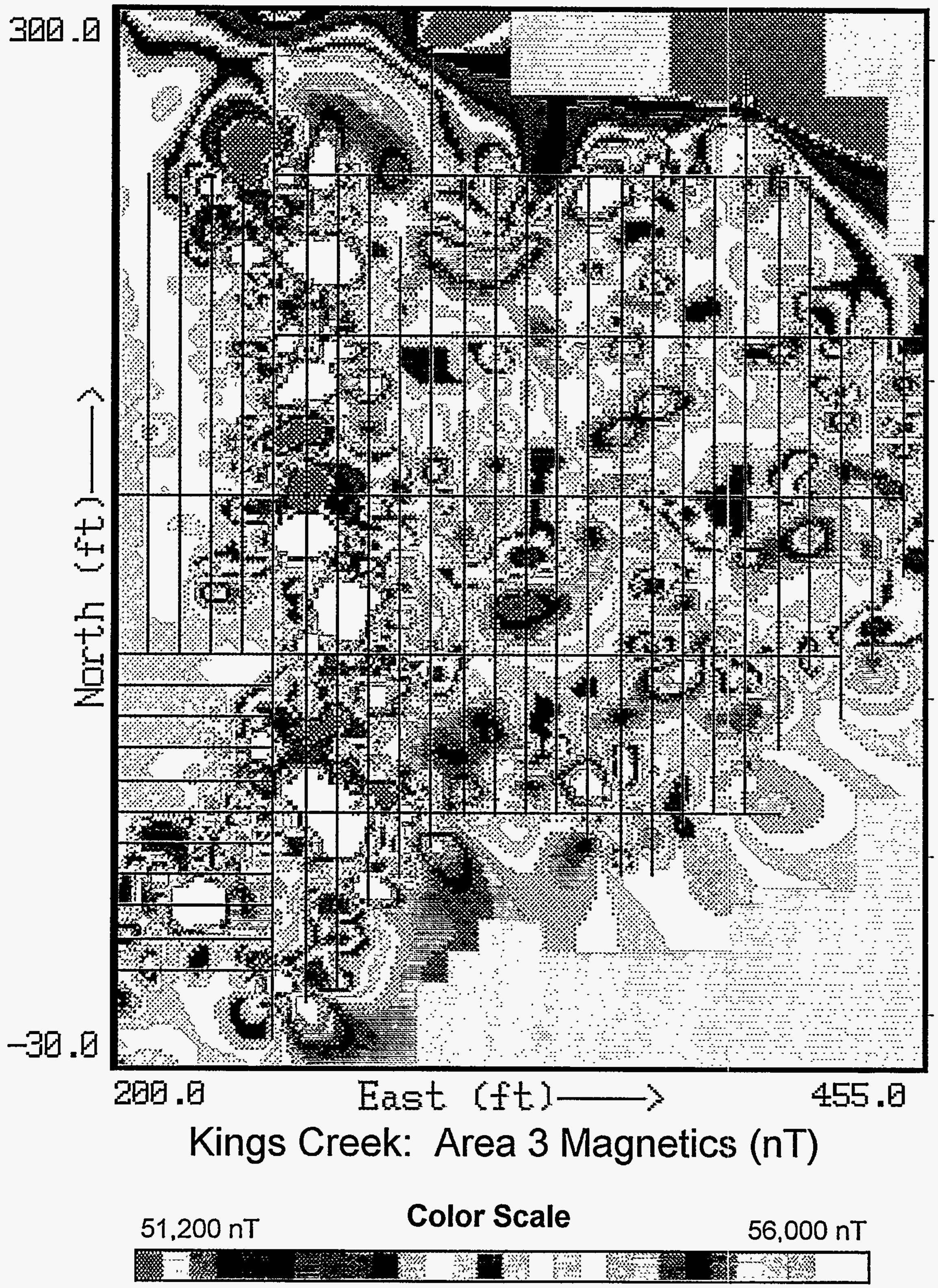


FIGURE 9 Area 3, Total Field Magnetics Map

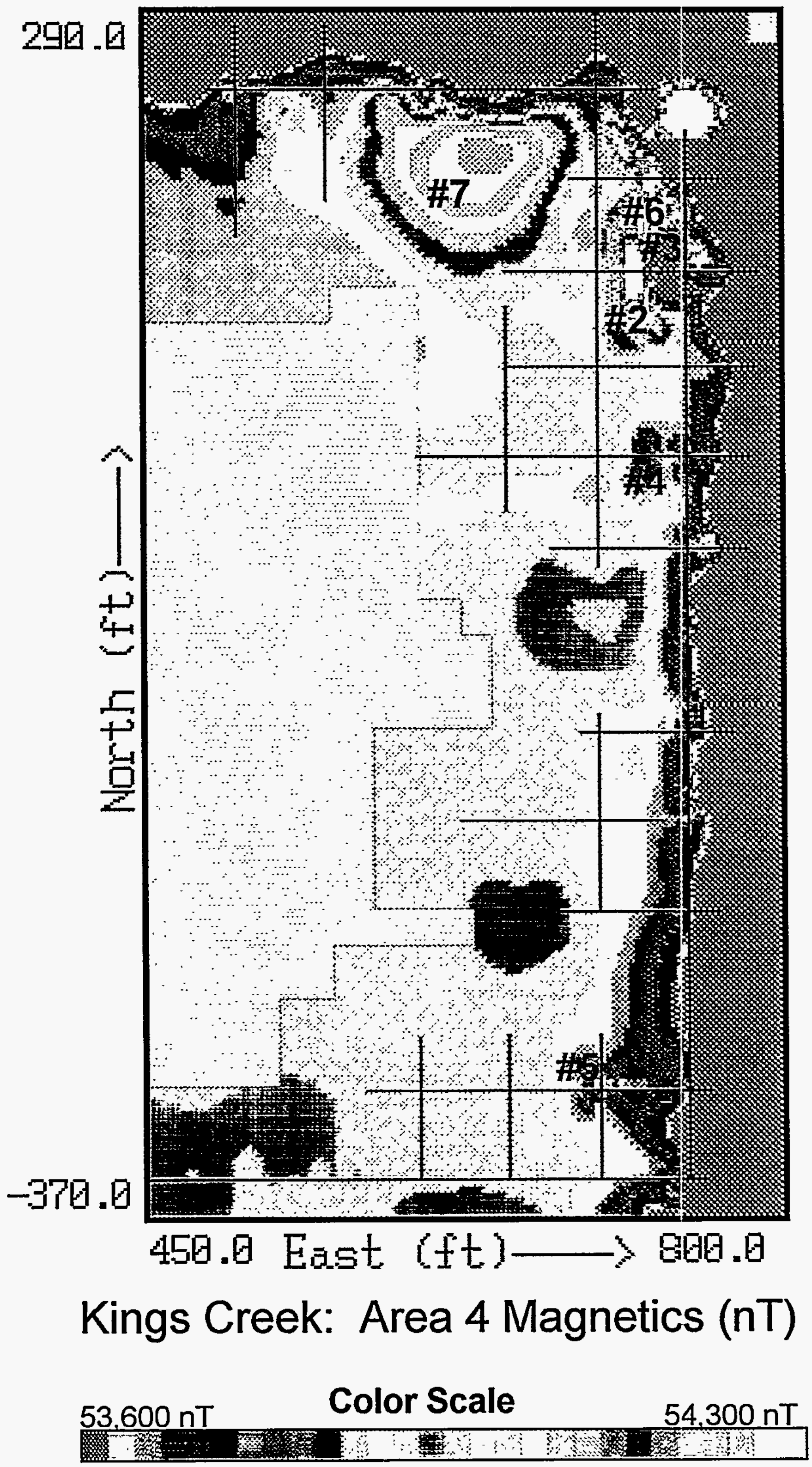


FIGURE 10 Area 4, Total Field Magnetics Map

Initially, the Kings Creek study area was surveyed along north-south traverses spaced 50 ft apart. East-west tie line traverses were collected at approximate 100-ft intervals where allowed by the vegetation cover. In-field analysis of the preliminary data indicated that Areas 2 and 3 (Figures 8 and 9) contained anomalies that required more detailed examination. Additional surveys were conducted in these two areas (the Kings Creek Disposal Site and the 30th Street Landfill) with profiles spaced 10 ft apart to further delineate the boundaries of the anomalies. Gradiometer surveys were performed between the total field survey profiles in Areas 1 and 4 to determine whether smaller clusters or point source ferrous features were inadvertently missed during the total field magnetic survey (see Section 2.2).

Errors introduced into the magnetic data due to uncorrected diurnal variations and insufficient response speed to changing signals were small compared with the amplitudes of the anomalies detected. Therefore, the anomalies displayed on the magnetic maps are qualitatively significant. Some error, however, can be introduced through inadvertent changes in instrument position or attitude relative to the ground surface. Moving around obstacles or changing walking pace may also produce some positioning error. Marks were placed on the data at 50-ft intervals and at the beginning and end of each survey line. Digital and graphic data readouts are included with the data logging computer. If significant errors were noted while conducting the survey, the profile was redone. Careful control of data acquisition and processing procedures kept errors to a minimum.

Magnetic anomalies detected in the survey area can, in many cases, be explained by ferrous objects on the surface; however, others remain unexplained. Anomalies were observed throughout the Edgewood area where amphibolite was used as road fill. Table 1 lists 71 magnetic anomalies (by area), their coordinates (at the center of each anomaly), and a brief description of each. If the anomaly encompassed a large area, a coordinate range is listed. Anomalies associated with the roadway and security fence systems, bounding the areas to the east and north, are not listed.

2.1.1 Area 1

Area 1 is a wooded location north of the Kings Creek Disposal Site (Figure 5). This area was surveyed to identify the northern boundary of the disposal site and determine whether this section was used as an undocumented burial site. Figure 7 presents the total field magnetic data for Area 1. The color contour interval for Figure 7 is reduced by a factor of seven from that presented in the map of the entire study area (Figure 6). This reduction results in smaller-magnitude anomalies appearing as a greater color contrast.

As listed in Table 1, the majority of the magnetic anomalies detected in Area 1 are caused by metallic debris visible at the surface. Other anomalies scattered throughout Area 1 are caused by unknown, buried sources.

TABLE 1 Location and Description of Magnetic Anomalies Detected in the Kings Creek Study Area

Area	Coordinates North	Coordinates East	Anomaly Description
1	690	0	Steam heat radiator and other metallic debris
	610	50	Cyclone fencing
	370	150	Gravel fill and metal culvert
	330	0	Source unknown
	300	-35	Source unknown
	385	-250	Metal canister
	500	-300 + -390	Two anomalies, source unknown
	270	150	Metal canister
	50	-345	Steel cable
	400	-125	Metal pipe
	300	-5	Source unknown
	400	30	Metal fragments
	420	50	Metal fragments
	365	50	Metal gas canister
	295	150	Source unknown
2	180	0	Push-out mound
	150 to 190	-50	Burn pit and push-out with metal fragments
	110 to 120	-100	Burn pit push-out
	80	-90	Mound with metal drum fragments
	75 to 80	-110	Round metal objects (fuses?)
	50	-70	Source unknown, push-out area
	10 to 50	-80 to -50	NE/SW-trending area of buried metal cylinders with tops at surface
	60	-30	Mound of rusted cylinder and drum parts
	50	-70	Source unknown, push-out area
	60	5	Metal fragments, push-out area
	45	0	Source unknown, push-out area
	30	30 + 40	Two anomalies, source unknown, push-out area
	10 to 20	15 to 30	Source unknown, mound with pine trees surrounded by non-vegetated area
	-35 to -10	20 to 50	Area covered with rusted metal fragments
	-5 to 15	-20 to -10	Area covered with rusted metal fragments
	-20	-60	Metal on surface
	-60	0	Source unknown
	-50	90	Source unknown, shoreline
	-35	100	Source unknown
	-10	90 + 100	Two anomalies, metal debris, push-out
	25 to 45	125 to 135	Pin flags and push-out mound
	-30	140	Metal debris
	0	150	Metal cylinder
	0	170	Metal debris
	-20	170	Source unknown, near shoreline
	-10	190	Source unknown, near shoreline

TABLE 1 (Cont.)

Area	Coordinates North	Coordinates East	Anomaly Description
	5 to 40	180 to 190	Two railroad rails, possibly other buried materiel
	110	170	Source(s) unknown, location of GPR anomaly
	130	175	Source unknown
	140	95	Source unknown
	100	80 + 95	Two anomalies, source unknown
	100	40	Source unknown, push-out
	100	20	Metal debris
	115 to 135	20 to 40	Source unknown, push-out area
	140	0 to 15	Source unknown, push-out area
3	40	215	Source unknown
	10 to 30	220 to 240	Metal debris, probable buried fill
	0	250	Metal debris
	-10	260	Source unknown, shoreline
	40	300	Source unknown, edge of phragmites
	120	230	Source unknown, small mound
	180	210	Metal debris, small mound
	165	445	Metal debris at edge of survey
	250	350	Gravel pile
	250	335	Argonne trailer
	0 to 250	240 to 280	Linear anomalous area with some metal debris visible, approximate western edge of landfill
	50 to 250	280 to 450	Anomalous probable fill area, no visible metal, may extend farther south into phragmites
4	-300	700	Source unknown
	50	740	Metal fencing
	150	725	Metal fencing
	150	740	Metal fencing
	200	730	Source unknown

2.1.2 Area 2

Area 2 is a partially wooded location containing the former Kings Creek Disposal Site and associated push-out mounds of soil and debris. Stressed vegetation and bare ground are associated with previous activities at the site. The majority of this section was surveyed on a 10-ft grid spacing.

Figure 8 presents the total field magnetic data for Area 2. The southwestern portion of the area contains surficial metallic debris, including dismantled cylinders, fuses, and rusted metal chips. The southeastern portion of Area 2 contains surficial and buried metal objects and is probably the boundary of the 30th Street Landfill. Table 1 reveals that isolated anomalies, caused by unknown buried objects, are located throughout Area 2. One unknown anomaly, located at 110N/170E of the survey grid (#1, Figure 8), corresponds to the location of an anomaly detected during the GPR survey and may represent a small buried tank or drum.

2.1.3 Area 3

Area 3 (30th Street Landfill) is an open, brushy area bounded by low-lying cattail and phragmite wetlands to the east and south. The treeline to the west (approximately 250E on the survey grid) is the approximate boundary of the landfill. This section was surveyed on a 10-ft grid spacing.

The majority of Area 3 is magnetically anomalous (Figure 9). The eastern boundary of this section, with 3–4 ft of relief above sea level, likely represents the eastern edge of landfilling. Filling probably extended farther south into an area where heavy phragmite cover prevented surveying. The central portion of the landfill is covered with soil and vegetation. Some metallic objects are visible along the eastern boundary and, especially, the western boundary of Area 3, where cover soil has been removed or collapsed into cavities, creating holes 2–3 ft deep. Table 1 provides a description of the anomalies detected in Area 3.

2.1.4 Area 4

Area 4 is east of the 30th Street Landfill, separated from the landfill by wetland. This heavily vegetated section is divided by three arms of the wetland extending toward the east (Figure 5). Area 4 was surveyed on a grid spacing of 50 ft to determine whether additional landfilling occurred at this location. The grid orientation of Area 4 is slightly different from that in the other three sections to account for the section's irregular shape (see Figure 5). A magnetic map of Area 4 is presented in Figure 10; magnetic anomalies are listed in Table 1. The contour interval for Figure 10 is reduced in comparison to Figures 6, 8, and 9, resulting in smaller-magnitude anomalies appearing with a greater color change.

Five anomalies were detected during the total field magnetic survey in Area 4. Partially buried fencing (located at 150N/725E, 150N/740E, and 50N/740E) resulted in three anomalies (#2, #3, and #4, respectively, Figure 10). Two anomalies of unknown source at -300N/700E and 200N/730E (#5 and #6, respectively, Figure 10) may also be associated with fencing material. The color contour change in the north-central portion of Area 4 (#7, Figure 10) is an artifact of the contouring program. As indicated by the profile lines, no data were collected in this area, which is marsh.

2.2 Magnetic Gradiometer Survey

A magnetic gradiometer was used during the study to clear areas prior to placement of survey stakes and geophones. The gradiometer was also used between survey profiles in areas surveyed on a 50-ft grid spacing (primarily Areas 1 and 4). Fine-grid (10-ft) total field magnetic surveys were not conducted in Areas 1 and 4 because of the heavy vegetation cover and the relative lack of magnetic features detected during the 50-ft grid surveys. The instrument used for the magnetic gradiometer survey produces an audible signal that changes pitch over anomalous areas. The locations of anomalies detected during the gradiometer survey are overlaid onto magnetic maps in Figures 11 and 12.

Numerous small magnetic anomalies are scattered throughout the section north of the former Kings Creek Disposal Site. The black outlines on Figure 11 represent areas where the density of anomalies was too high for individual identification. Metallic debris, including fencing and construction debris as well as amphibolite gravel, is visible near the fenceline to the east. The larger features to the southwest are associated with metallic debris pushed out of the former burn pits. The origin of the northeast-to-southwest-trending anomalous area is unknown, but the feature may represent a former road leading to the Kings Creek Disposal Site.

Area 4 also contains numerous small magnetic anomalies (Figure 12). The majority of the anomalies are located near the current fenceline and represent old fencing material. The origin of other scattered anomalies, located away from the fenceline, is unknown.

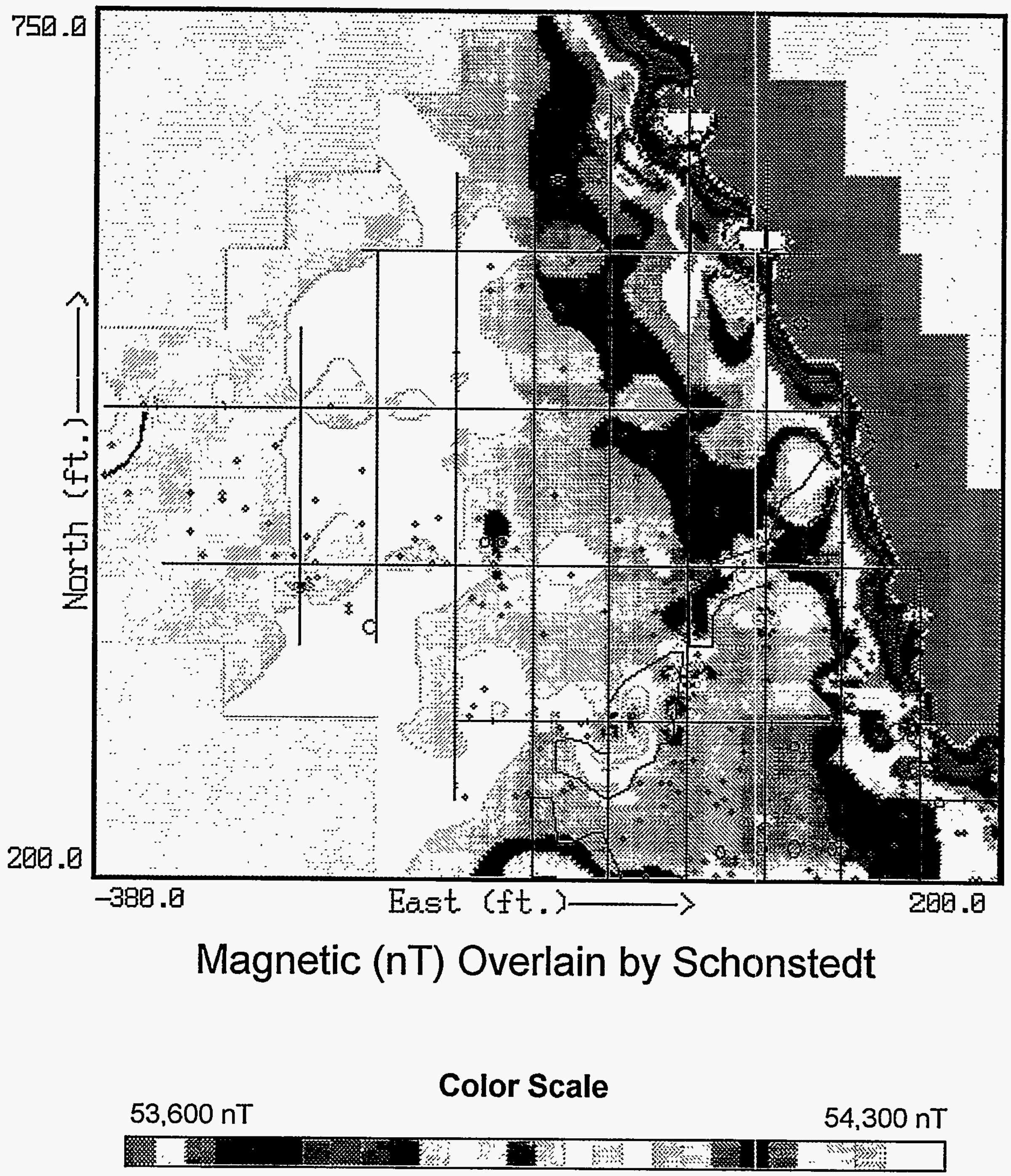


FIGURE 11 Total Field Magnetics Map Overlain by Magnetic Gradiometer Anomalies, North of Former Kings Creek Disposal Site

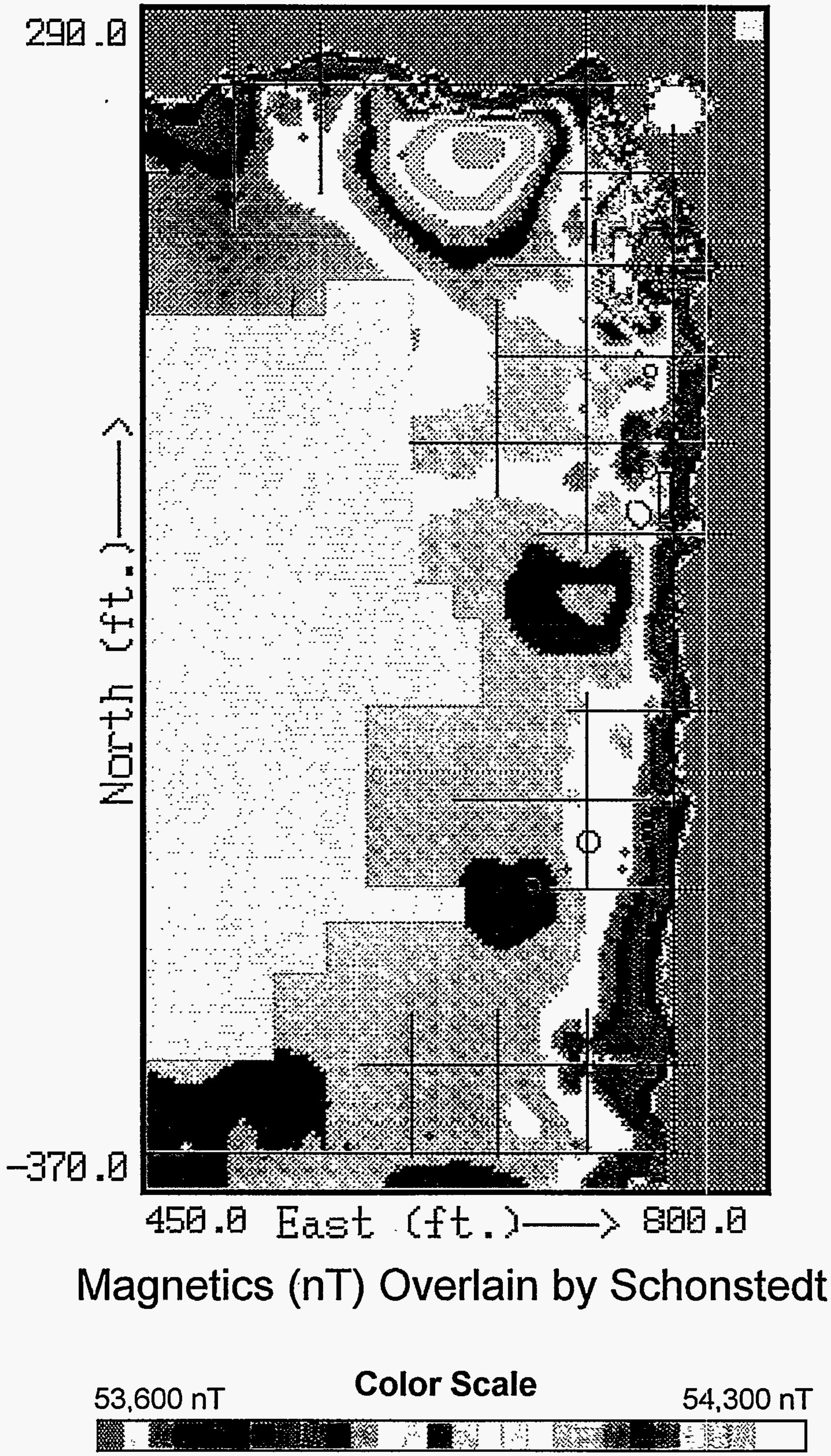


FIGURE 12 Total Field Magnetics Map Overlain by Magnetic Gradiometer Anomalies, East of 30th Street Landfill

3 Electrical Conductivity Survey

Horizontal conductivity measurements were obtained by using a Geonics EM-31, an electromagnetic induction instrument that provides mean values of apparent conductivity in the subsurface. Data were collected on 50-ft and 10-ft transects similar to those used for the total field magnetic survey (Figure 5). Data were acquired every 0.5 s, resulting in data points spaced 1.0–1.5 ft apart, depending on traverse rate. Fiducial marks were placed every 50 ft to correctly position the data within each profile. Figure 13 is a color contour map of the conductivity values of the entire study area.

The EM-31 instrument measures the apparent subsurface conductivity from just beneath the land surface to a depth of approximately 18 ft. Factors affecting subsurface conductivity include the following: depth to groundwater, chemical composition of groundwater, presence of clay minerals, type of clay minerals, presence of metals, and presence of amphibolitic roadfill. The EM-31 data were interpreted in conjunction with the magnetic, GPR, topographic, and boring data for the Kings Creek study area. These other data were used to help identify the potentially conflicting factors affecting the measured apparent conductivity.

The EM-31 survey area was divided into the same four sections used for the magnetic data survey (Figures 14 through 17). Apparent conductivities shown on the maps range from approximately -60 to 380 mS/m; the greatest conductivity ranges were observed near the 30th Street Landfill and near large surficial metallic objects (fences and debris). Although metals are good conductors, their shape and orientation in relation to the EM-31 instrument can result in an electromagnetic field in which the apparent conductivity, as read by the EM-31, is negative. Negative conductivities are an artifact of crossing high-conductivity gradients with the EM-31 boom. When crossed at right angles by the EM-31, an elongated piece of metal (such as a buried pipe) will produce three banded anomaly lineaments. The lineaments will consist of a central minimum bounded by two maxima (Geonics Limited 1992). This EM-31 signature for buried pipes has previously been observed at Beach Point in APG (see McGinnis et al. 1994a). The EM-31 contour interval in the figures representing Areas 1 and 4 (Figures 14 and 17) has been reduced from that presented in Figure 13, which represents the entire study area, to illustrate the more subtle conductivity changes in these less disturbed areas.

EM-31 measurements were also collected during an offshore geophysical survey performed by ANL. The surveyed area included the near shore adjacent to the Kings Creek study area. A portion of the offshore EM-31 survey data is discussed in conjunction with the onshore data from Area 3.

3.1 Area 1

Conductivity values for Area 1 are shown in Figure 14. Two low-conductivity anomalies, located in the northern portion of Area 1 at approximately 690N/00E and 650N/30E (#8 and #9, respectively, Figure 14), are associated with metallic debris. A conductivity high was found at

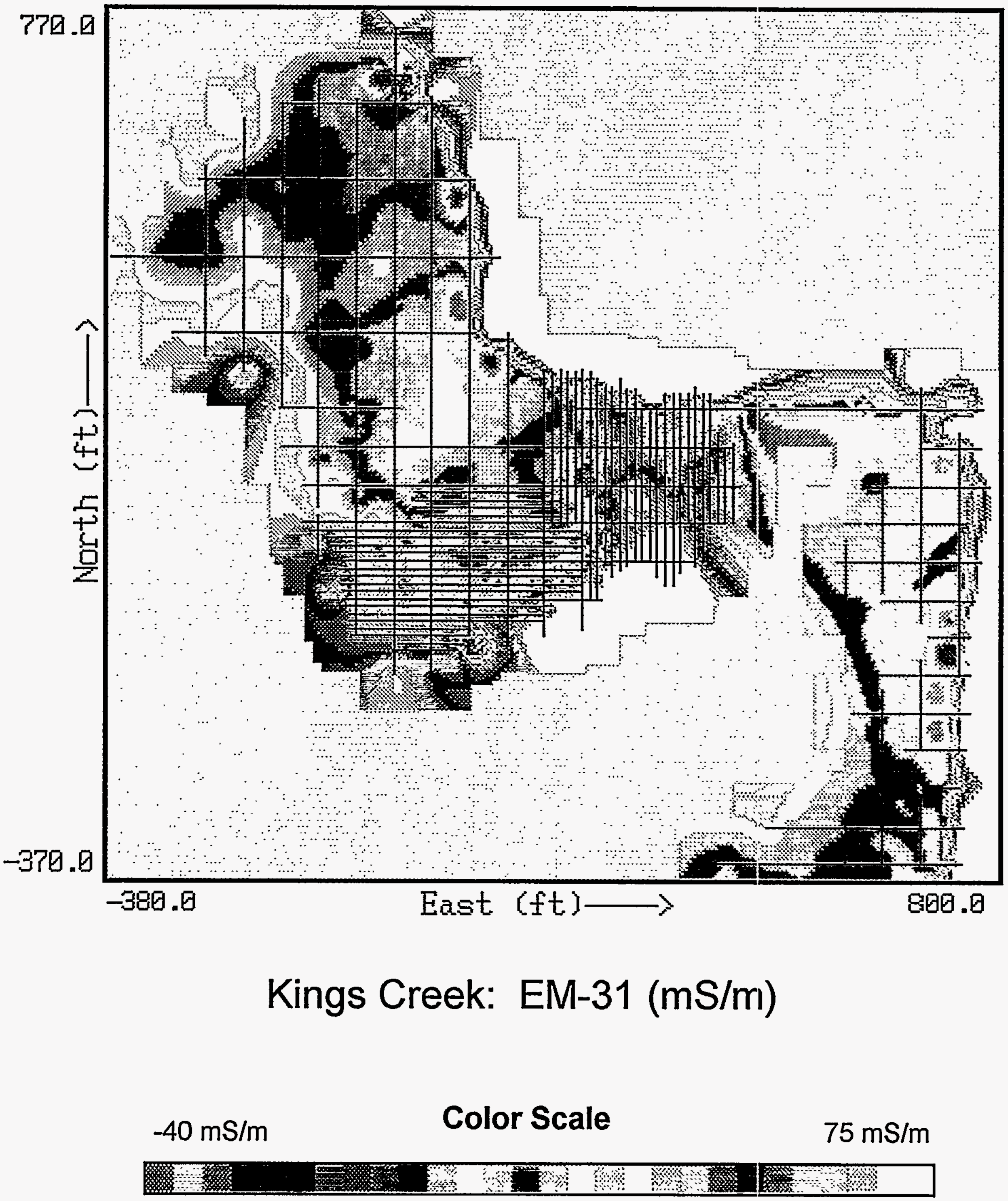


FIGURE 13 Kings Creek Study Area, EM-31 Electromagnetics Map

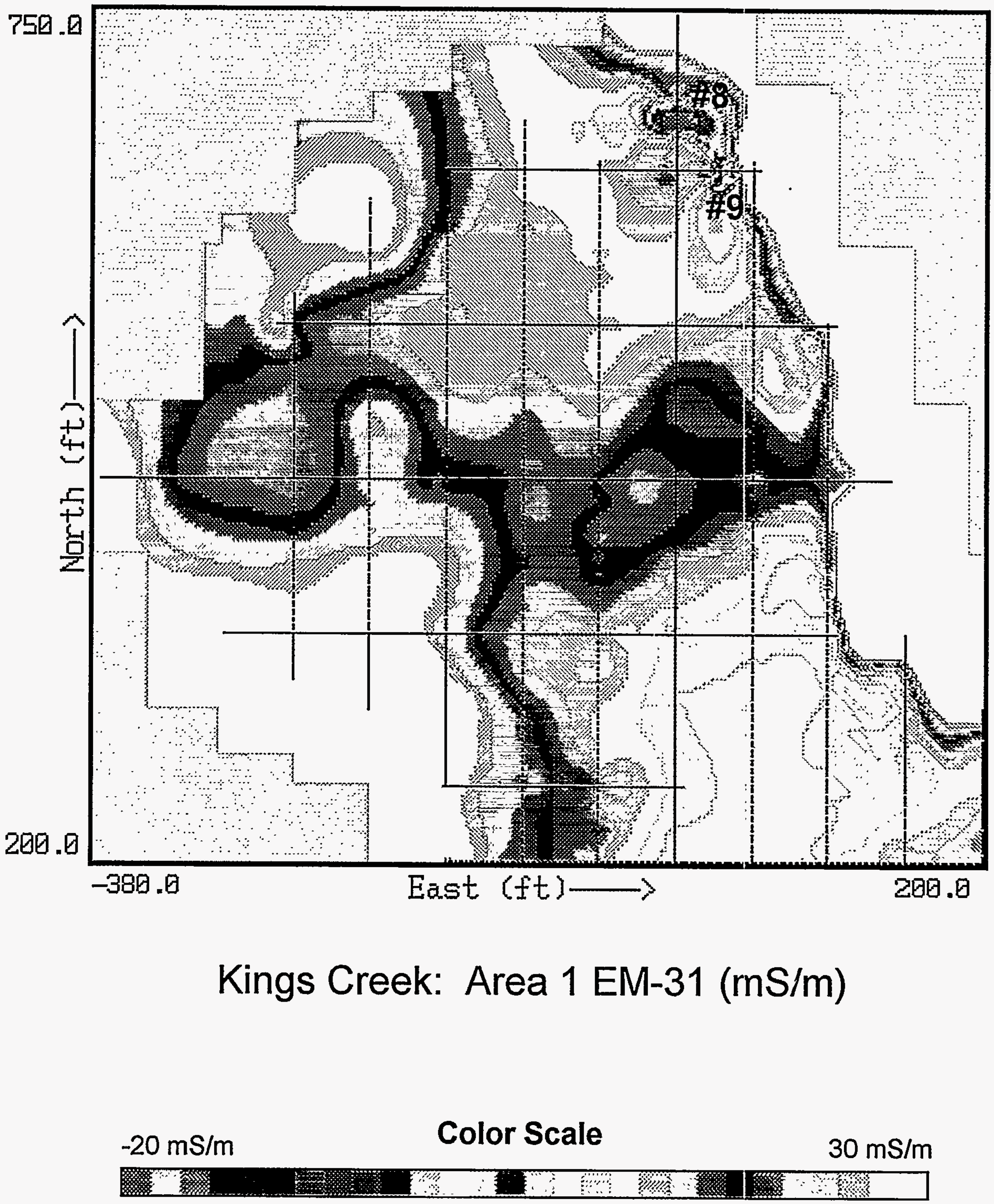


FIGURE 14 Area 1, EM-31 Electromagnetics Map

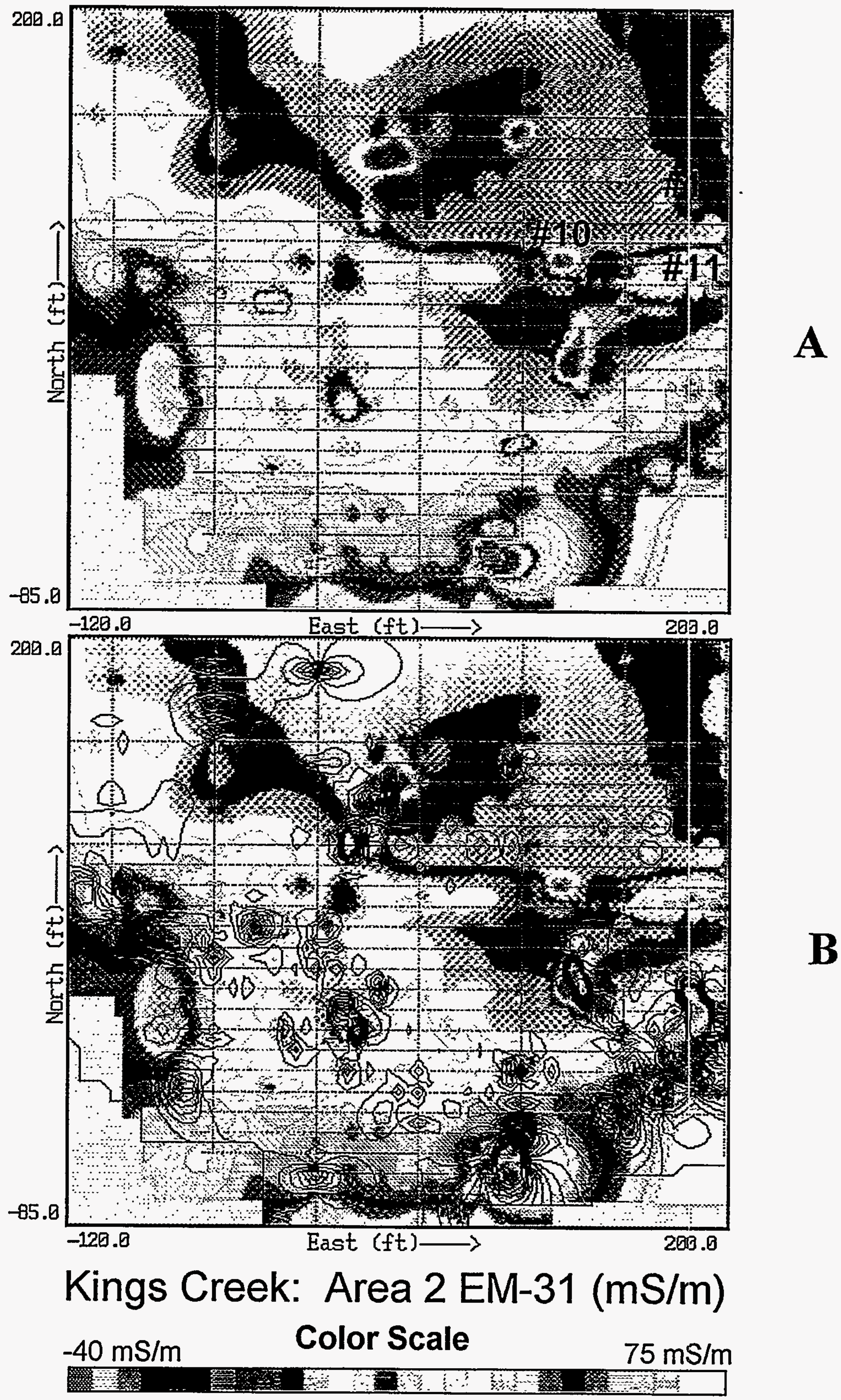


FIGURE 15 A: Area 2, EM-31 Electromagnetics Map; B: Area 2, EM-31 Overlain by Magnetic Contours

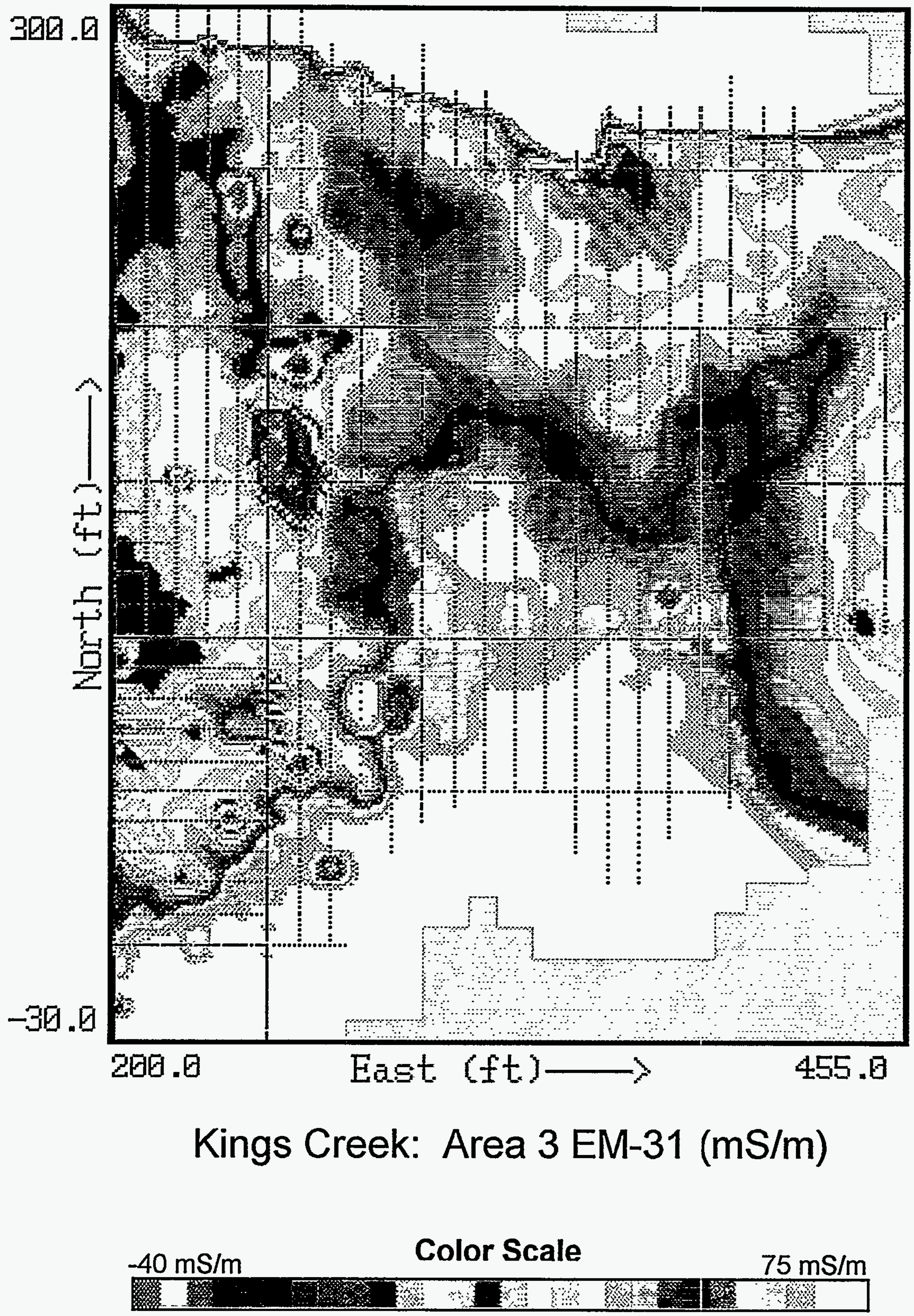
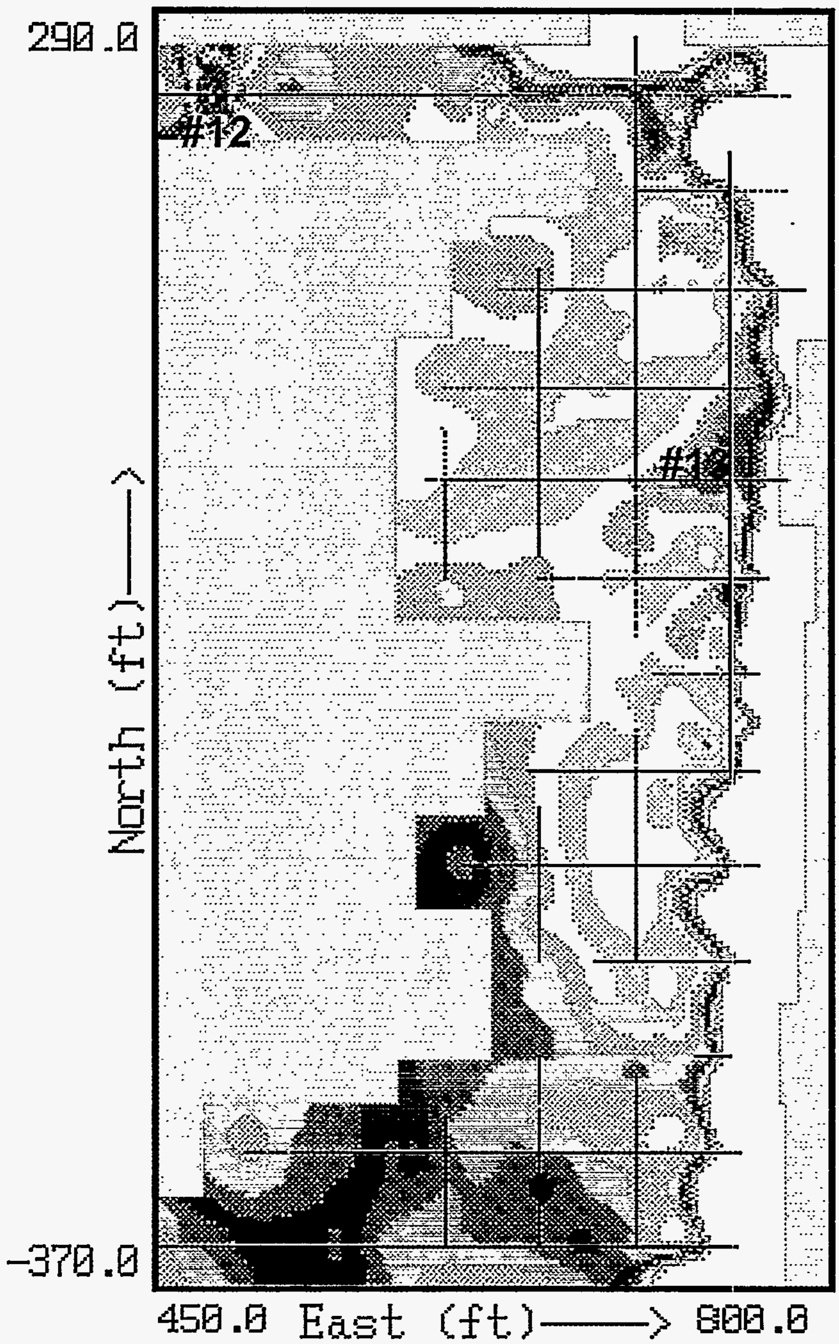


FIGURE 16 Area 3, EM-31 Electromagnetics Map



Kings Creek: Area 4 EM-31 (mS/m)

FIGURE 17 Area 4, EM-31 Electromagnetics Map

the fenceline along the eastern boundary of Area 1. Metallic objects can provide either a high or low conductivity anomaly depending upon their size, shape, and orientation. Other highs along the northwest, west, and southwest edges of the section are likely caused by the surface water in Kings Creek.

The northeast/southwest-trending, relatively higher-conductivity feature detected in the central portion of Area 1 is likely caused by the site topography (Figure 2). Generally, the depth to the water table in lower topographic areas will be shallower, resulting in a higher average conductivity for the relatively shallow depths measured by the EM-31 (i.e., the upper 18 ft). Lithology may also be a factor; if more clays are present in the shallow subsurface, slightly higher conductivities will result.

3.2 Area 2

Conductivity values for Area 2, the approximate location of the former Kings Creek Disposal Site, are shown in Figure 15A. The figure shows several isolated areas of low conductivity, indicated by the colder colors. Most of these low-conductivity zones correspond to buried or surficial magnetic anomalies. Figure 15B shows the EM-31 conductivity contours (in color) overlain by the black line magnetic contours. Two low-conductivity anomalies detected by the EM-31 at 80N/120E and 70N/180E (#10 and #11, respectively, Figure 15A) do not correspond to magnetic anomalies. This finding may result from a positioning error during the magnetic survey caused by the thick vegetative undergrowth in these areas. Another low-conductivity anomaly, located at 110N/170E (#1, Figure 15A), was detected during both the magnetic and GPR surveys.

In general, no features indicative of lithologic change or buried paleochannels are revealed by the EM-31 data for Area 2. Conductivities gradually increase toward Kings Creek, which would be expected based on the presence of surface water and metallic debris at some locations (Figures 15A and 15B). No large-scale buried features were detected by the EM-31 survey in the former Kings Creek Disposal Site.

3.3 Area 3

Conductivity values for Area 3, the approximate area of the 30th Street Landfill, are shown in Figure 16A. The complex patterns of EM-31 anomalies, located along the western and southwestern boundaries of the 30th Street Landfill, likely represent buried and surficial metallic debris.

The conductivity feature of most interest in Area 3 is the centrally located zone of relatively higher conductivity. This feature is believed to represent the site of a former estuary that was later used as a landfill. The EM-31 data correspond to the location of the former estuary, with upstream lobes extending toward the northwest and northeast. Additional evidence of a deeper paleochannel at this location, both onshore and offshore, is presented with the discussion of the GPR surveys in Section 5.

EM-31 data were also collected in the offshore portion of the embayment adjacent to Area 3. The location of this portion of the offshore survey is shown in Figure 18. The electromagnetic data reveal relatively higher conductivities 200 ft into Kings Creek (Figure 19). These higher conductivities indicate the presence of clayey estuarine sediments and groundwater with relatively higher conductivity. A more detailed evaluation of the offshore geophysical study will be presented in a separate report.

3.4 Area 4

Conductivity values for Area 4, east of the landfill/disposal areas, are shown in Figure 17. One low-conductivity anomaly, located at 250N/490E (#12, Figure 17), represents a steel culvert beneath the roadway. As described in the beginning of this section, the shape and orientation of

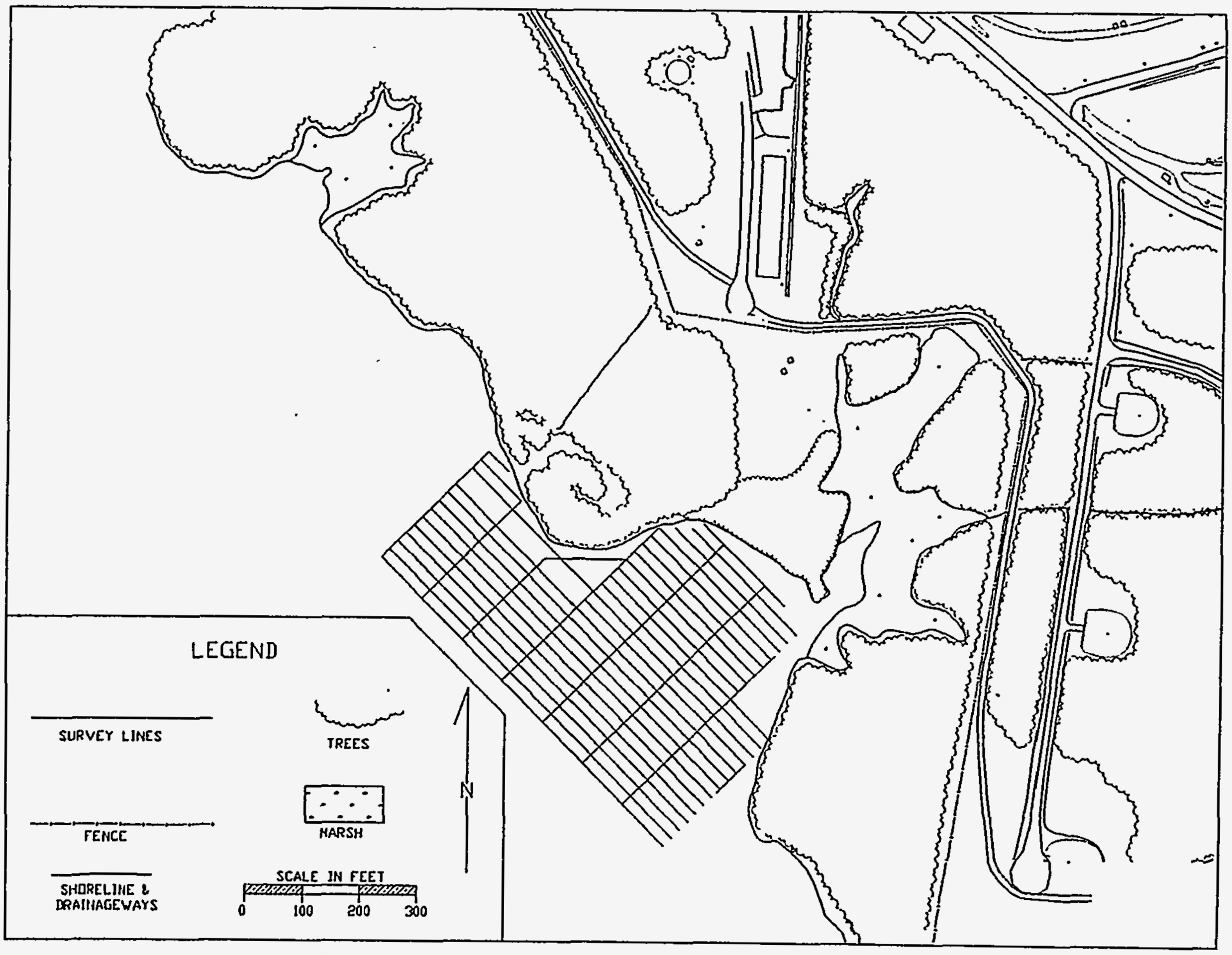


FIGURE 18 Location of EM-31 Offshore Profiles

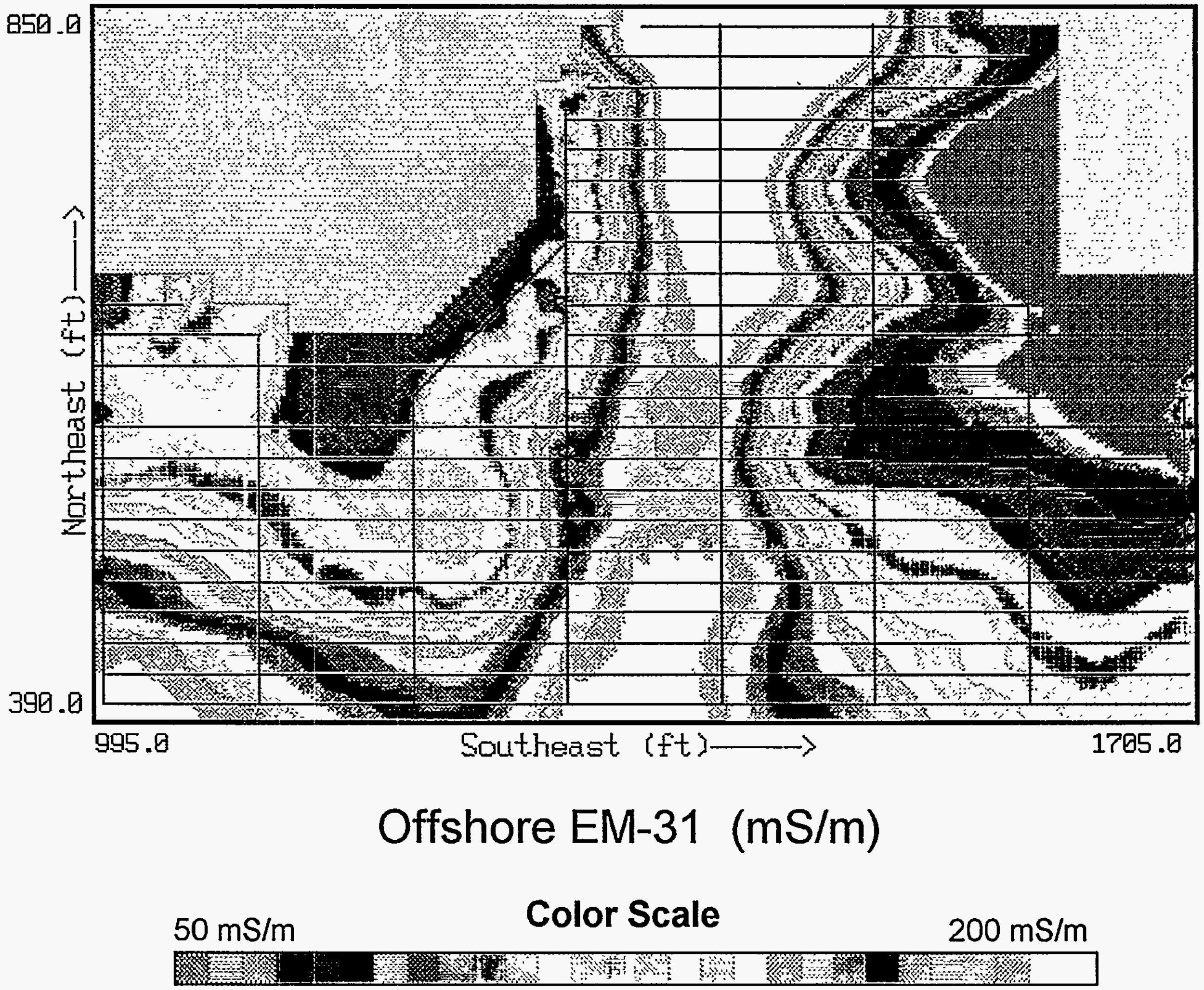


FIGURE 19 Kings Creek Offshore EM-31 Electromagnetics Map

the metal culvert can produce an apparent conductivity low. High-conductivity anomalies, caused by the fenceline and the amphibolite roadfill material, were found in the northern portion and along the eastern edge of Area 4. Also, partially buried fencing material, located at approximately 50N/730E (#13, Figure 17), may create the conductivity high extending westward at this location.

The data presented in Figure 17 were plotted using a smaller contour interval than that used for Areas 2 and 3 to highlight the more subtle conductivity changes in this relatively quiet area. Slightly higher conductivities in the southern portion of Area 4 likely represent a greater clay content in the upper 18 ft of sediment. A recently installed soil boring (WBR-27) in this area (approximate location shown in Figure 20) exhibited predominantly clayey sediments to 19 ft below surface, with a sand zone between 9.0 and 13.6 ft. Farther north in Area 4, conductivities were lower because of greater amounts of sand in the subsurface. The lithology found in recently installed soil boring WBR-23 (Figure 20) was predominantly sands and silty sands to

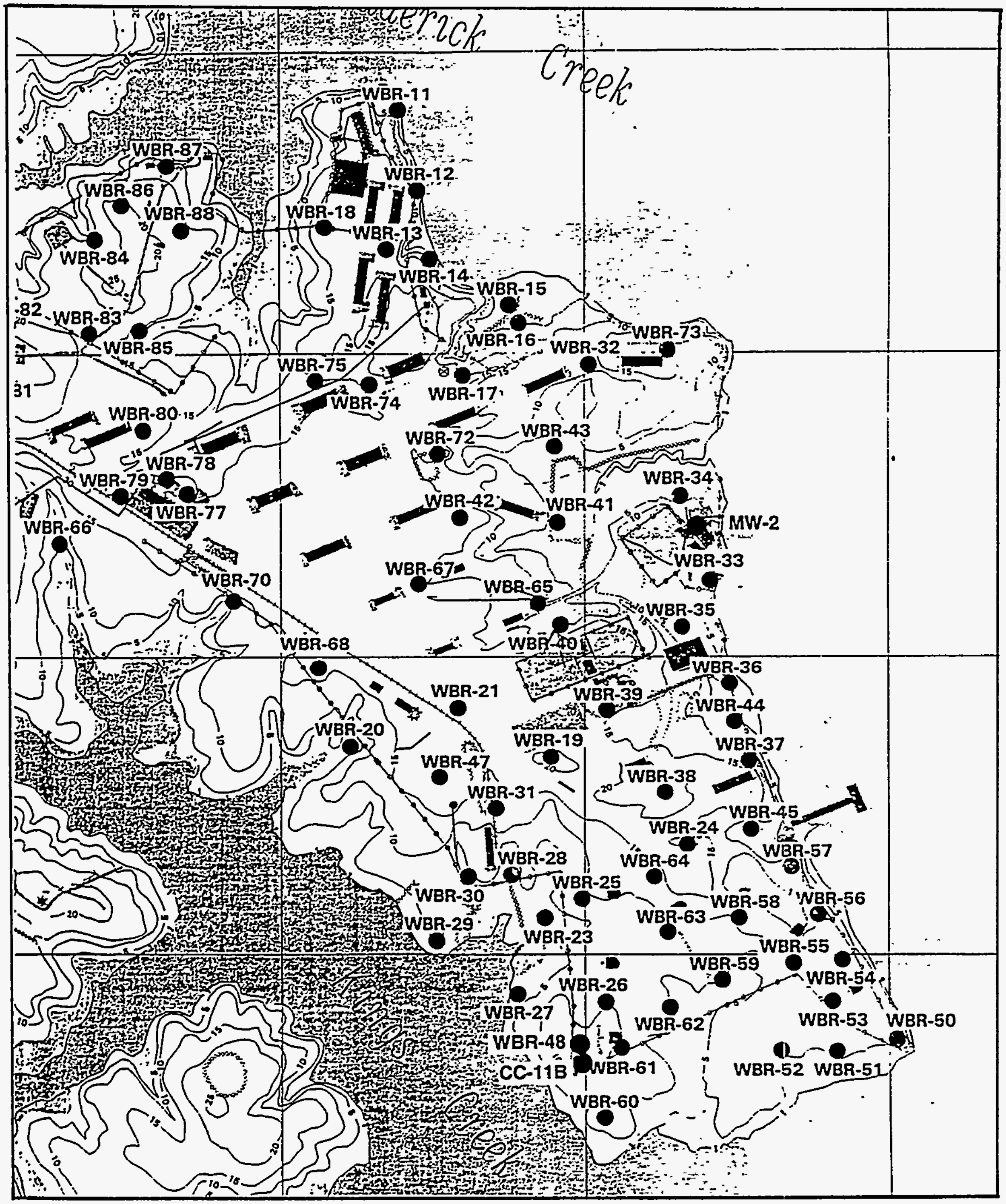


FIGURE 20 Monitor Well Location Map, Bush River Peninsula (adapted from U.S. Army Corps of Engineers 1994)

approximately 41 ft below land surface. Conductivity, soil boring, and GPR data (see Sections 4 and 5) indicate that a paleochannel, trending east-west, is present at this location. Boring logs are included as Appendix A.

4 Geophysical Well Logging

Downhole natural gamma and electromagnetic induction (conductivity/resistivity) well logging were performed on eight monitor wells installed in 1994 (WBR-19, WBR-20, WBR-23, WBR-35, WBR-38, WBR-42, WBR-43, and WBR-47) and two previously installed site monitor wells (CC-11B and MW-2) on the Bush River Peninsula (Figure 20). The natural gamma and conductivity/resistivity well logs are presented in Appendix B. Four of the logged wells (WBR-19, WBR-20, WBR-23 and WBR-47) are located in the vicinity of the Kings Creek study area. Following the Kings Creek geophysical surveys, monitor well WBR-48 was installed adjacent to monitor well CC-11B. Boring logs for these five wells are included in Appendix A. In addition to the natural gamma and electromagnetic induction downhole geophysical techniques, downhole seismic logging was performed on monitor well CC-11B; the results of the downhole seismic logging are presented in Section 6.2.

Prior to the insertion of the downhole well logging equipment, the headspace of the monitor well was checked with a photoionization detector and a Geiger-Mueller counter. The downhole probes and cable were decontaminated following logging at each well by washing with a nonphosphate detergent and double rinsing with distilled water. Paper towels used to wipe the probe and cables were also surveyed by using the Geiger-Mueller counter.

A logging speed of 10 ft per minute was employed with each method. Data were collected going both up and down the wells to check for repeatability. All data were stored on the field computer used to operate the logging programs.

The natural gamma logging technique measures naturally occurring gamma radiation in the subsurface. In general, higher gamma activity is found within clayey sediments than within sands. Electromagnetic induction data indicate the subsurface conductivity, which is primarily a function of the pore water chemistry below the water table. Natural gamma, conductivity, and resistivity (which is the inverse of conductivity) logs are presented in Appendix B. Soil boring logs for monitor wells WBR-19, WBR-20, WBR-23 and WBR-47, located near the Kings Creek study area (Figure 20), were available to compare the downhole geophysical data with the actual lithology found in these boreholes. A column presenting the lithology, as obtained from the soil boring logs, has been added to the natural gamma and conductivity/resistivity logs for these four wells (Appendix B). A column presenting the lithology obtained from the soil boring log for monitor well WBR-48 (recently installed adjacent to monitor well CC-11B) has been added to the natural gamma and conductivity/resistivity logs for monitor well CC-11B. A good correlation between the geophysical logs and the soil boring logs for these four wells is evident.

5 Ground-Penetrating Radar Surveys

The primary objective of the GPR surveys was to provide a better understanding of the shallow stratigraphy in and around the King's Creek Disposal Site and the 30th Street Landfill. GPR was also used to help locate buried anthropogenic anomalies. Because of the dense vegetation within most of the study area, GPR surveying was limited. Profiles were collected along the fence line, paths, and abandoned roads in the woods, and in an open grassy area near the survey center. GPR profiling was also performed offshore from the study area. The GPR profile locations are shown in Figure 21.

Both the 100- and 300-MHz antennas, in a bistatic configuration, were used along the GPR profiles. The antennas were separated by a fixed distance of 4.5 ft. Onshore profiles were collected in a continuous mode using an all-terrain vehicle to tow the antennas. The offshore data were collected by using a small bass boat as the towing vehicle; the antennas were placed on the bottom of an inflatable rubber raft towed behind the boat. Range settings between 100 and 600 nanoseconds (ns) were used to collect the GPR profiles. The profiles collected with the 300-MHz antennas at a range setting of 300 ns provided the best data in most onshore locations. The 100-MHz antennas were more effective over water, with a range of 500 ns. All of the profiles shown have been computer-processed with a boxcar filter. Adjustments in the gains have been made for some of the profiles to help remove high-frequency noise and enhance structure at depth. The approximate depth given for the profiles is based on a two-way travel time of 9 ns/ft for the soils and 18 ns/ft for the offshore water column. The two-way travel times for the soils and water are estimates based on velocities given by the manufacturer (GSSI 1987). GSSI estimates the two-way travel time for "average soil" at between 7 and 9 ns/ft. The slower velocity of 9 ns/ft was used because of the shallow water table and saturated soils.

5.1 Offshore GPR Surveys

Figures 22A and 22B illustrate a GPR profile collected approximately 30-40 ft offshore from the Kings Creek study area. The location of this profile is shown in Figure 21 (profile #16). The profile was collected by using the 100-MHz bistatic configuration with an antenna separation of 4 ft and a range setting of 500 ns. Figure 22A is shown without the interpretation; Figure 22B shows the interpreted structures. This profile reveals southeast- and northwest-dipping structures that are likely the sides of a paleochannel. The paleochannel measures over 500 ft wide and the thalweg extends below the depth of penetration. The depth of penetration is inferred to be approximately 45 ft below the creek bottom. The water depth is between 2-3 ft. The upper 10 ft of sediment is composed of very soft silts and clays. The loss of signal over the middle portion of this paleochannel suggests that the channel may be filled with more clayey, saturated sediments that are difficult to penetrate with GPR. The profile also shows what may be old terraces on each side of the channel. The GPR data collected offshore will be presented in a future report.

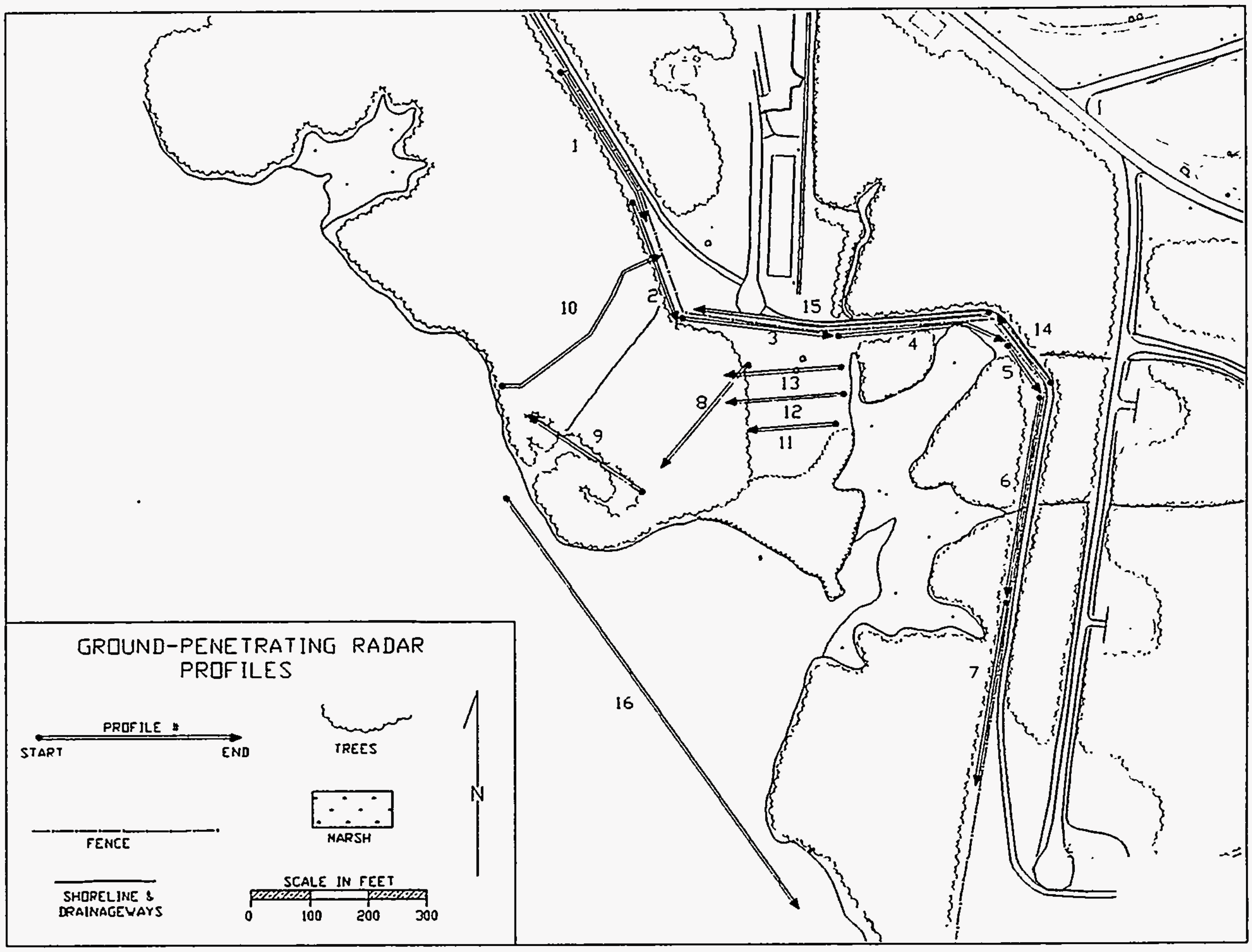


FIGURE 21 Ground-Penetrating Radar Profile Locations

5.2 Onshore GPR Surveys

The onshore GPR data also reveal dipping structures that may be associated with paleochannels. Figures 23A and 23B show a portion of what may be a paleochannel beneath the former location of the 30th Street Landfill. The profile shown in Figures 23A and 23B was collected from east to west along the 150N grid line. The location of this profile is shown in Figure 21 (profile #12). The east-dipping structure may be the west side of a paleochannel. This profile also shows some buried debris approximately 6-7 ft below the ground surface from 400E to 380E. Near-surface debris can be seen over the last 25 ft of the profile.

Figures 24A and 24B, which illustrate a profile collected from east to west along grid line 200N (profile #13 on Figure 21), show both sides of a paleochannel with the thalweg at approximately 350E. The bottom of the channel is approximately 35 ft below the ground surface. This profile also shows an undulating surface between 5 and 15 ft below the ground surface, which likely represents two shallow paleochannels superimposed over the deeper, older paleochannel. On the basis of the current water depth in Kings Creek, which is 5 ft or less, this undulating reflector cannot represent pre-fill topography. The paleochannel system developed in the Kings Creek estuary during the Pleistocene Epoch was subsequently filled with Holocene sediments. Some buried debris, located within the upper few feet, is also evident in the profile.

The GPR profile presented in Figures 25A and 25B (profile #15 on Figure 21) also shows two possible paleochannels. This profile was collected from east to west inside the security fence with the 100-MHz bistatic antenna configuration at a range setting of 400 ns. During collection of this profile, there was likely an intermittent loose antenna connection that appears as a strong flat ring down the entire profile or as sharp breaks in the signal. The paleochannel on the east end measures approximately 175 ft wide, with the thalweg at a depth of approximately 22 ft below ground surface. The deeper channel on the west end is over 250 ft wide and roughly 33 ft deep. Channel fill materials can also be seen on this profile as flat-lying reflectors.

Profile #14 (Figures 26A and 26B) was collected from southeast to northwest inside the security fence with the 100-MHz bistatic antenna at a range setting of 400 ns. The northwest end of profile #14 joins the east end of profile #15 (Figure 21). A west-dipping structure in the northwestern portion of this short profile likely represents a continuation of the shallow paleochannel structures visible on the east side of profile #15 (Figures 25A and 25B).

Figures 27A and 27B show another paleochannel that is much smaller and shallower than the other subsurface features detected using GPR methods. This profile (profile #6 in Figure 21) was collected along the eastern edge of the survey area. The paleochannel corresponds to an existing drainageway at grid coordinates -30N/770E. The thalweg of this channel is approximately 7 ft below the ground surface and the channel width is roughly 30 ft. On the basis of well log data and, potentially, EM-31 electromagnetic data (Figure 17), another paleochannel is suspected at approximately 100N along this profile. Poor signal penetration is the result of ground surface conditions in this area.

Some anthropogenic anomalies are shown in Figure 28. This figure shows the last 75 ft of profile #8 (Figure 21) within the former Kings Creek Disposal Site. The anomaly centered at grid coordinates 110N/170E is most likely a cylindrical object, based on its hyperbolic shape. The object is buried about 1 ft below the ground surface. The debris shown at the end of the profile is also buried in the upper 1 ft of the subsurface.

The profile presented in Figures 29A and 29B was collected roughly parallel to the shoreline from southeast to northwest across the area, which is void of vegetation. The location of this profile is shown in Figure 21 as profile #9. A small, shallow paleochannel is apparent at the beginning of the profile. The former burn pit is also evident. The burn pit measures roughly 25 ft across. The depth to the bottom of the pit is difficult to identify because of the ringing reflectors, but is probably less than 3 ft, which is the approximate depth to the water table inferred from the site topography.

A

B

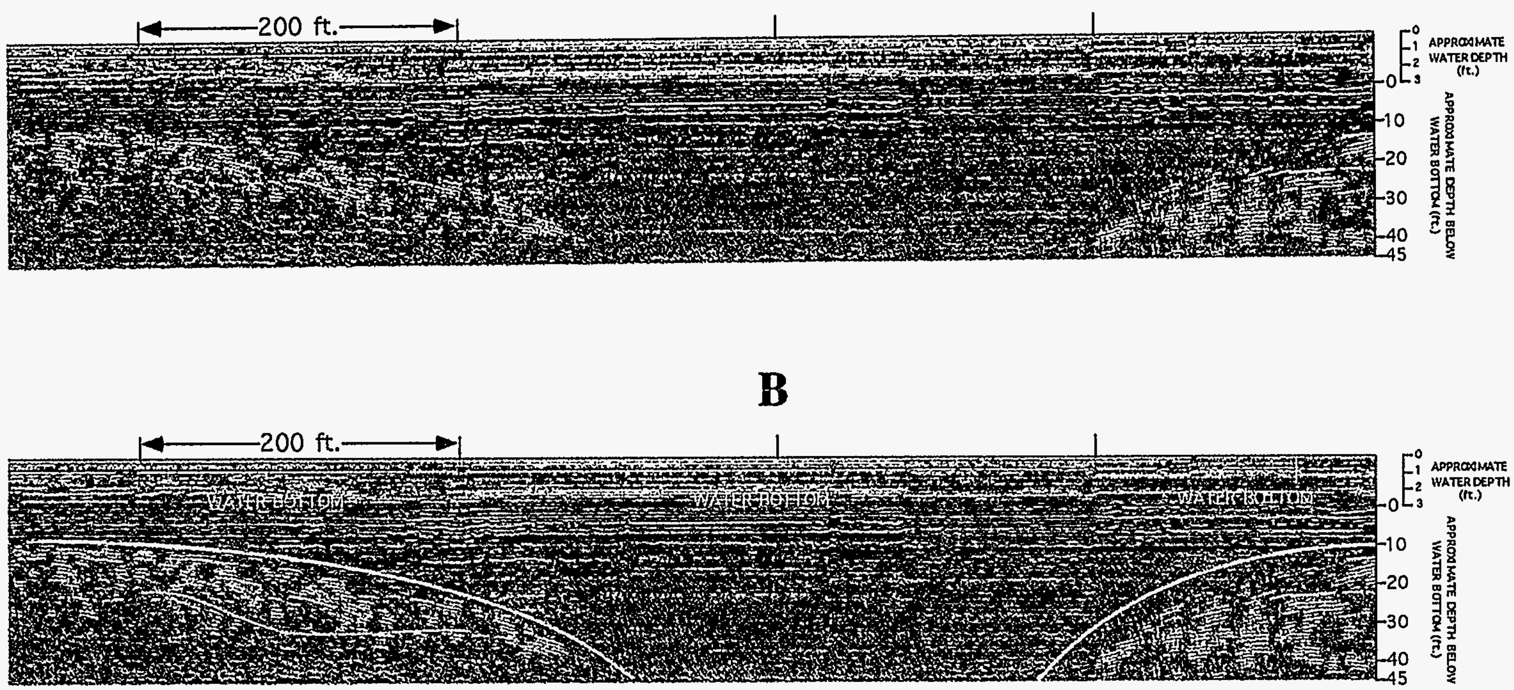


FIGURE 22 A: GPR Profile #16 (Offshore); B: GPR Profile #16 with Interpretation

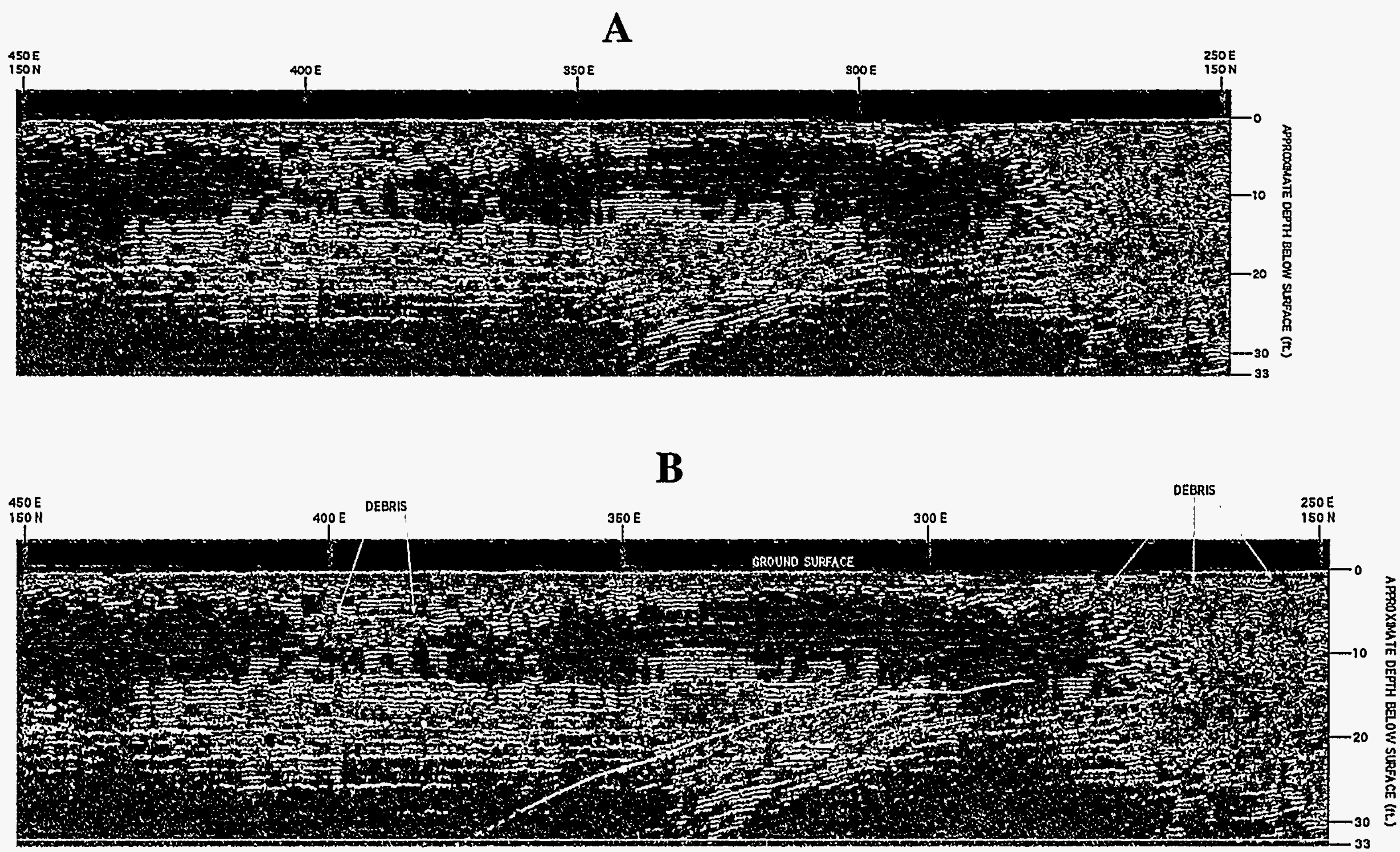
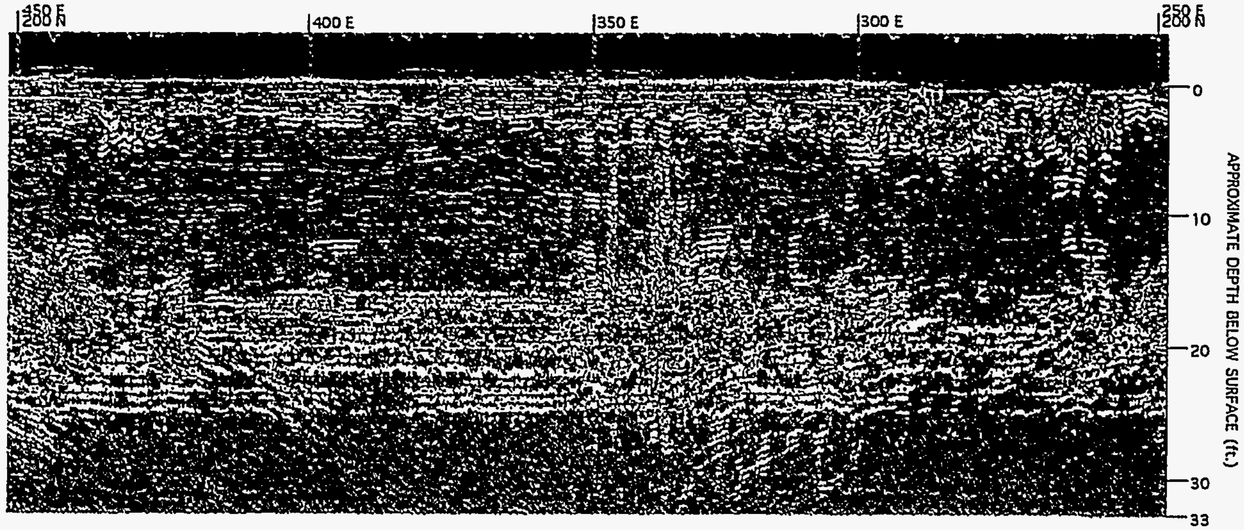


FIGURE 23 A: GPR Profile #12; B: GPR Profile #12 with Interpretation

A



B

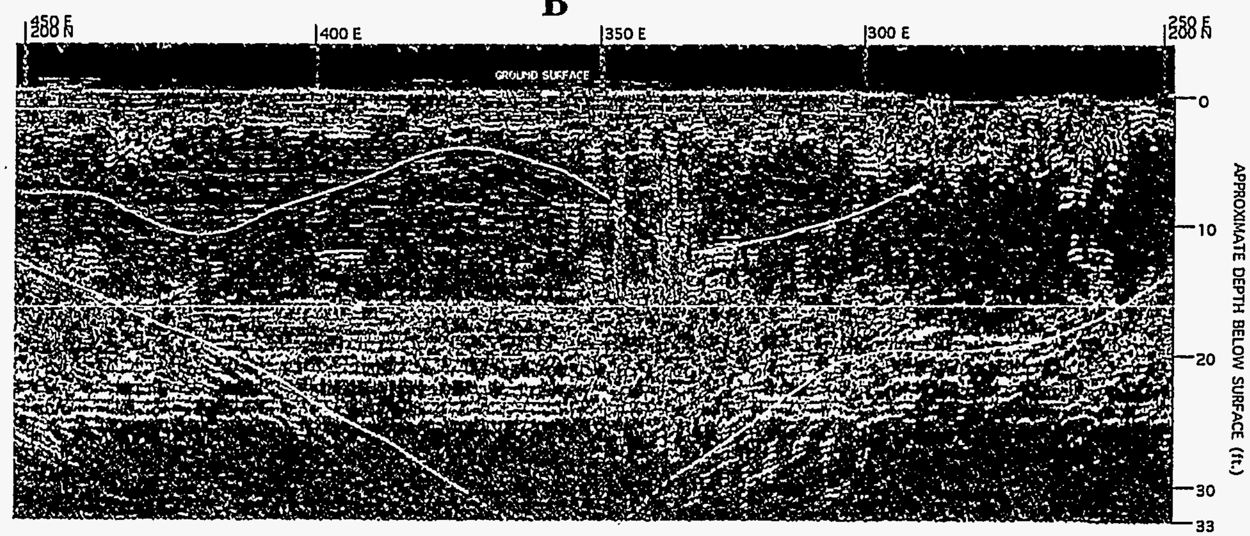
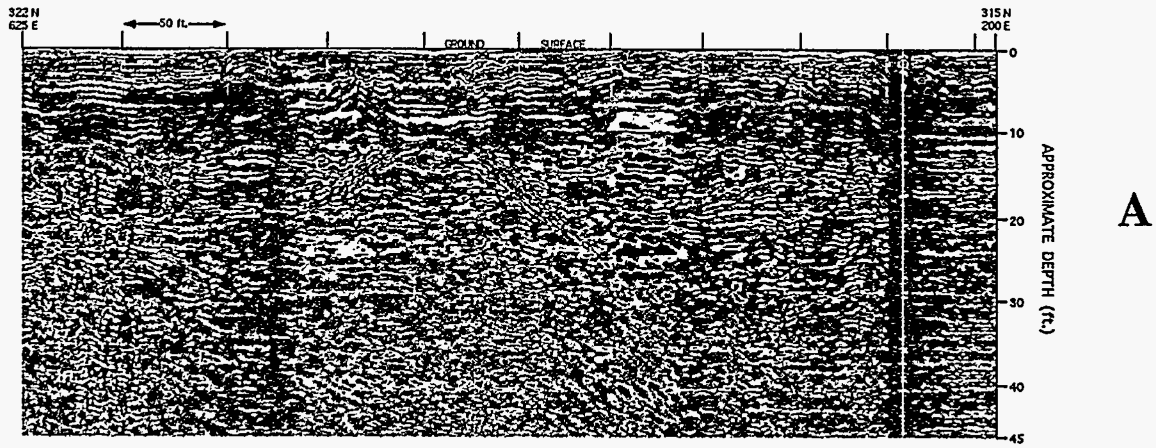


FIGURE 24 A: GPR Profile #13; B: GPR Profile #13 with Interpretation



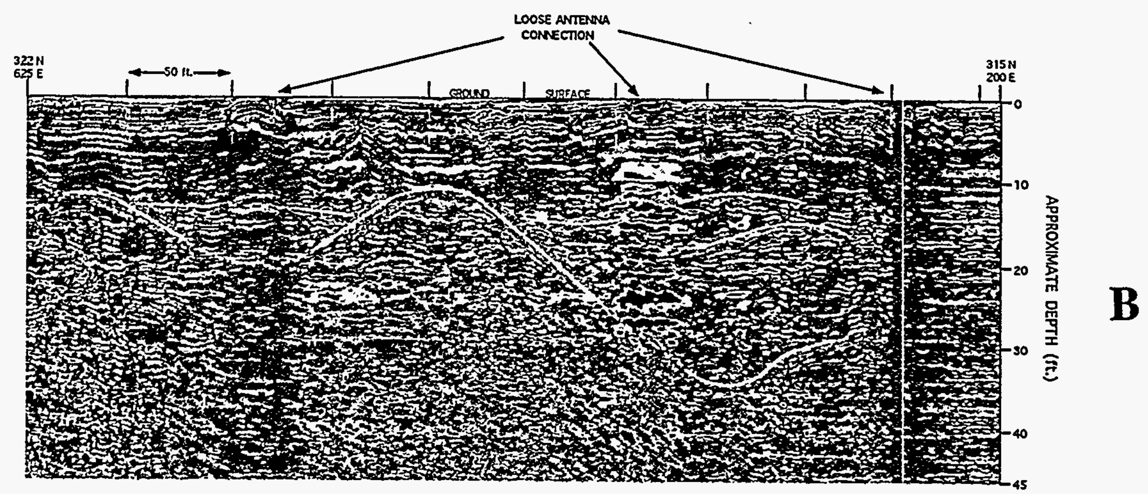


FIGURE 25 A: GPR Profile #15; B: GPR Profile #15 with Interpretation

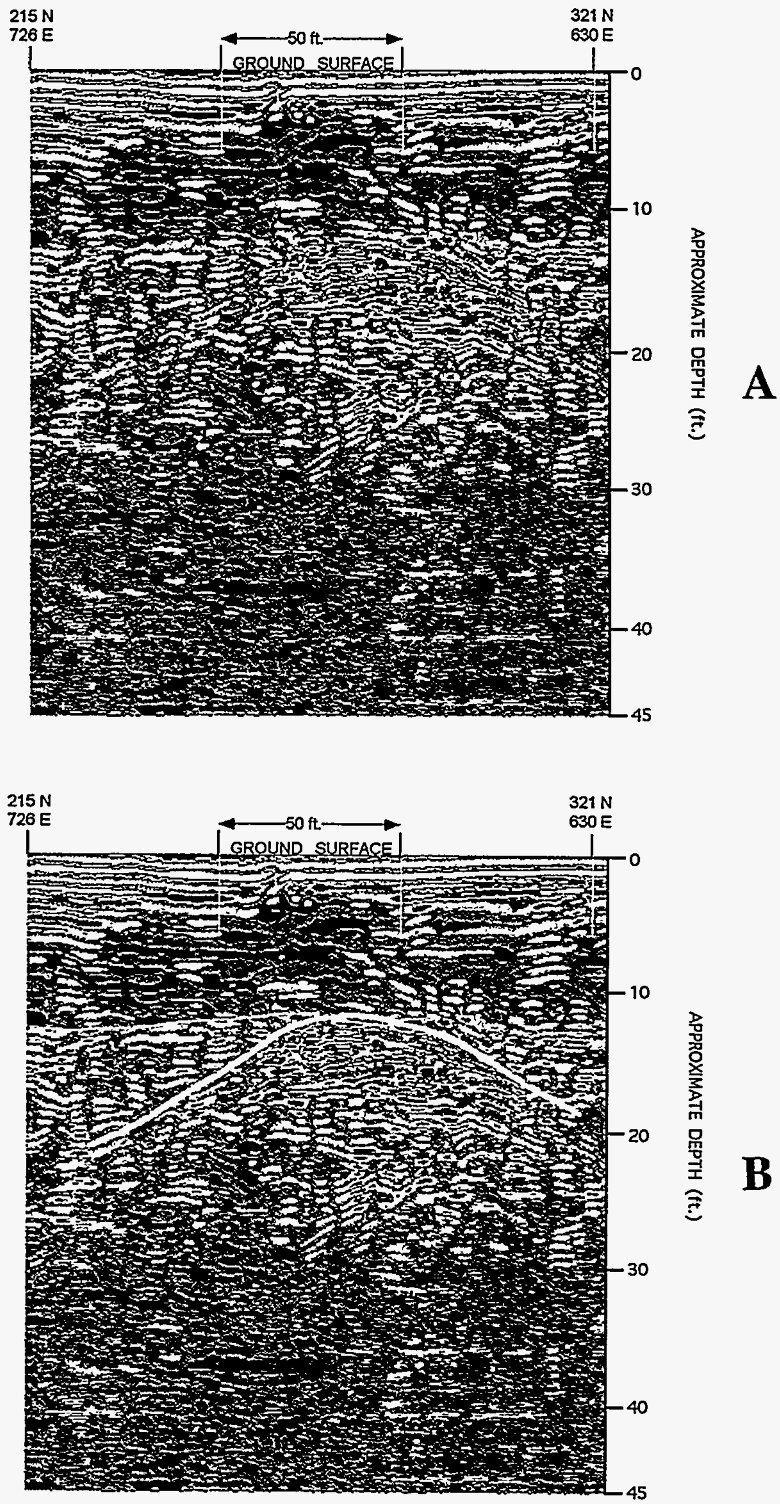


FIGURE 26 A: GPR Profile #14; B: GPR Profile #14 with Interpretation

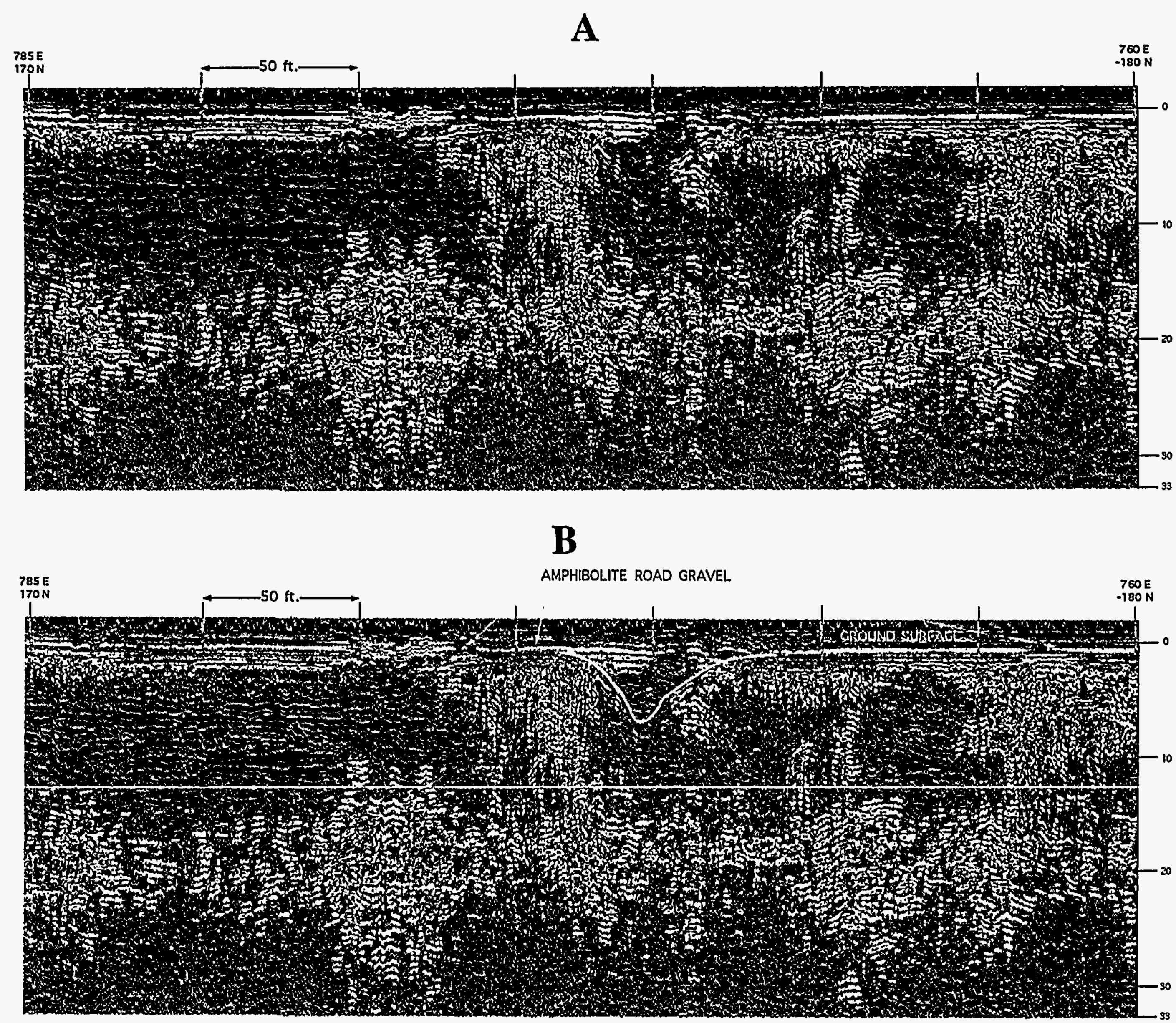


FIGURE 27 A: GPR Profile #6; B: GPR Profile #6 with Interpretation

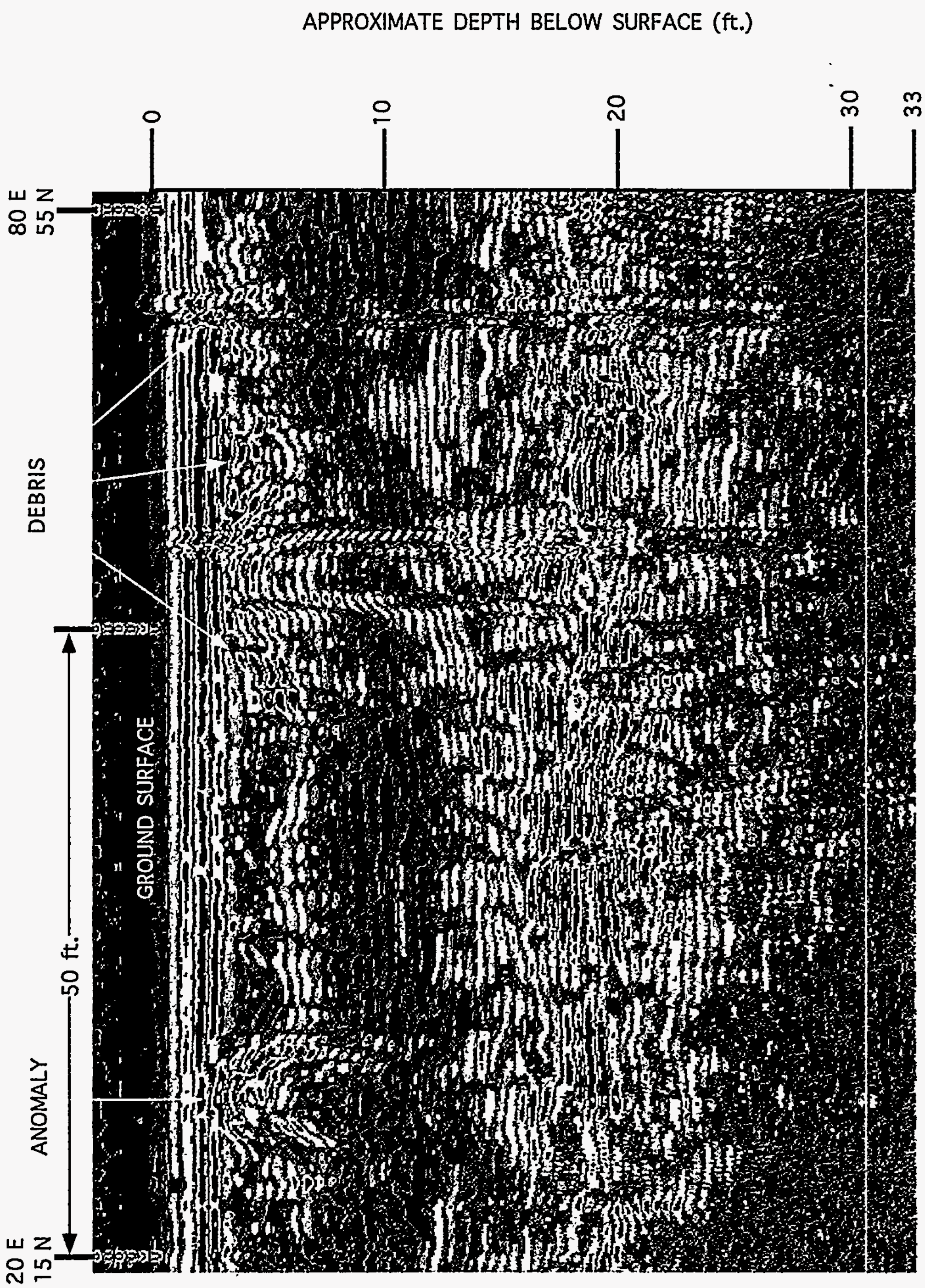


FIGURE 28 GPR Profile #8

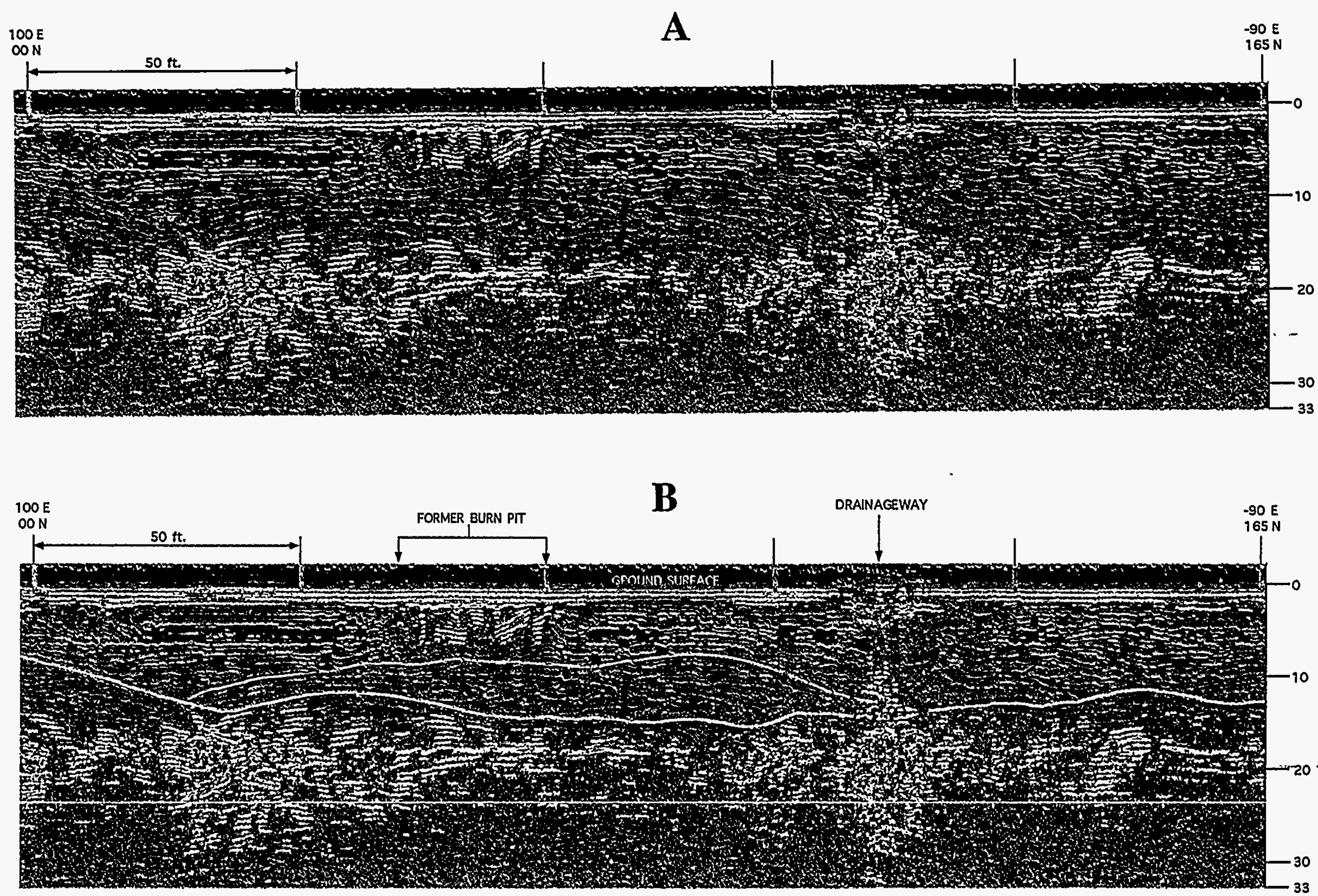


FIGURE 29 A: GPR Profile #9; B: GPR Profile #9 with Interpretation

6 Seismic Surveys

Three seismic refraction and three seismic reflection profiles were recorded in the Kings Creek study area. The seismic surveys were conducted to provide geophysical information on lithologic units below the depth ranges reached by electromagnetic and GPR methods. Also, surface-to-borehole average velocity measurements were conducted at monitor well CC-11B to provide additional depth control for the seismic models. The locations of all seismic profiles, including refraction, reflection, and borehole surveys, are shown in Figure 30.

6.1 Seismic Refraction Surveys

One deep and two shallow refraction profiles were conducted to provide seismic velocity and depth information for strata from the ground surface to crystalline bedrock. Refraction survey parameters are summarized in Table 2. The deep refraction profile, line BRP-1, was used to obtain layer-velocity information to depths below 400 ft; the shallow refraction profiles, BRP-2 and BRP-3, were conducted to provide seismic velocity information for the near-surface sediment.

Conversion of the time-distance data into a velocity-depth model was performed using the SIPT2 processing software developed by RIMROCK Geophysics, Inc. (1992). Average velocities obtained from a borehole check-shot were also used to help constrain this model.

Refraction data are useful for determining interval velocities for stratigraphic and nonstratigraphic units when the velocity increases with depth. Lithologic units that have similar or lower velocities than overlying units do not refract energy back to the surface, and thus, are not detected by the refraction method. In addition, thin, high-speed layers may not be detected if their thickness is less than the wavelength of the seismic energy for that particular refraction survey. This limiting thickness is generally on the order of "tens of feet" for seismic refraction prospecting. In short, the velocity-depth model derived only from seismic refraction analysis may be incomplete. Velocity information for layers transparent to the refraction data is provided by a borehole check-shot (discussed in Section 6.2).

Interpretation of shallow refraction lines BRP-2 and BRP-3 results in a two-layer model consisting of unsaturated sediment above the water table and saturated sediment below (Figures 31A and 31B). A velocity of 1,154 ft/s was computed for Layer 1; a velocity of 5,761 ft/s was determined for the saturated sediment (Layer 2). The shallow refraction data also show that lateral velocity variations exist in the Layer 1 material. These variations probably arise from differences in saturation, compaction, and composition of these sediments. The shallow seismic data demonstrate that (1) lateral variations in seismic velocity are significant near the surface, and (2) static corrections in seismic reflection data are to be expected. A depth of 8-13 ft and a seismic velocity of 5,761 ft/s were computed for Layer 2, which is interpreted to comprise saturated sediments at or below the water table.

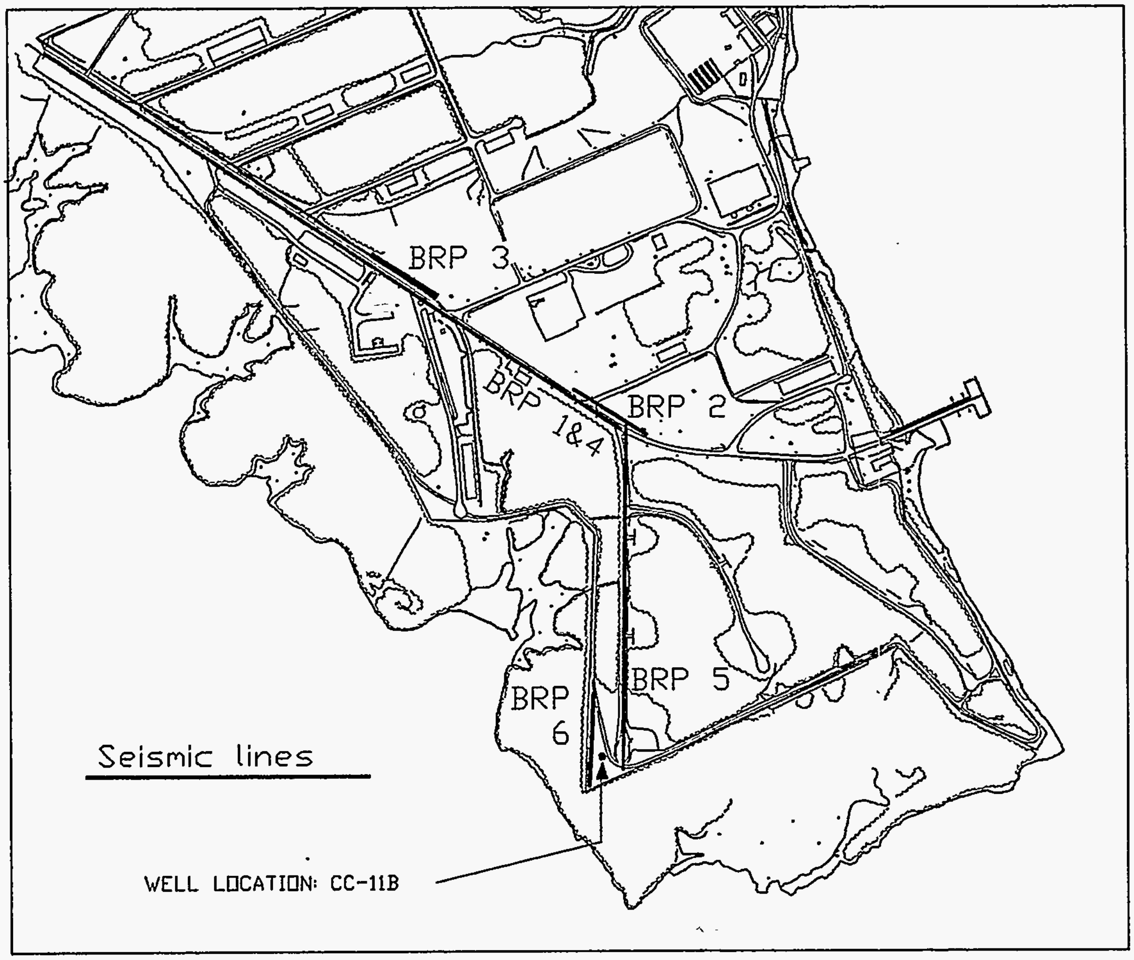


FIGURE 30 Seismic Profile Locations

TABLE 2 Seismic Refraction Profiles near the Kings Creek Study Area

	Line Identification Number		
Parameters	BRP-1	BRP-2	BRP-3
Seismic source	EWG	Hammer	Hammer
Geophone interval (ft)	30	5	5
Geophones per spread	23	12	12
Number of spreads	3	1	1
Total length of spreads (ft)	2,040	55	55
Number of shots	18	9	9
Maximum shot-to-phone distance (ft)	2,650	210	185

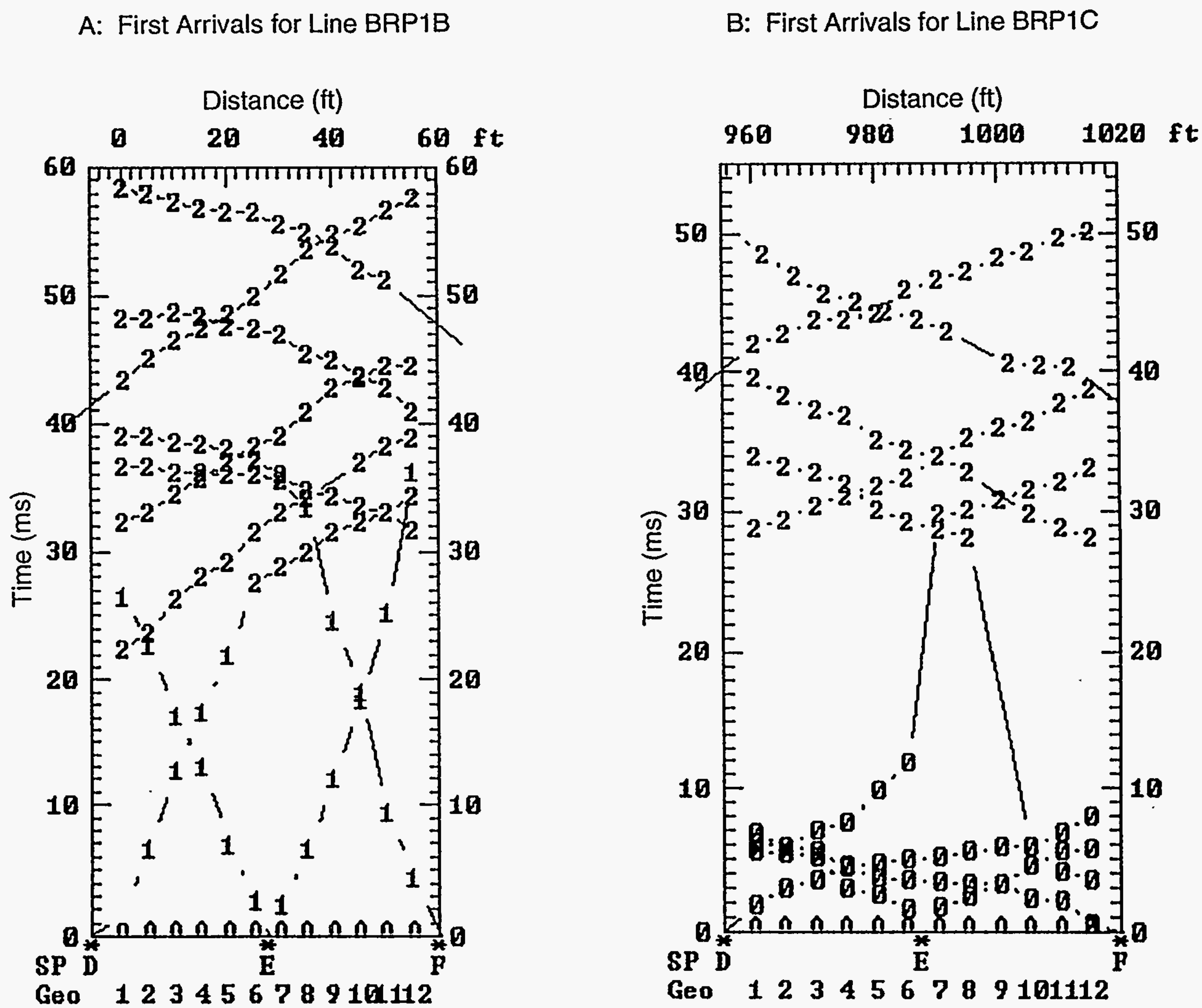


FIGURE 31 First Arrival Time versus Distance Data from Seismic Refraction Lines BRP-2 (A) and BRP-3 (B)

The deepest and highest-velocity layer, identified as Layer 3 on the time-distance plot for seismic refraction profile BRP-1 (Figure 32), has a seismic velocity of 16,790 ft/s. Layer 3, at a depth ranging between 420 and 440 ft, represents Precambrian crystalline rock that underlies Cretaceous sediment.

Figure 33 shows the relationship between seismic velocity and depth, based on both refraction and borehole data. The interval velocity curve derived from refraction data is based on the inversion of both shallow and deep refraction time picks. The figure also illustrates a curve for average velocity versus depth, showing the weighted average of all interval velocities between the surface and the corresponding depth. The average-velocity-versus-depth information is used to generate a depth scale for seismic reflection data. Interval velocities from both refraction and borehole techniques were used in the average velocity calculations.

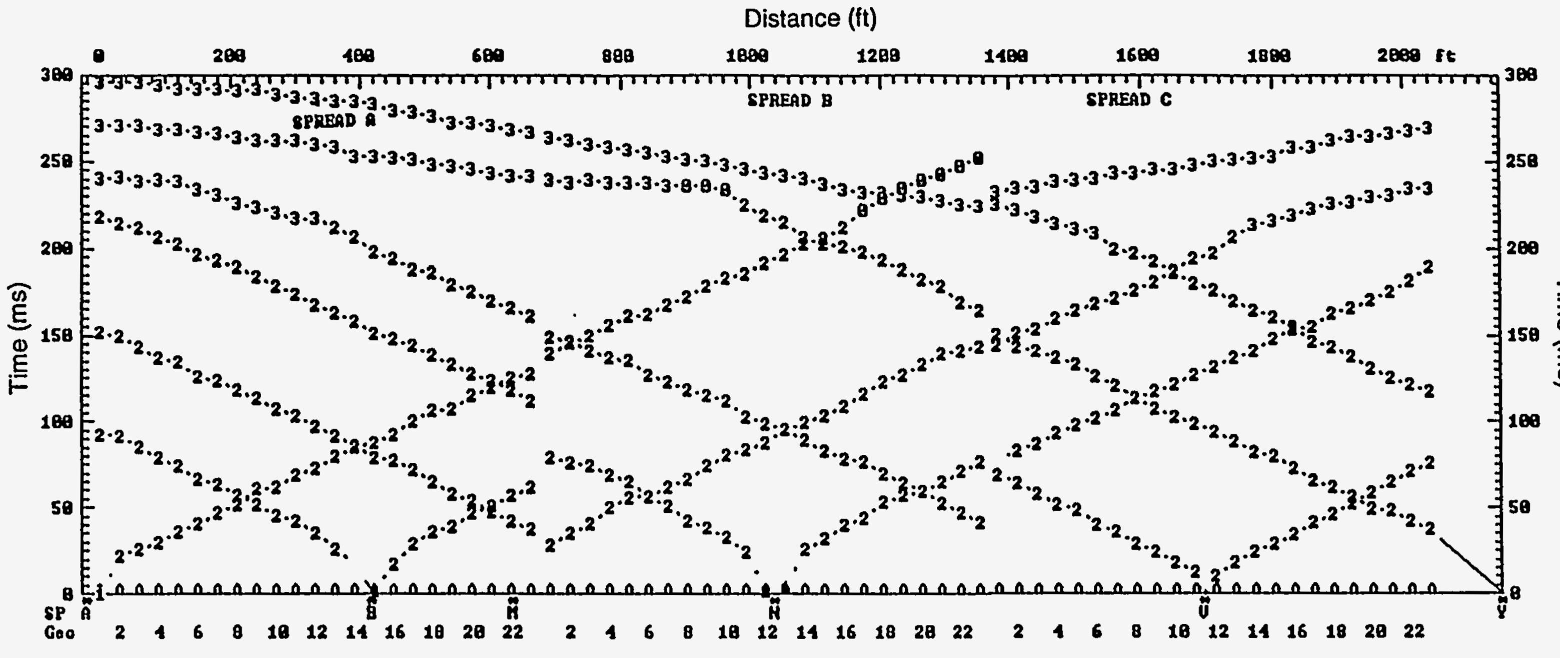


FIGURE 32 First Arrival Time versus Distance Data from Seismic Refraction Line BRP-1

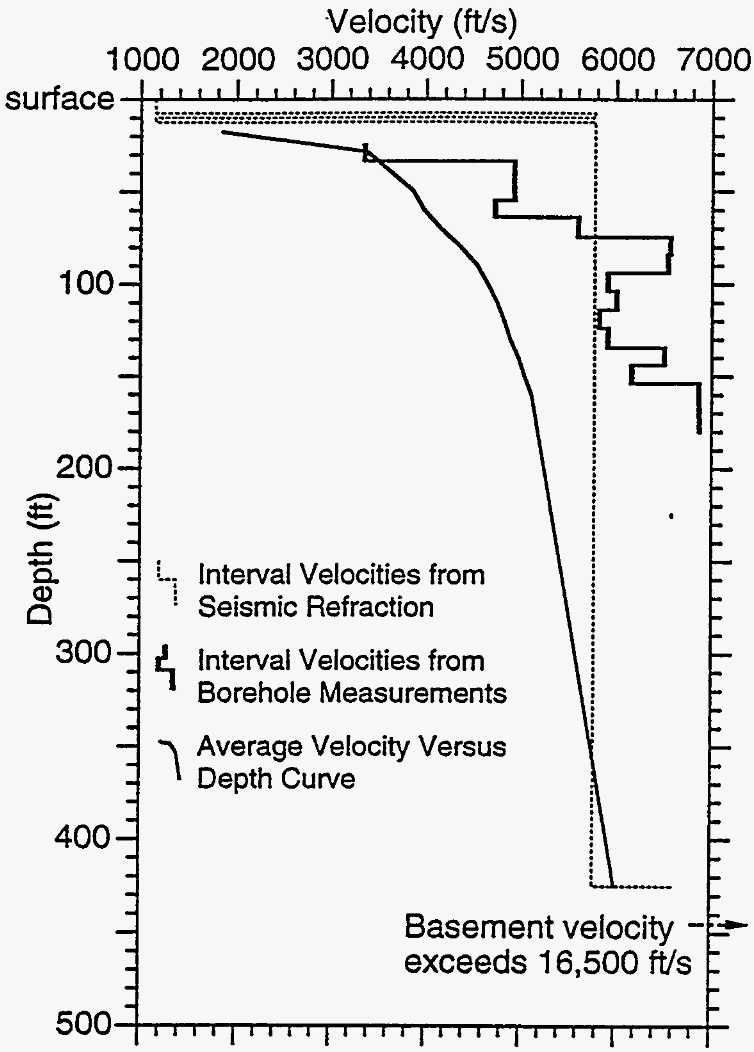


FIGURE 33 Velocity-Depth Model Obtained by Inverting Seismic Refraction Data and Borehole Seismic Data

The velocity-depth model in Figure 33 does not account for lateral velocity variations over the Bush River Peninsula, but is useful in obtaining approximate depth calculations for reflectors in the seismic reflection data presented in Section 6.3. The depth estimates, however, must be used cautiously. The depth of the low-velocity layer near the surface, which was set at 4.0 ft in the model, is known to vary from 0 to at least 10 ft based on the two shallow refraction profiles. The lateral velocity variations near the surface can cause an error of several percentage points in the depth estimation.

6.2 Downhole Seismic Velocity Measurements

Surface-to-borehole average velocity measurements were conducted at monitor well CC-11B (Figure 30). The survey was conducted by lowering a down-hole geophone to a known depth and recording the travel time for signals produced from a sledgehammer source located at various distances from the borehole. Sets of measurements were collected with the geophone at 10-ft intervals within the monitor well, starting at 160 ft below the top of casing and proceeding to 50 ft below the top of casing (which was 3.0 ft above land surface). An additional set of measurements was taken with the geophone at 29 ft below the top of casing. Shallower measurements were not recorded because of poor signal quality near the surface. Horizontal source offset distances of 25, 50, 75, and 100 ft northwest of monitor well CC-11B were used for each set of measurements.

Average velocities were obtained by dividing the slant distance between each source-location/receiver-location pair by the travel time. Interval velocities were calculated by using differences in both slant distance and travel time between the current reading and the reading at the adjacent shallower depth. Velocity calculations were repeated for each horizontal offset and compared. Using slant distance in the velocity calculations caused some systematic error, which resulted in artificially high velocity calculations. The error, which was greater at greater offsets, resulted from refracted first arrivals. In creating the velocity-depth model, preference was given to shorter offsets to minimize this error. Lateral variations were assumed to be relatively minor compared with vertical variations in the velocity calculations.

The relationship between seismic velocity and depth based on both refraction and borehole data is shown in Figure 33. Velocity information obtained from the borehole survey is more detailed than data from the refraction surveys. Unlike the refraction method, the borehole technique is not adversely affected by low-velocity layers and can detect thin layers of relatively low velocity.

The interval velocity model presented in Figure 33 (based on borehole measurements) shows an increase in velocity between about 60 and 70 ft, followed by a decrease at approximately 90 ft, and another increase at about 130-150 ft. The gamma and conductivity logs for borehole CC-11B both show relatively higher readings for the 50- to 120-ft depth range (see Appendix B). Following the downhole geophysical measurements conducted on monitor well CC-11B, monitor well WBR-48 was installed to a depth of 133 ft below surface adjacent to well CC-11B. The boring log for well WBR-48 is included in Appendix A; the lithology for this well is plotted on the gamma and conductivity/resistivity logs for well CC-11B. A high clay content was observed between 47.5 and 101 ft, which closely corresponds to the geophysical logs and generally agrees with the seismic velocity model.

6.3 Seismic Reflection Surveys

Three seismic reflection profiles, two deep and one shallow, were conducted to record variations in stratigraphy for strata from the ground surface to the crystalline basement in the vicinity of the Kings Creek study area. Survey parameters are summarized in Table 3. The profile locations are shown in Figure 30.

TABLE 3 Seismic Reflection Profiles near the Kings Creek Study Area

Parameters	Line Identification Number		
	BRP-4	BRP-5	BRP-6
Type	Deep	Deep	Shallow
Seismic source	EWG	EWG	Hammer
Offset (ft)	90	90	18
Geophone interval (ft)	6	6	3
Number of shots	428	202	77
Number of 24-channel spreads	408	192	72
Total length of survey (ft)	2,442	1,146	213

Two deep reflection lines (BRP-4 and BRP-5) are located adjacent to the north and the east sides of the Kings Creek study area, respectively (Figure 30). Processed seismic sections for lines BRP-4 and BRP-5 are shown in Figures 34 and 35. The deep seismic reflection data were processed using EAVESDROPPER software developed at the Kansas Geological Survey (1993). Processing steps included trace editing and muting, bandpass filtering, velocity analysis, and CDP sorting and stacking. Seismic arrivals prior to 65 milliseconds (ms) were muted to remove first-arrival refracted energy from the seismic data.

Figures 34 and 35 show stacked seismic sections extending from north (left) to south (right). The north extent of line BRP-5 (left edge of Figure 35) begins approximately where the south extent of line BRP-4 ends (right edge of Figure 34). The stick diagrams at the bottom of both figures show the major reflections.

The crystalline bedrock is observed in both lines at a depth of approximately 450 ft in the north (Figure 34) and dipping to nearly 550 ft in the south (Figure 35). The estimated basement depth reported in the literature for the APG area ranges from 350 ft (Southwick, Owens, and Edwards 1969) to 800 ft (Otton and Mandle 1984). The bedrock depth interpreted from seismic data reported for the Beach Point Peninsula, located a few thousand feet south of the Bush River Peninsula (Figure 1), is about 560 ft (McGinnis et al. 1994a). The crystalline basement generally dips to the southeast at an angle of less than one degree in the vicinity of APG (Bennett and Meyer 1952; Dingman et al. 1956; Southwick, Owens, and Edwards 1969).

Another less prominent but relatively continuous reflector is observed at a depth of about 275 ft dipping gradually to the south in both Figures 34 and 35. The source of the reflector is below any deep boreholes at the Bush River Peninsula and the reflector has not been observed in other geophysical data sets. The continuous nature of the reflector suggests that the feature might be an important hydrogeological boundary.

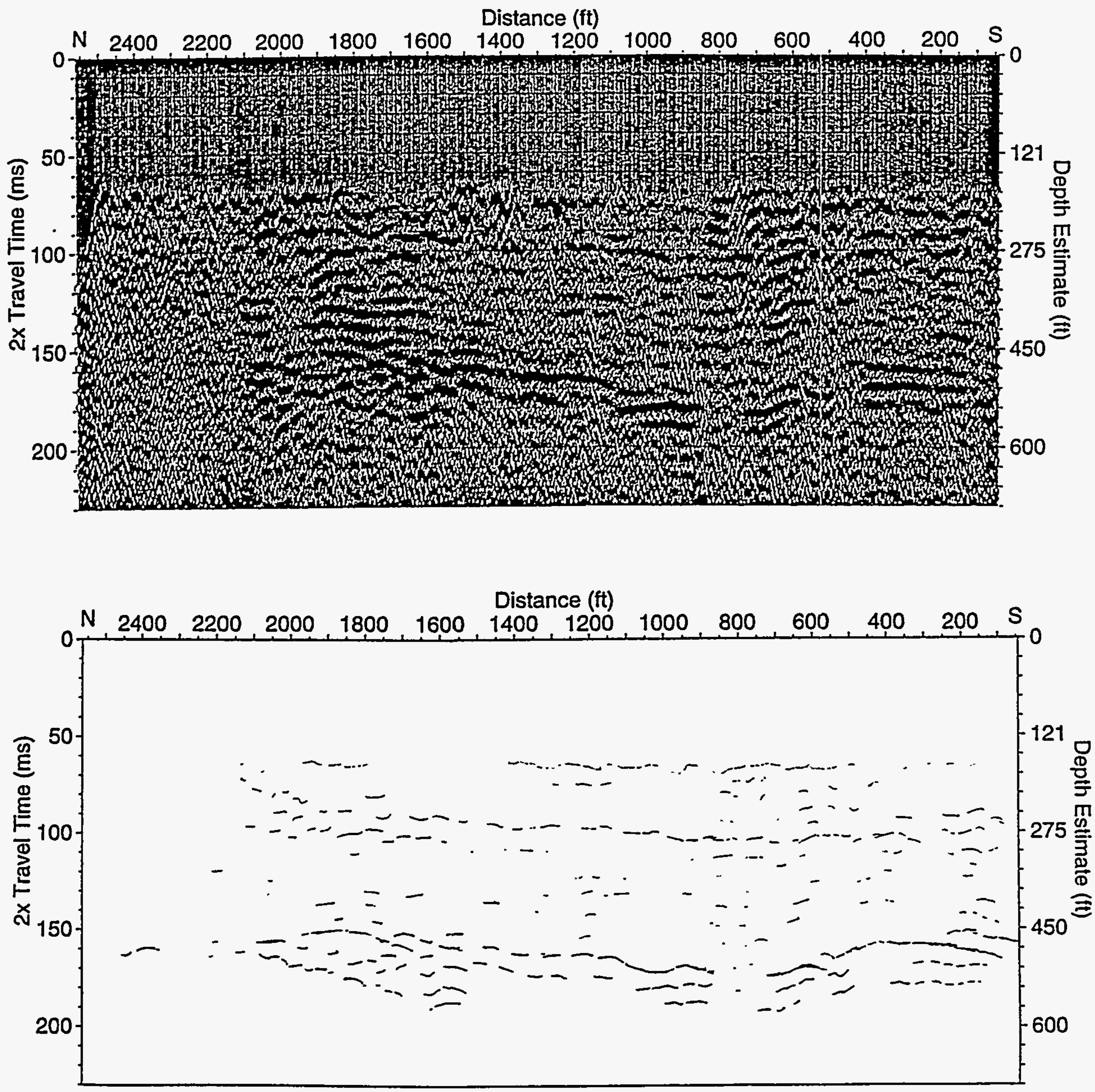


FIGURE 34 Seismic Reflection Profile for Line BRP-4

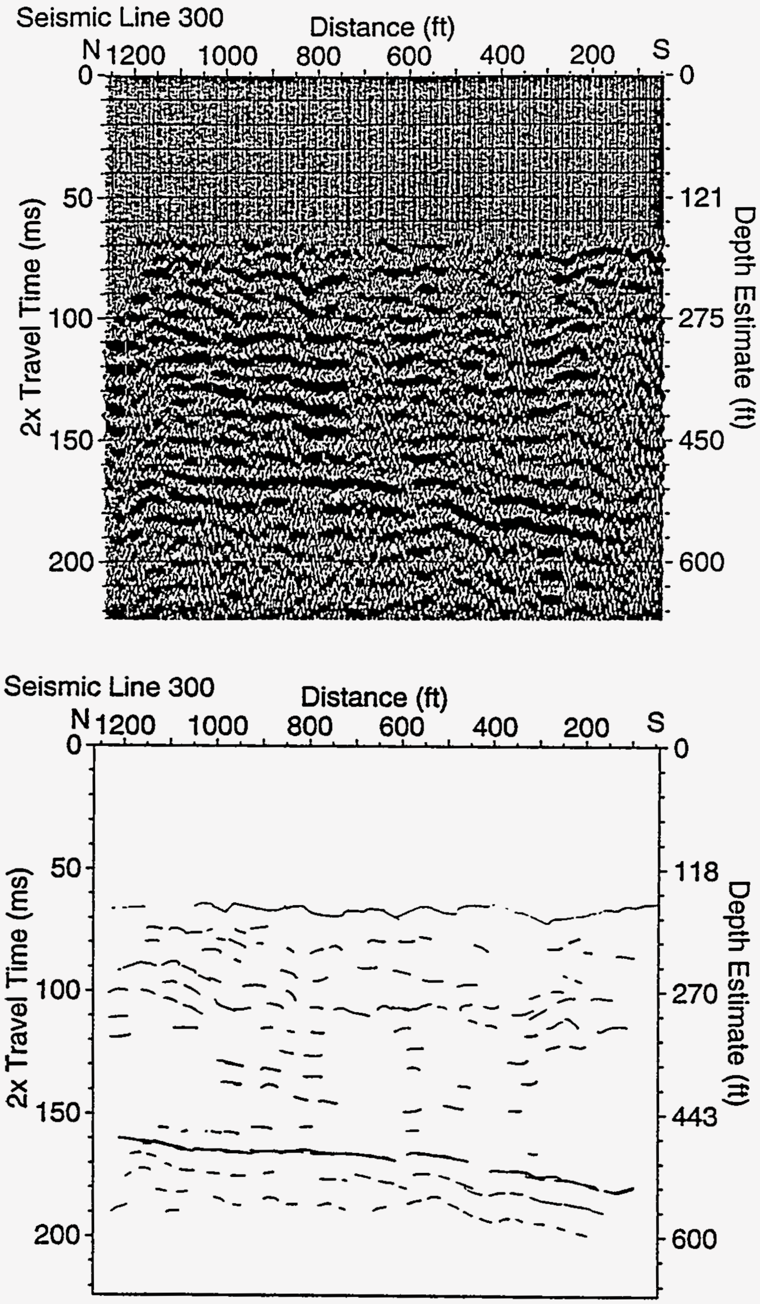


FIGURE 35 Seismic Reflection Profile for Line BRP-5

One shallow reflection line, BRP-6, is located south of the Kings Creek study area, adjacent to monitor well CC-11B (Figure 30). A processed seismic section for line BRP-6 is presented in Figure 36. Processing steps for line BRP-6 were similar to those used for lines BRP-4 and BRP-5, except that the first-arrival mute was applied to signals prior to about 20 ms (versus 65 ms for the deeper reflection lines). The seismic section in Figure 36 extends from north (left) to south (right) and shows reflectors for depths as shallow as 35 ft. The distance scale is in feet from monitor well CC-11B. The stick diagram at the bottom shows the major reflections as interpreted from the seismic section.

A continuous reflector is observed at a depth of approximately 40-50 ft. The geophysical well logs for monitor well CC-11B show a layer of increased gamma and conductivity values beginning at about 48 ft and extending to about 120 ft, typical for clay-rich sediments. The reflector in the shallow reflection line (Figure 36) may correspond to the top of the confining layer at the base of the surficial aquifer (Figure 4). No seismic reflection from the bottom of the clay-rich layer was observed because of static noise and signal reverberation in the seismic section.

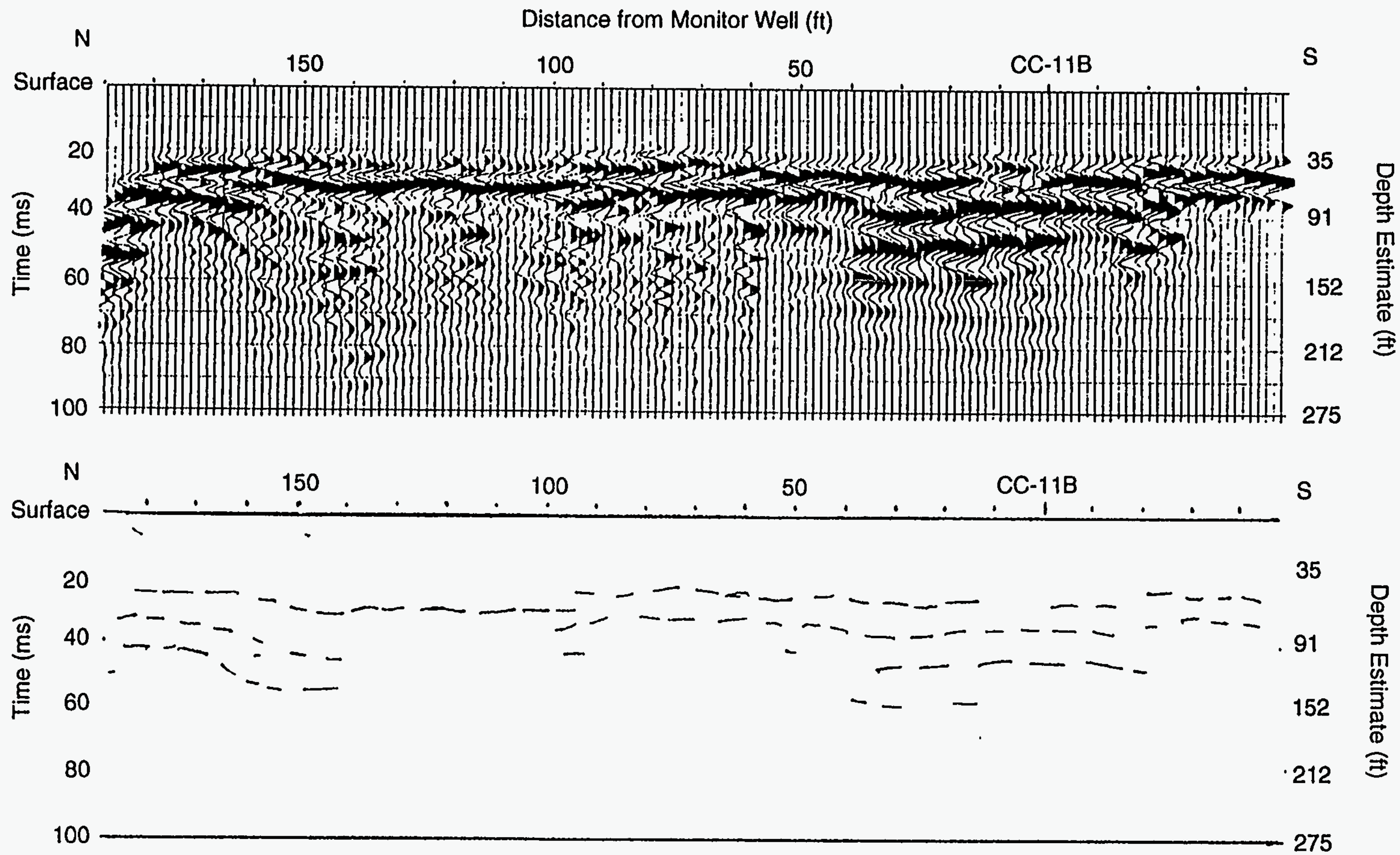


FIGURE 36 Seismic Reflection Profile for Line BRP-6

7 Discussion

7.1 Areal Extent of Kings Creek Disposal Site and 30th Street Landfill

Geophysical technologies, including magnetics, seismic reflection and refraction, borehole geophysics, electromagnetics, and GPR, have been utilized in the environmental investigation of the Kings Creek study area. These geophysical techniques, combined with visual observations, have helped define the areal extent of the former Kings Creek Disposal Site and the 30th Street Landfill.

Total field magnetics data and magnetic gradiometer surveys north of the former burn pits at the Kings Creek Disposal Site (Figure 11) indicate that metal debris is scattered throughout the area surveyed. A linear trend of magnetic anomalies is present running southwest from the north-south-trending fenceline toward the former burn pits. The origin of this feature is unknown, but the trend may indicate remnants of a previous site access road. These anomalous zones are not believed to be large-scale (i.e., tens of feet) waste burial areas, although smaller, isolated areas of buried wastes and/or munitions cannot be ruled out.

Variations in EM-31 conductivity data for the former Kings Creek Disposal Site, including the surveyed area to the north, are produced by changes in the near-surface geology and metal debris. On the basis of the spatial association of geophysical anomalies, the extent of the former Kings Creek Disposal Site is likely confined to the areas of currently disturbed or absent vegetation and the associated berms formed by pushed-out materials from the burn pits.

Limited GPR data were obtained from the former Kings Creek Disposal Site because of the heavy vegetation covering much of the area. One anomalous feature, detected by the GPR, magnetic, and electromagnetic surveys, is located at approximately 110N/170E (#1, Figures 8 and 15A) of the survey grid. This feature, illustrated in Figure 28, may represent a buried drum or small tank. Further characterization of this subsurface feature is recommended.

The total field magnetic survey was used to map the areal extent of the 30th Street Landfill. The western extent of the main landfill body is defined by the 240E north-south grid line (Figure 9). The majority of the discontinuous magnetic anomalies west of the 240E line can be explained by surficial debris, but further characterization may be necessary because buried ferrous objects may also be present at these locations. The landfill is believed to be confined by the security fence to the north, but the fence overwhelms any other magnetic and electromagnetic signals, making it impossible to pinpoint the exact northern boundary. The eastern boundary of the landfill corresponds to the western limits of the present wetland. No indication of landfilling was found farther to the east (Figures 10, 12, and 17). The limits of landfilling to the south, into the current wetland, are not known. Geophysical surveys have not been conducted farther south because of the thick phragmite cover present at this location. However, geophysical surveys performed offshore from the wetland during late summer 1994 indicate that metallic debris is present near the shoreline.

The 30th Street Landfill is located in a former wetland. GPR data indicate that the western boundary of the landfill is also the location of the western edge of a paleochannel. On the basis of GPR data (profiles #12 and #13, Figures 23 and 24), the total depth of fill at the 30th Street Landfill is approximately 8-10 ft. The EM-31 data presented in Figure 16A show the location of the pre-landfill wetland as a conductive high resulting from Holocene and Pleistocene clayey sediments and fill material. Offshore electromagnetic surveys have indicated that a more conductive subsurface zone is present at the location of a paleochannel that extends into Kings Creek from the 30th Street Landfill (Figure 18). The origin of this more conductive material offshore is clayey sediments deposited in the paleochannel at depths measurable with the EM-31 (upper 18 ft).

7.2 Hydrogeologic Framework

Well logs of recently installed monitor wells provide the basic subsurface geologic control for the remedial investigation/feasibility study currently being conducted in the Bush River Peninsula area (see Figure 20 and Appendix A). Geophysical methods (including GPR, EM-31, seismic reflection and refraction, and downhole gamma and induction logging) complement the basic area-wide studies conducted to define the geologic and hydrogeologic framework beneath the study area.

GPR imaging provides a detailed display of reflectors to depths up to 45 ft. The reflectors represent contacts separating recently deposited channel-fill complexes from underlying sediments. These contacts also constitute irregularities in the base of the surficial aquifer. The channel-fill complexes in the APG area are the result of multiple erosion/deposition events that occurred during the successive low sea-level stands and subsequent marine transgressions of the Pleistocene Epoch. The GPR profile presented in Figure 24 is a good example of two superimposed erosion/deposition events beneath the 30th Street Landfill. At this location, two more recent, shallow channel features are superimposed on an older, deeper paleochannel.

Seismic imaging, in conjunction with downhole logging, shows details of the shallow and deep facies beneath the study area. The top of the confining layer (at the base of the surficial aquifer) appears as a continuous reflector at a mean depth of 45 ft below land surface (Figure 36). Downhole gamma and conductivity logs of monitor well CC-11B suggest that this confining layer extends to a depth of approximately 120 ft below land surface. Reflectors dipping eastward at approximately 275 ft below the surface (Figure 34) mark undifferentiated depositional sequences of Cretaceous, Atlantic Coastal Plain strata. The top and bottom of the upper confined aquifer cannot be defined on the basis of reflection data alone. The eastern-dipping Cretaceous strata rest on a crystalline bedrock ranging in depth from 450 ft north of the Kings Creek study area (Figure 34) to nearly 550 ft in the south (Figure 35).

7.3 Subsurface Paleochannel Locations

It is important to define the paleochannel locations because their basal sediments often consist of materials of greater hydraulic conductivity (sands and gravels) that form the base of the surficial aquifer. The current drainageway and wetland locations in the Bush River Peninsula are good indicators of the locations of Pleistocene drainage systems. The Pleistocene paleochannels can be deeply incised into the underlying Cretaceous sediments; depths to the base of these features have been found to be at least 50 ft below sea level offshore (Figure 22) and greater than 35 ft below land surface onshore (monitor well WBR-23, Appendix A).

Preliminary subsurface data collected during the geophysical studies at Kings Creek were used to help select the locations of the recently installed site monitor wells. On the basis of the boring logs for these wells and the electromagnetic and GPR subsurface data collected, the approximate locations of major paleochannel features have been mapped and are presented in Figure 37. As the figure shows, a major paleochannel extends into Kings Creek from the wetland adjacent to, and including, the 30th Street Landfill. Multiple branches of the channel to the west,

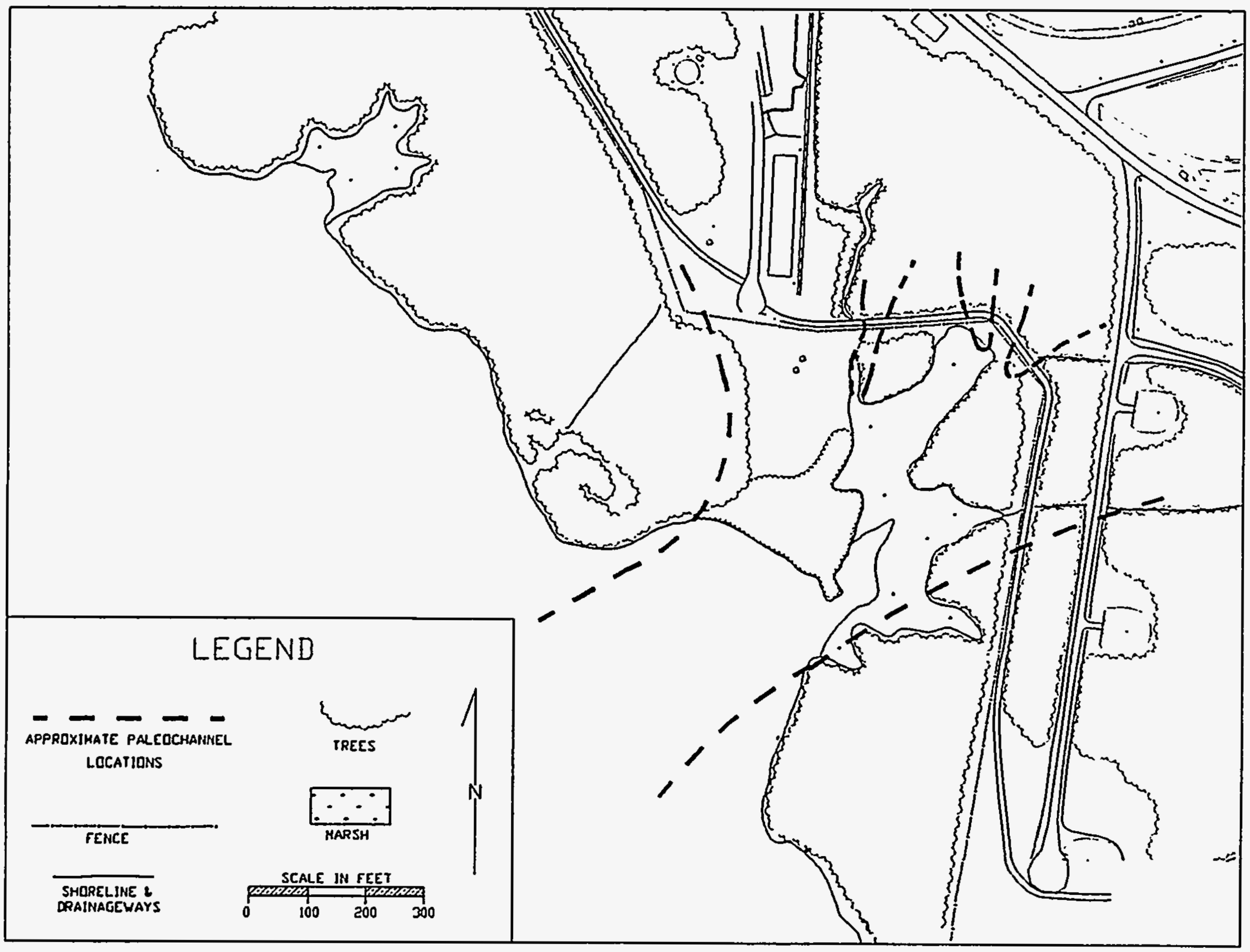


FIGURE 37 Approximate Paleochannel Locations Inferred from GPR Data

east, and north appear to meet at this wetland location. The west channel branch extends through the 30th Street Landfill at a depth of 25 to 30 ft below sea level. This branch is visible on GPR profiles #12, #13, and the western (right) side of #15 (Figures 23 through 25). Additional, shallower features (8–10 ft below ground surface), which likely represent later erosional features, are superimposed on the deeper feature in profile #13 (Figure 24). The shallower features correspond to two EM-31 conductivity highs extending northward in the 30th Street Landfill (Figure 16B).

Another paleochannel extends eastward from the wetland area. The channel boundaries at this location are less precise because of the lack of good GPR reflectors in the eastern section of the study area. This paleochannel is defined largely from logs for monitor wells WBR-23 and WBR-25 (Appendix A).

Two shallow (approximately 20 ft below ground surface) paleochannel branches extend toward the north. These branches are defined by GPR profiles #14 (Figure 26) and #15 (Figure 25) along the security fenceline north of the 30th Street Landfill (Figure 21). GPR data at these locations indicate two shallow channel features that may be superimposed over a deeper channel body, similar to those observed in the western branch. Review of the boring log for monitor well WBR-19 (Appendix A) indicates that paleochannel-type sediments are present at this location (Figure 20). Additional data collection is necessary to confirm the continuity of channel locations farther north.

Mapping the location of these potential hydraulically conductive zones is very important in understanding the hydrology of the surficial aquifer and the potential for interconnection between the surficial aquifer and the underlying upper confined aquifer (referred to as the Canal Creek aquifer on Figure 4). Five soil borings (BR-1 through BR-5, Figure 2) and recently installed monitor well WBR-48 provide depth information for the top of the Cretaceous upper confined aquifer. Monitor well WBR-48 is the closest control point to the Kings Creek study area. The top of the upper confined aquifer at the location of WBR-48 is approximately 100 ft below land surface (approximately 90 ft below sea level). Both sides of the offshore paleochannel are visible on GPR profile #16 (Figure 22), but the total depth of the thalweg has not been determined due to signal loss below a depth of approximately 50 ft below sea level. Extrapolating the slope of the two channel sides gives the depth of the thalweg at approximately 80 ft below sea level.

8 Summary and Conclusions

During the 1920s and 1930s, chemical munitions and wastes were reportedly burned at the former Kings Creek Disposal Site. Active landfilling reportedly occurred at the 30th Street Landfill in the 1960s and, probably, early 1970s (Nemeth 1989), and buried munitions have been discovered at the landfill, although no records of munitions disposal at this site are available.

A series of geophysical surveys, supported by a site drilling program, was undertaken to define the hydrogeologic framework and potential contaminant migration pathways beneath the study area. The areal extent of metallic wastes was mapped by using magnetic and electromagnetic methods. The following specific conclusions have been drawn based on the results of the surveys:

1. The areal extent of the 30th Street Landfill has largely been defined. No evidence was found of any landfilling to the east, across the wetland from the landfill.

2. No large-scale disposal by burial appears to be associated with the former Kings Creek Disposal Site, but small-scale waste burial cannot be ruled out. Magnetic anomaly maps prepared for the entire study area reveal an unknown subsurface anomaly at 110N/170E on the site grid that may represent a buried drum or small tank.

3. The general hydrogeologic framework beneath the Kings Creek study area has been defined. A Pleistocene channel-fill complex greater than 50 ft in depth runs beneath the 30th Street Landfill and into Kings Creek.

4. Seismic profiling revealed Cretaceous sediment ranging in thickness up to 500 ft. Gentle easterly dips in the sediment conform to published descriptions of the Cretaceous structure.

5. The Precambrian-age crystalline bedrock lies at a depth of 450–550 ft beneath the Bush River Peninsula.

6. Contaminant pathways from the 30th Street Landfill along the base of the surficial aquifer may be outlined by a conductive subsurface feature extending offshore into Kings Creek. This potential pathway corresponds to the location of a Pleistocene paleochannel outlined by GPR methods (see Conclusion 3). It is not known whether the offshore-trending paleochannel breaches the upper confined aquifer. Soil borings would be necessary to further characterize the subsurface hydrogeology.

9 References

Bennett, R.R., and R.R. Meyer, 1952, *Geology and Ground-Water Resources of the Baltimore Area,* Bulletin 4, Maryland Department of Geology, Mines, and Water Resources.

Cordell, L., et al., 1992, *Potential Field Geophysical Software: Version 2,* U.S. Geological Survey Open-File Report 92-18.

Dingman, R.J., et al., 1956, *The Water Resources of Baltimore and Harford Counties,* Bulletin 17, Maryland Department of Geology, Mines, and Water Resources.

Geonics Limited, 1992, EM-31 *Operating Manual (for Models with Two Digital Meters),* Mississauga, Ontario, Canada.

Geophysical Survey Systems, Inc., 1987, *Operations Manual for Subsurface Interface Radar (SIR System-3).*

Kansas Geological Survey, 1993, EAVESDROPPER Seismic Reflection Processing Software, Version 3.0, 1930 Constant Ave., Campus West, Lawrence, Kansas.

Kehrin, R.T., et al., 1988, *The Surficial Sediments of the Chesapeake Bay, Maryland — Physical Characteristics and Sediment Budget,* Report No. 48, Maryland Geological Survey.

Lorah, M.M., and D.A. Vroblesky, 1989, *Inorganic and Organic Ground-Water Chemistry in the Canal Creek Area of Aberdeen Proving Ground, Maryland,* Water Resources Investigations Report 89-4022, U.S. Geological Survey.

McGinnis, L.D., et al., 1994a, *Environmental Geophysics at Beach Point, Aberdeen Proving Ground, Maryland,* ANL/ESD-23, Argonne National Laboratory, Argonne, Ill.

McGinnis, L.D., et al., 1994b, *Environmental Geophysics of the Pilot Plant on the West Branch of Canal Creek, Aberdeen Proving Ground, Maryland,* ANL/ESD/TM-74, Argonne National Laboratory, Argonne, Ill.

Nemeth, G., 1989, *RCRA Facility Assessment Report, Edgewood Area, Aberdeen Proving Ground, Maryland,* prepared by U.S. Army Environmental Hygiene Agency for Aberdeen Proving Ground, Test and Evaluation Command, U.S. Army Material Command.

Oliveros, J.P., and D.A. Vroblesky, 1989, *Hydrogeology of the Canal Creek Area, Aberdeen Proving Ground, Maryland,* Water Resources Investigations Report 89-4021, U.S. Geological Survey.

Otton, E.G., and R.J. Mandle, 1984, *Hydrogeology of the Upper Chesapeake Bay Area, Maryland, with Emphasis on Aquifers in the Potomac Group,* Report No. 39, Maryland Geological Survey.

RIMROCK Geophysics, Inc., 1992, SIPT2 Refraction Processing Software, Version 3.2, Boulder, Colo.

Southwick, D.L., J.P. Owens, and J. Edwards, Jr., 1969, *The Geology of Harford County, Maryland,* Maryland Geological Survey.

Thurmond, V., 1993, *North-South Stratigraphic Cross-Section of the Bush River Area,* U.S. Army Corps of Engineers — Baltimore District, Internal Document.

U.S. Army Corps of Engineers, Baltimore District, 1994, *Detailed RI Work Plan for Cluster 15, Edgewood Area, Aberdeen Proving Ground, Maryland.*

Appendix A:

Soil Boring Logs

Hole No. WBR-19

DRILLING LOG	DIVISION: CENAB-EN-GG	INSTALLATION: EDGEWOOD	SHEET 1 OF 3 SHEETS

1. PROJECT: RI/FS EDGEWOOD	10. SIZE AND TYPE OF BIT: 3¼ x 8¼" CUTTERHEAD
2. LOCATION (Coordinates or Station): CLUSTER 15	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: COE - MOBILE	12. MANUFACTURER'S DESIGNATION OF DRILL: CME 75
4. HOLE NO. (As shown on drawing title and file number): WBR-19	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: 11 — UNDISTURBED:
5. NAME OF DRILLER: J. BUTTS	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED: 8/30/94 — COMPLETED: 9/1/94
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING: 73.7 %
9. TOTAL DEPTH OF HOLE: 47.5'	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0	CL-ML	SANDY SILTY CLAY, SAND FINE GR, SUBANG., VY STIFF TO 3.4' THEN MED STIFF - SOFT, SOME GRASS AT VERY TOP, YELLOWISH BROWN TO 2.7' [10YR5/6] THEN LT GRAY [2.5Y7/2] W/ BROWNISH YELLOW [10YR 6/8] STREAKS & MOTTLING, RUSTY METALLIC DEBRIS SCATTERED THROUGHOUT, LESS THAN 2 CM IN SIZE (0.0-5.1)	5.1/5.0	S-1	3½" DRIVE SPOON 8/30/94 DTW - 9' IN 30' HOLE; MAY NOT BE TRUE DTW; MAYBE PUSHED UP 8/31/94 HOLE COLLAPSED TO 7.9' 9/1/94 @0835 DTW - 12' THRU AUGERS FROM GROUND [BELIEVE THIS IS TRUE WATER LEVEL] DTW - 14.61' FROM TOC @1400 (~ON COMPLETION) 9/2/94 @ 1345 DTW - 14.34' FROM TOC (24 HRS)
	5.0	CL-ML	SAME SANDY SILTY CLAY AS FROM 2.7'-5.0', SOFT, MOIST (5.0-6.8)	2.9/5.0	S-2	
		ML	GRADES OVER UPPER 0.6' INTO SANDY SILT, SAND FINE GR, SUBROUNDED, WELL SORTED, MOIST, LT YELLOWISH BROWN [10YR 6/4], HVY MINS COMMON (6.8-7.9)			
	10.0	ML	SANDY SILT, SAND FINE GR, SUBROUNDED, WELL SORTED, HVY MINS COMMON, LT GRAY [10YR 7/2], MOIST (10.0-10.5)	2.5/5.0	S-3	
		SP	SAND, FINE-MED GR, REL POORLY SORTED, SUBROUNDED, TR HVY MINS, WET, BROWNISH YELLOW TO 12.0, THEN LT GRAY [10YR 6/8, THEN 10YR 7/2] (10.0-12.5)			
	15.0	SP	SAME SAND AS ABOVE, BROWNISH YELLOW [10YR 6/6 AND 10YR 6/8] AND LT GRAY [10YR 7/2], SAT., OCC. 1-2 CM SUBROUNDED GRAVEL	2.6/5.0	S-4	H_2O ENCOUNTERED
	20.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT: RI/FS EDGEWOOD | HOLE NO. WBR-19

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | **Hole No.** WBR-19

PROJECT: RI/FS. | INSTALLATION: EDGEWOOD | SHEET 2 OF 3 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0	SW	SAND, FINE-CRSE. GR, SUBRNDED, POORLY SORTED, OCC SUBRNDED GRAVEL UP TO 1" IN SIZE, TR. HVY MINS, SAT, YELLOW [10YR7/6] FOR UPPER 1.7', THEN BRNISH YELLOW [10YR6/6] (22.1-24.7)	2.9/5.0	S-5	ASSUMING CLAY DEPTH IS TRUE, LOSS OF RECOVERY FROM SAND. GIVEN THAT 25-30' SPOON WAS ALL SAND, ABOVE ASSUMPTION PROBABLY INCORRECT
		CL	CLAY, VY STIFF, GRAYISH BROWN [10YR5/2] (24.7-25.0)			
	25.0	SP	SILTY SAND, SAND FINE GR, SUBRNDED, WELL SORTED, TR. HVY MINS, SAT., LT YELLOWISH BROWN [10YR6/4] (25.0-25.5)			
		SW	SAND, FINE-MED GR, MOD WELL SORTED, SUBRNDED, OCC SUBRNDED GRAVEL UP TO 0.5" IN SIZE IN BOTTOM 0.3', TR HVY MINS, SAT., SAME LT YEL. BROWN (25.5-27.7)	4.4/5.0	S-6	
		SP	SAND, FINE GR, RNDED-SUBRNDED, WELL SORTED, SAT., LT GRAY [10YR7/2] (27.7-29.4)		S-7	
	30.0	SP	SAND, FINE-MED GR, MOD WELL SORTED, SUBRNDED, TR HVY MINS, SAT., LT YELLOWISH BROWN [10YR6/4] (30.0-31.7)			
		SP-SM	SAND, FINE GR, SUBRNDED, WELL SORTED, SOME SILT, SAT., GRAY [10YR6/1] (31.7-33.8)	3.8/5.0	S-8	
	35.0	SP-SM	SAME SAND AS ABOVE, ABUN. LIGNITE NEAR BOTTOM 0.2' BUT STARTS APPEARING @ 37.7', SEVERAL PYRITE CEMENTED SAND NODULES FROM 37.7' DOWN, VY STIFF CLAY LENSE AT 36.6-36.7' DARK GRAY [10YR 4/1], SAND IS SAME GRAY AS ABOVE (35.0-39.0)	4.0/5.0	S-9	
Δ SCALE ↓	40.0	SP-SM	SAME SAND AS ABOVE (40.7-43.8)	4.3/5.0	S-10	
	41.25					
	42.5					
	43.75	CL	CLAY, VY STIFF, GRAY [10YR6/1] (43.8-45.0)			
	45.0					

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1980 OF - 428 - 603 | PROJECT: RI/FS EDGEWOOD | HOLE NO. WBR-19

LOG (Cont Sheet) | ELEVATION TOP OF HOLE | Hole No. WBR-19

PROJECT RI/FS | INSTALLATION EDGEWOOD | SHEET 3 OF 3 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	45.0	CL	CLAY, STIFF - VY STIFF, LT BROWNISH GRAY [10YR6/2] AND BROWN [10YR5/3], TR. MICA (45.0-47.5)	2.5/2.5	S-11	
	47.5		BOH			

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1980 OF-620-603 | PROJECT RI/FS EDGEWOOD | HOLE NO. WBR-19

Hole No. WBR-19B

DRILLING LOG	DIVISION: CENAB-EN-GG	INSTALLATION: APG-EDGEWOOD	SHEET 1 OF 1 SHEETS

1. PROJECT: RI/FS EDGEWOOD
2. LOCATION (Coordinates or Station): CLUSTER 15
3. DRILLING AGENCY: COE-MOBILE DIST.
4. HOLE NO. (As shown on drawing title and file number): WBR-19B
5. NAME OF DRILLER: J. BUTTS
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE: 20'
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL: CME 75
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 10/5/94 | COMPLETED 10/5/94
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING: 79.0 %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		OL	SILTY CLAY, MED STIFF, W/ FINE-CRSE GR ANGULAR-SUBANG SAND, ROOTS, SCATTERED IRON FRAGS, BROWN [10YR5/3] (0.0-0.4)			3 1/2" DRIVE SPOON
		CL-ML	SILTY CLAY, V STIFF, STREAKY BRNSH YELLOW [10YR6/8] AND LT GRAY [10YR7/2], BECOMING BRNSH YELLOW [10YR6/6] AT 1.6' (0.4-2.8)	5.4/5.0		NO SAMPLES BEING TAKEN DUE TO PROXIMITY TO WBR-19 DTW IN WBR-19 - 14.11' FROM TOC
		CL	CLAY, MED STIFF-SOFT, STREAKY YELLOWISH BROWN [10YR5/6] AND LT GRAY [10YR7/2], YELLOW PREDOMINATES IN UPPER 1.3', LT GRAY IN LOWER 1.3' (2.8-5.4)			10/5/94 DTW - 12.1' FROM GROUND THRU 15' AUGERS IN 20' HOLE DTW - 13.88' FROM TOC @ 1300 (ON COMPLETION)
	5.0	CL	SAME AS ABOVE, SOFT, WET (5.0-6.7)			10/7/94 DTW - 14.12' FROM TOC @ 0820 (>24 HRS)
		ML	SANDY SILT, SAND FINE GR, ANGULAR-SUBANGULAR, MOD. WELL SORTED, TR. HVY MINS + MICA, WET TO SAT IN SPOTS, LT GRAY [10YR 7/2] AND LT YELLOWISH BROWN [10YR6/4] W/ STRONG BROWN [7.5YR 5/8] MOTTLING (6.7-9.0)	3.0/5.0		
	10.0	ML	SAME AS ABOVE, LT GRAY [10YR7/2] (10.0-11.0)			
		SW	GRADES FROM ML INTO SAND, FINE-CRSE GR. SUBANGULAR-SUBANG, POORLY SORTED, TR. HVY MINS, WET, BECOMING SAT TOWARD BOTTOM, WHITE [10YR 8/2] (11.0-12.4)	2.4/5.0		▽ SAT SAND ENCOUNTERED (NOTE POOR RECOVERY)
	15.0	SW	SAME AS ABOVE, SCATTERED ANGULAR 1/2" GRAVEL AT BASE, YELLOWISH BROWN [10YR5/6] OVER LOWER 0.2' (15.0-16.7)			
		CL	CLAY, V SOFT, WET, W/ FINE GR SUBROUNDED SAND, LT GRAY [10YR7/2] (16.7-17.1)	5.0/5.0		
		SP	SAND FINE-MED GR, ANGULAR-SUBANGULAR, MOD WELL SORTED			
		CL	SANDY CLAY, V SOFT, SAND FINE GR ANGULAR-SUBROUNDED, WELL SORTED, SAT, GRAYISH BROWN [10YR5/2] (17.3-17.7)			
	20.0	SP	SAND, FINE GR, SUBROUNDED-SUBANG, WELL SORTED, TR. HVY MINS & MICA, SAT., V PALE BROWN [10YR7/3 + 7/4] (17.7-20.0)			

DEPTH	HNU (PPM) BKGD	HNU (PPM) SAMPLE	RAD (MR/HR) BKGD	RAD (MR/HR) SAMPLE
B'GRND	6.3	—	0.01	—
0-5'	6.6	6.7	0.01	0.01
5-10'	6.6	6.9	0.01	0.015
10-15'	6.2	6.8	0.015	0.015
15-20'	6.3	7.0	0.01	0.01

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. 804

PROJECT: RI/FS EDGEWOOD | HOLE NO. WBR-19B

Hole No. WBR-20

DRILLING LOG	DIVISION CENAB-EN-GG	INSTALLATION APG - EDGEWOOD	SHEET 1 OF 2 SHEETS

1. PROJECT RI/FS EDGEWOOD	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) CLUSTER 15	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY COE- MOBILE DIST.	12. MANUFACTURER'S DESIGNATION OF DRILL CME 75
4. HOLE NO. (As shown on drawing title and file number) WBR-20	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER J. BUTTS	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 9/28/94 — COMPLETED 9/29/94
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING 79.7 %
9. TOTAL DEPTH OF HOLE 38'	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		CL-ML	SANDY SILTY CLAY, SOFT, ABUN. ROOTS, SAND FINE GR, SUBANG., DK GRAYISH BROWN [10YR4/2] (0.0-0.4')			3 1/2" DRIVE SPOON 3 1/4" HSA
		CL-ML	SILTY CLAY W/ SOME FINE GR, SUBANGED SAND, MED STIFF, SOME ROOTS, YELLOWISH BROWN [10YR5/6] (0.4-1.3')			
		FILL-CL	SANDY CLAYEY SILT, STIFF-VY STIFF, FRIABLE, SAND FINE GR, SUBANGED, YELLOWISH BROWN [10YR5/8] TO 2.2', THEN MIXED SAME YEL BRN AND WHITE [10YR8/2] (1.3-3.5)	4.8/5.0	S-1	9/29/94 DTW - 9.33' FROM TOC @ 0950 (ON COMPLETION) 9/30/94 DTW - 8.56' FROM TOC @ 1000 (24 HRS)
		ML	SANDY SILT, SAND FINE GR, ENDED-SUBANGED, WELL SORTED, BRNISH YELLOW [10YR6/8] TO 4.3', THEN STRONG BROWN [7.5YR5/8] (3.5-4.8)			
	50	ML	SAME AS ABOVE, PREDOM. VY PALE BROWN [10YR8/3] W/ SOME SAME STRONG BROWN (5.0-7.5)		S-2	
		CL-ML	SILTY CLAY, STIFF-VY STIFF, LT BRNISH GRAY [10YR6/2] W/ STRONG BROWN [7.5YR5/8] MOTTLING (7.5-9.6)	4.6/5.0		
	100	CL-ML	SAME SILTY CLAY, TR. MICA, SOME ROOTS (10.0-12.6)	4.4/5.0	S-3	
		CL	CLAY, SOFT OVER TOP 0.4', THEN MED. STIFF, LIGNITE COMMON, BROWN [10YR 5/3] OVER TOP 0.4', THEN VY DARK GRAY [10YR3/1], MOIST (12.6-14.4)			▼ IN 25' HOLE THRU AUGERS FROM GROUND
	150	CL	SAME CLAY, STIFF-MED. STIFF, LIGNITE LESS ABUNDANT (15.0-18.2)	3.2/5.0	S-4	▼ IN 35' OPEN HOLE FROM GROUND
	200					

Remarks table (column g):

Depth	HNU (PPM) B'GRND	HNU (PPM) SAMPLE	RAD (MR/HR) B'GRND	RAD (MR/HR) SAMPLE
B'GRND	3.7	—	0.01	—
0-5'	3.1	3.1	0.01	0.01
5-10'	2.9	2.9	0.015	0.015
10-15'	2.7	2.7	0.01	0.01
15-20'	2.1	2.5	0.01	0.01
20-25'	1.5	1.5	0.01	0.01
25-30'	1.1	1.1	0.01	0.01
30-35'	0.8	0.8	0.015	0.015
35-38'	2.4	2.4	0.01	0.01

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT RI/FS EDGEWOOD | HOLE NO. WBR-20

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | **Hole No.** WBR-2D

PROJECT: RI/FS EDGEWOOD | INSTALLATION: APG - EDGEWOOD | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0	CL	SAME AS ABOVE, LIGNITE ABUNDANT (20.0-21.6)			
		SC	CLAYEY SAND, SAND FINE-MED GR, SUBRNDED-SUBANG, MOD. WELL SORTED, SAT, TR. LIGNITE, SCATTERED CRSE GR SAND AND SUBRNDED GRAVEL UP TO 0.5" IN SIZE, GRAY [10YR6/1] (21.6-23.6)	3.6/5.0	S-5	∇ SAT. SAND ENCOUNTERED
	25.0	SP	SAND, FINE-MED GR, SUBRNDED, MOD. WELL SORTED, OCC. CRSE GR & SUBRNDED GRAVEL UP TO 0.5" IN SIZE, SAT., SAME GRAY, CLAYEY IN SPOTS, TR HVY MINS (25.0-27.0)		S-6	
		SM	SILTY SAND, SAND VY FINE GR, RNDED-SUBRNDED, WELL SORTED, LIGNITE COMMON, SOFT CLAY LENSES AT 27.0-27.2', 27.4-27.7', & 27.9-28.0', SAT., VY DARK GRAYISH BROWN [10YR3/2] (27.0-29.7)	4.7/5.0		
	30.0	SM	SAME AS ABOVE GRAVEL COMMON UP TO 1" IN SIZE, SUBRNDED, AT CONTACT W/ CLAY (30.0-31.6)			
		CL	CLAY, VY STIFF, TR. MICA, BROWN [7.5YR5/3] W/ SWIRLS OF WEAK RED [10R5/4] (31.6-33.2)	3.2/5.0	S-7	DRILLER FEELS CLAY ENCOUNTERED @ ~31.5'
	35.0	CL	SAME AS ABOVE	1.8/3.0	S-8	
	38.0		BOH			

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1960 OF-628-605 | PROJECT: RI/FS EDGEWOOD | HOLE NO: WBR-2D

Hole No. WBR-21

DRILLING LOG	DIVISION: CENAB-EN-GG	INSTALLATION: EDGEWOOD	SHEET 1 OF 2 SHEETS

1. PROJECT: RI/FS EDGEWOOD	10. SIZE AND TYPE OF BIT: 3 3/4" 8 1/4" CUTTERHEAD
2. LOCATION (Coordinates or Station): CLUSTER 15	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: COE - MOBILE DIST.	12. MANUFACTURER'S DESIGNATION OF DRILL: CME 75
4. HOLE NO. (As shown on drawing title and file number): WBR-21	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 5; UNDISTURBED
5. NAME OF DRILLER: J. BUTTS	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 9/12/94; COMPLETED 9/13/94
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING: 92.4 %
9. TOTAL DEPTH OF HOLE: 25'	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0	OL	SILT, SOME FINE GR SUBANG-ANG SAND, ABUN ROOTS, SCATTERED 0.5" QTZ GRAVEL, BROWN [10YR 5/3] (0-0.5)			3 3/4" HSA 3 1/2" DRIVE-SPOON
		CL-ML	SILTY CLAY, VERY STIFF, FRIABLE TO 2.5', SCATTERED FINE GR SAND, SUBANG, SCATTERED ROOTS TO BOTTOM, MOTTLED YELLOWISH BROWN [10YR 5/4], GRAY [10YR 6/1], AND STRONG BROWN [7.5YR 5/8] (0.5-4.2)	4.2/5.0	S-1	9/13/94 DTW - 10.67' FROM GROUND IN HOLE COLLAPSED TO 11' W/ 3 3/4" HSA LEFT IN HOLE OVERNIGHT DOWN TO ~12.5' DTW WAS ~10'11" FROM GROUND DTW - 12.94' FROM TOC @ 1040 (ON COMPLETION) 9/14/94 DTW - 12.60' FROM TOC @ 0815 (~24 HRS)
	5.0	CL-ML	SAME AS ABOVE, BUT WET (5.0-6.6')	4.9/5.0	S-2	
		ML	SANDY SILT, SAND FINE-MED GR, POORLY SORTED, SUBANG, HVY MINS & MICA COMMON, WET, SAND DECREASES TOWARD BASE, VY PALE BROWN [10YR 7/4] (6.6-8.2')			
		ML-CL	CLAYEY SILT, SOFT, TR HVY MINS & MICA, LT YELLOWISH BROWN [10YR 6/4]			HNU BK / SAMPLE: 0-2.5' 3.0 / 3.0; RAD BK / SAMPLE: 0.01 / 0.01
	10.0	CL-ML	SAME AS ABOVE, GRADING INTO SILTY CLAY VY STIFF, MICA COMMON, SCATTERED FINE GR SUBROUNDED SAND, LT GRAY [10YR 7/1] WITH BRNISH YELLOW [10YR 6/6] STREAKS (10.0-11.1)	4.0/5.0	S-3	
		SW	SAND, FINE-MED GR, OCC COARSE GR, SUBROUNDED, REL POORLY SORTED, TR. HVY MINS, SAT., VY PALE BROWN [10YR 8/4], BECOMING STRONG BROWN [7.5YR 5/8] AT 13.1' (11.1-14.0)			— SAT. SANDS ENCOUNTERED
	15.0	CL-ML	SILTY CLAY, MED STIFF, MOIST, LT BRNISH GRAY [10YR 6/2] AND PALE BROWN [10YR 6/3] (15.0-16.2)	5.0/5.0	S-4	
		SM	SILTY SAND, SAND FINE GR, REL WELL SORTED, SUBROUNDED-SUBANG, TR HVY MINS + MICA, SAT., CLAYEY SAND FROM 16.6-17.1', COLOR OF SM IS VY PALE BROWN [10YR 7/4] TO CLAYEY SAND WITH BRNISH YELLOW [10YR 6/6] (16.2-18.3)			
	20.0	CL	CLAY, VY STIFF, GRADES FROM MOIST SILTY CLAY, MED. STIFF OVER TOP 0.8', GRAY [10YR 5/1] W/ BRNISH YELLOW [10YR 6/8] STREAKS IN SILTY CLAY (18.3-20.0)			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: RI/FS EDGEWOOD | HOLE NO. WBR-21

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE

Hole No. WBR-21

PROJECT RI/FS EDGEWOOD | INSTALLATION EDGEWOOD | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		CL	SAME CLAY, VY STIFF, GRAYISH BROWN [10YR5/2] TO 21.5', THEN DARK GRAY [5YR4/1] (20.0-25.0)	5.0/5.0	S-5	
	25.0		BOH			

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1980 OF-628-603 PROJECT RI/FS-EDGEWOOD HOLE NO. WBR-21

Hole No. WBR-23

DRILLING LOG	DIVISION: CENAB-EN-GG	INSTALLATION: APG - EDGEWOOD	SHEET 1 OF 2 SHEETS

1. PROJECT: RI/FS EDGEWOOD	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station): CLUSTER 15	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: COE - MOBILE DIST.	12. MANUFACTURER'S DESIGNATION OF DRILL: CME 75
4. HOLE NO. (As shown on drawing title and file number): WBR-23	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER: J. BOTTS	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED: 10/6/94 — COMPLETED: 10/7/94
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE: 45'	18. TOTAL CORE RECOVERY FOR BORING: 74.5 %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			GRAVEL, ROAD SURFACE		NO SAMPLE	3½" DRIVE-SPOON
	1.0	OL	SANDY SILTY CLAY TOPSOIL, SOFT, SAND FINE GR, RNDED, ABUN ROOTS, 1 ROOT FRAG 4" IN MAX DIMENSION, BROWN [10YR5/3] (1.0-1.6)			10/6/94 DTW - 4.3' FROM GRAVEL THRU 30' AUGERS
		ML-CL	CLAYEY SILT, FRIABLE, BECOMING STIFF TOWARDS BASE WHERE CLAY CONTENT INCREASES, SCATTERED FINE GR RNDED SAND, RARE 1" RNDED QTZ GRAVEL, YELLOW [10YR7/6] W/ LT GRAY [10YR7/2] TOWARDS BASE, SCATTERED ROOTS IN UPPER HALF (1.6-4.7)	3.7/4.0	S-1	10/7/94 DTW - 6.67' FROM TOC @ 1425 (ON COMPLETION) 10/11/94 DTW - 6.44' FROM TOC @ 0750 (>24 HRS)
	5.0	CL-ML	SILTY CLAY, MED STIFF, MOIST TO WET OVER LOWER 0.2', BECOMING SANDY CLAY OVER LOWER 0.2', SAND IS FINE-MED GR, RNDED, ROOTS COMMON, MOSTLY LT GRAY [10YR 7/2] W/ YELLOWISH BROWN [10YR5/8] MOTTLING, BECOMING GRAY [10YR 6/1] OVER LOWER 0.5' (5.0-6.5)			▽ SAT. SAND ENCOUNTERED
		SP	SAND, FINE GR, SUBRNDED-SUBANG, WELL SORTED, TR HVY MINS, SAT., VY PALE BROWN [10YR7/3] (6.5-9.1)	4.1/5.0	S-2	
	10.0	SP	SAME AS ABOVE (10.0-12.3)			
		SW	SAND, FINE-CRSE GR, RNDED-SUBANG, POORLY SORTED, SAND 0.5" SUBRNDED GRAVEL, SOME CLAY, SAT. (12.3-12.7)	4.8/5.0	S-3	
		SW	SAND FINE-CRSE GR, RNDED-SUBANG, POORLY SORTED, SAT., YELLOWISH RED [5YR5/8] (12.7-13.5)			
		SP	SAME SAND AS AT TOP OF SPOON, BRWSH YELLOW [10YR 6/6], 1 2" RNDED GRAVEL AT CONTACT W/ SM BELOW (13.5-14.6)			
	15.0	SM	SILTY SAND, SAND VY FINE GR, RNDED, WELL SORTED, SAT, WHITE [10YR 8/2] (14.6-14.8)			
		SM	SILTY SAND, SAND VY FINE GR, RNDED, WELL SORTED, SAT, WHITE [10YR8/2], TR. HVY MINS	4.4/5.0	S-4	
	20.0					

Remarks (continued):

	DEPTH	HNU (PPM) BKGD	HNU (PPM) SAMPLE	RAD (MR/HR) BKGD	RAD (MR/HR) SAMPLE
HNU #1	BKGD	5.3	—	0.01	—
HNU #1	1.0-5.0'	5.2	5.2	0.01	0.01
HNU #1	5.0-10.0	4.9	4.9	0.01	0.01
HNU #1	10.0-15.0	6.6	6.6	0.01	0.01
HNU #1	15.0-20.0	6.6	6.8	0.01	0.01
HNU #2	BKGD	7.4	—	—	—
HNU #2	20.0-25.0	7.7	8.4	0.01	0.01
HNU #2	25.0-30.0	6.8	8.1	0.01	0.01
HNU #2	30.0-35.0	5.1	7.7	0.01	0.01
HNU #2	35.0-40.0	4.4	7.1	0.01	0.01
HNU #2	40.0-45.0	3.2	6.3	0.01	0.01

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT: RI/FS EDGEWOOD HOLE NO. WBR-23

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE — **Hole No.** WBR-23

PROJECT: RI/FS EDGEWOOD — INSTALLATION: APG-EDGEWOOD — SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
Δ SCALE ↓	20.0	SM	SAME AS ABOVE, W/ SOME REDDISH YELLOW [7.5YR 6/8] FROM 20.9-21.3 (20.0-23.0)	3.0/5.0	S-5	
Δ SCALE ↓	25.0	SM	SAME AS ABOVE, W/ CLAYEY SILT LENSES ~0.5" THICK, FROM 25.9' TO BASE (25.0-26.4)			
		SP	SAND, FINE GR, RNDED, WELL SORTED, TR. HVY MINS, LIGNITE COMMON OVER LOWER 0.2', SAT., GRAY [10YR 6/1] (26.4-28.1)	3.1/5.0	S-6	
Δ SCALE ↓	30.0	SP	SAME SAND AS ABOVE, LIGNITE COMMON, SANDY SILTY CLAY, STIFF, OCCURS AS LAYERS UP TO 0.3' THICK (30.0-33.0)	3.0/5.0	S-7	ATTEMPTED TO EXCLUDE CLAY IN SAMPLE
	35.0	SP & CL	SAME SAND, CLAY LENSES MAKE UP ~50% OF SAMPLE, CLAY IS STIFF, LT BRNISH GRAY [10YR 6/2], LIGNITE COMMON (35.0-37.9)	2.9/5.0	S-8	COMPOSITE SAMPLE
	40.0	SP & CL	SAME AS ABOVE (40.0-40.9)			
		CL	CLAY, PREDOM VY STIFF BUT STIFF IN SPOTS, MULTICOLORED IN STREAKS: BROWN [10YR 5/3 + 4/3], LT BRNISH GRAY [10YR 6/2] AND WEAK RED [10R 4/4], SCATTERED LIGNITE (40.9-43.8)	3.8/5.0	S-9	
	45.0		BOH			

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1980 OF-628-603

PROJECT: RI/FS EDGEWOOD — HOLE NO. WBR-23

Hole No. WBR-24

DRILLING LOG	DIVISION CENAB-EN-GG	INSTALLATION EDGEWOOD	SHEET 1 OF 2 SHEETS

1. PROJECT RI/FS EDGEWOOD	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) CLUSTER 15	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY COE - MOBILE DIST.	12. MANUFACTURER'S DESIGNATION OF DRILL CME 75
4. HOLE NO. (As shown on drawing title and file number) WBR-24	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER J. Butts	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE [✓ VERTICAL] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED 9/13/94 — COMPLETED 9/14/94
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE 32'	18. TOTAL CORE RECOVERY FOR BORING 84.7 %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		OL	SILTY TOPSOIL, SOME FINE GR RNDED-SUBRNDED SAND, ABUN. ROOTS, ONE 2" GRAVEL, LT YELLOWISH BROWN [10YR 6/4] (0.0-0.6)			3½" DRIVE SPOON 3¼" HSA 9/14/94 DTW – 18.1' IN 30' HOLE THRU AUGERS (FROM GROUND) @ 0900 – 20.66' FROM TOC @ 1340 (ON COMPLETION) 9/15/94 DTW – 20.06' FROM TOC @ 0825 (~24 HRS)
		CL	CLAY, VY STIFF, SOME SILT, TR. MICA, FRIABLE TO 1', SCATTERED ROOTS TO 1.7', VY PALE BROWN [10YR7/4] TO 3.2', THEN LT GRAY [10YR7/2], YELLOWISH RED MOTTLING [5YR5/8] THRUOUT, BECOMING MED. STIFF OVER BOTTOM 0.2' (0.6-4.9)	4.9/5.0	S-1	
	5.0	CL	CLAY, MED. STIFF, BECOMING SOFT & MOIST AT 7.1', LT BRNISH GRAY [10YR 6/2] w/ BRNISH YELLOW [10YR 6/8] MOTTLING, MOTTLING ASSOC. w/ OXIDIZED FRAGMENTS ≤ 1 CM IN SIZE, MAYBE METALLIC DEBRIS? (5.0-8.1)	4.1/5.0	S-2	
		ML	SANDY SILT, SAND FINE GR, SUBRNDED, HVY MINS COMMON, MOIST, VY PALE BROWN [10YR7/4] w/ SOME SAME BRNISH YELLOW (8.1-9.1)			
	10.0	ML	SAME SANDY SILT, TR. MICA BECOMES WHITE [10YR8/2] AT 12.7' (10.0-13.3')	3.3/5.0	S-3	
	15.0	ML-CL	SAME AS ABOVE EXCEPT SAT. AT 15.5', BECOMING CLAYEY FROM 16.4-17.5', FINE GR SUBRNDED SAND LENSE AT BASE (15.0-17.6')	3.3/5.0	S-4	
		CL	SANDY CLAY, VY STIFF, SAND FINE GR, RNDED, WET, STREAKY LT GRAY [10YR7/1] YELLOWISH BROWN [10YR5/8] AND YELLOWISH RED [5YR5/8] (17.6-18.3')			
	20.0					

DEPTH	HNU BGRD	HNU SAMPLE	RAD SAMPLE
BGRD	1.2	—	0.015
0.0-5.0	1.1	1.1	0.015
5.0-10.0	1.6	2.1*	0.01
10.0-15.0	2.0	2.2	0.01
15.0-20.0	2.0	2.0	0.01
20.0-25.0	2.1	2.1	0.01
25.0-32.0	1.9	1.9	0.01

*TOP 1FT

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT RI/FS EDGEWOOD — HOLE NO. WBR 24

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | **Hole No.** WBR-24

PROJECT: RI/FS EDGEWOOD | INSTALLATION: EDGEWOOD | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0	CL	SAME-SANDY CLAY FOR TOP 0.1', BECOMING CLAY WITH SOME FINE GR. ANGL SAND, MED. STIFF (20.0-22.5)	5.0/5.0	S-5	
		SP	SAND, FINE-MED GR, SUBANGULAR-ANGULAR, REL. POORLY SORTED, TR. HVY MINS., SAT., YELLOW [10YR7/6], VY PALE BROWN [10YR7/4] AND BRNSH YELLOW [10YR6/8] OVER BOTTOM 0.2' (22.5-25.0)		S-6	
	25.0	SP	SAME AS ABOVE, TR. 1 CM ANGL GRAVEL AT BASE (25.0-27.3)	4.8/5.0		
		CL	CLAY, VY STIFF, STREAKY DARK GRAY [10YR4/1] AND LT BRNISH GRAY [10YR6/2], SOME SILT (27.3-29.3)		S-7	
	30.0	ML-CL	SANDY CLAYEY SILT, MED STIFF, SAME LT BRNISH GRAY (29.3-29.8)			
			BOH			

FORM 1836-A (ER 1110-1-1801) GPO 1980 OP-626-603 | PROJECT: RI/FS EDGEWOOD | HOLE NO. WBR-24

Hole No. WBR-25

DRILLING LOG	DIVISION CENAB-EN-GG	INSTALLATION EDGEWOOD	SHEET 1 OF 2 SHEETS
1. PROJECT RI/FS EDGEWOOD		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station) CLUSTER 15		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY COE - MOBILE DIST.		12. MANUFACTURER'S DESIGNATION OF DRILL CME 75	
4. HOLE NO. (As shown on drawing title and file number) WBR-25		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER J. BUTTS		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 9/14/94 COMPLETED 9/23/94
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING	81.8 %
9. TOTAL DEPTH OF HOLE 40'		19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0	ML	SILT, FRIABLE, SOME FINE GR. RNDED SAND, OCC. ROOTS, PALE BROWN [10YR6/3] FOR THE 0.1', THEN V.Y. PALE BROWN [10YR8/4] (0.0-1.4)			3½" DRIVE SPOON 3¾" HSA 9/15/94 DTW - 8.5' THRU AUGERS IN 20' HOLE & STILL RISING @ 1035 -7.3' THRU AUGERS IN 35' HOLE @ 1240
		ML-CL	CLAYEY SILT, VERY STIFF, FRIABLE, TR. ROOTS & FINE GR RNDED SAND, MOTTLED LT YELLOWISH BROWN [10YR6/4] AND BRNISH YELLOW [10YR6/8] (1.4-4.6)	4.6/5.0	S-1	9/23/94 DID NOT TAKE DTW ON COMPLETION BECAUSE FILTER PACK EMPLACEMENT FORCED WATER LEVEL TO NEAR GROUND LEVEL; WATER IS SLOWLY DROPPING TO TRUE DTW OF ~5' 9/26/94 DTW - 7.07' FROM TOC @ 0810 (>24 HRS) ▽ SAT. SAND ENCOUNTERED
	5.0	SM	SILTY SAND, SAND FINE GR, SUBRNDED, WELL SORTED, SAT., LT BRNISH GRAY [10YR6/2] (5.0-5.9)			
		SP	SAND, FINE-MED GR., SUBRNDED-RNDED, REL. POORLY SORTED, TR. HVY MINS & MICA., SAT., YELLOW [10YR7/6], REDDISH YELLOW [7.5YR6/8] AND PALE BROWN [10YR6/3] OCC. ½" SUBRNDED GRAVEL AT BASE (5.9-8.6)	3.6/5.0	S-2	HNU: Depth / Bkgd / Spoon / BZ: Bkgd 3.3 / — / 0.01; 0.0-5.0 3.4 / 3.6 / 0.01; 5.0-10.0 3.5 / 3.5 / 0.01; 10.0-15.0 3.0 / 3.0 / 0.01
	10.0	SP	SAND AS ABOVE (10.0-11.0)			
		SP	SAND, FINE GR, SUBRNDED, WELL SORTED, TR HVY MINS, SAT., BECOMES CLAYEY TOWARD BOTTOM, RNDED GRAVEL UP TO 2" IN SIZE AT BASE, V.Y. PALE BROWN [10YR 7/4] (11.0-12.5)	4.9/5.0	S-3	
		ML	SANDY SILT, SAND FINE GR, SUBRNDED, WELL SORTED, TR HVY MINS, SAT., WHITE [10YR8/2] (12.5-14.9)		S-4	
	15.0	CL	CLAY, MED. STIFF, TR. MICA, MOIST, YELLOWISH BROWN [10YR5/8] (15.0-15.5)			9/15/94
		SM	SILTY SAND, SAND FINE-MED GR, REL. POORLY SORTED, SUBRNDED, SAT., TR HVY MINS, V.Y. PALE BROWN [10YR7/4] W/ SPOTS OF YEL. BROWN [10YR5/8] (15.5-16.4)		S-5	
		SM	SILTY SAND, SAND V.Y. FINE GR, SUBRNDED, WELL SORTED, TR HVY MINS, WHITE [10YR8/2] NOTE: THIS IS SAME AS FROM 12.5-14.9'; DO NOT KNOW HOW MUCH OF SPOON IS REAL SAMPLE (16.4-17.2)	2.2/5.0		POOR RECOVERY PROBABLY RESULT OF BLOCKAGE IN SPOON; SAMPLE DEPTHS NOT ACCURATE
	20.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT RI/FS EDGEWOOD | HOLE NO. WBR-25

[illegible] LOG (Cont Sheet) | ELEVATION TOP OF HOLE | **Hole No.** WBR-25

PROJECT RI/FS EDGEWOOD | INSTALLATION EDGEWOOD | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0	SM	SILTY SAND, SAND VY FINE GR, SUBROUNDED-SUBANG., WELL SORTED, SAT., VY PALE BROWN [10YR 7/3] TO 21.5', BECOMING WHITE [10YR 8/2] (20.0-24.3)	4.3/5.0	S-6	
Δ SCALE ↓	25.0	SM	SAME SILTY SAND, SAME WHITE (25.0-30.0)	5.0/5.0	S-7	
Δ SCALE ↓	30.0	SM	SAME AS ABOVE (30.0-31.3)	4.9/5.0	S-8	
		SM	SAME SILTY SAND, EXCEPT TR. HVY MINS, 0.05' LIGNITE SEAMS AT TOP AND AT 33.1', COLOR OF SM IS GRAY [10YR 5/1] (31.3-34.9')			
Δ SCALE ↓	35.0	SM	SAME AS ABOVE (35.0-35.5)	3.2/5.0	S-9	
		CL	CLAY, STIFF, DARK GRAY [N4] OVER TOP 0.7' GRADES FROM SAND TO SANDY CLAY TO CLAY, SILTY SAND LENSE, 0.05' THICK AT 37.1' (35.5-38.2')			BUTS & BOWDEN BELIEVE CLAY WAS ENCOUNTERED AT ~36'
	40.0		BOH			

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1980 OF-629-603 | PROJECT RI/FS | HOLE NO. WBR-25

Hole No. WBR-26

DRILLING LOG	DIVISION CENAB-EN-GG	INSTALLATION EDGEWOOD	SHEET 1 OF 1 SHEETS
1. PROJECT RI/FS EDGEWOOD		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station) CLUSTER 15		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY COE — MOBILE DIST.		12. MANUFACTURER'S DESIGNATION OF DRILL CME 75	
4. HOLE NO. (As shown on drawing title and file number) WBR-26		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER J. BUTTS		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 9/17/94 / COMPLETED 9/19/94
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING	84.5 %
9. TOTAL DEPTH OF HOLE 20'		19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		OL	SILTY TOPSOIL, ROOTS, SOME FINE GR. SUBANG.-SUBROUNDED SAND, PALE BROWN [10YR 6/3] (0.0-0.3')			3½" DRIVE SPOON 3¾" ÷ SA
		CL-ML	SILTY CLAY, VY STIFF, RARE FINE GR. ROUNDED SAND, OCC. ROOTS AT TOP, ONE 1" ROUNDED QTZ GRAVEL AT 3.4', STRONG BROWN [7.5YR 5/6] AND BRNISH YELLOW [10YR 6/6] WITH LT GRAY [10YR 7/2] MOTTLING (0.3-4.6')	4.8/5.0	S-1	9/17/94 DTW – 8.95' FROM GROUND THRU AUGERS IN 20' HOLE W/ AUGERS PULLED UP TO ~14' – 8.68' FROM TOC @ 1640
	5.0	CL-ML	SANDY SILTY CLAY, SAND FINE GR, SUBROUNDED, SAME COLORS AS ABOVE (4.6-4.9')			9/19/94 DTW – 10.23' FROM TOC @ 0830 (ON COMPLETION)
		ML	SANDY SILT, SAND FINE GR, SUBROUNDED-ROUNDED, MOD. WELL SORTED, TR. HVY MINS & MICA, MOIST, BECOMING WET AT 6.0', GRADES INTO CL-ML BELOW, DISCRETE LAYERS OF BRNISH YELLOW [10YR 6/6] AND VY PALE BROWN [10YR 7/4] (5.0-7.2')		S-2	9/21/94 DTW – 10.23' FROM TOC @ 0940 (~48 HRS)
		CL-ML	SILTY CLAY, MED. STIFF - SOFT, SAT., OCC. FINE GR ROUNDED SAND, LT GRAY [10YR 7/2], STRONG BROWN [7.5YR 5/8] AND LT YELLOWISH BROWN [10YR 6/4] (7.2-8.6')	3.6/5.0		
	10.0	CL	CLAY, SOFT, SAT., LT BRNISH GRAY [10YR 6/2] AND GRAYISH BROWN [10YR 5/2], OCC. ORG. FRAGS W/ STRUCTURE VISIBLE (10.0-12.5')	3.5/5.0	S-3	▽ SAT. SAND ENCOUNTERED
		SM	SILTY SAND, SAND FINE GR, SUBROUNDED-ROUNDED, MOD. WELL SORTED, TR. HVY MINS, SAT., LT GRAY [10YR 7/2], THEN VY PALE BROWN [10YR 7/4] OVER BOTTOM 0.2' (12.5-13.5')			
	15.0	SM	SAME SILTY SAND, VY PALE BROWN [10YR 7/4], SOME ¼" SUBROUNDED GRAVEL (15.0-16.7')		S-4	
		SW	SAND, FINE-CRSE GR, POORLY SORTED, SUBROUNDED-ROUNDED, TR. HVY MINS, BECOMES COARSER TOWARD BASE, SAT., VY PALE BROWN [10YR 8/3] (16.7-17.8')	5.0/5.0		
	20.0	CL	CLAY, VY STIFF, TOP 0.3' COMPRISED OF ALTERNATING LAYERS OF CLAY AND FINE-MED GR SAT. SAND, ORG. FRAGS W/ STRUCTURE VISIBLE AT TOP OF CL, MULTICOLORED: REDDISH BROWN [5YR 4/4], YELLOWISH BROWN [10YR 5/6], WHITE [10YR 8/1], AND LT YELLOWISH BROWN [2.5Y 6/4] (17.8-20.0') BOH		S-5	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT RI/FS EDGEWOOD | HOLE NO. WBR-26

Hole No. WBR-27

DRILLING LOG	DIVISION CENAB-EN-GG	INSTALLATION APG - EDGEWOOD	SHEET 1 OF 1 SHEETS

1. PROJECT: RI/FS EDGEWOOD	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station): CLUSTER 15	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: COE - MOBILE DIST.	12. MANUFACTURER'S DESIGNATION OF DRILL: CME 75
4. HOLE NO. (As shown on drawing title and file number): WBR-27	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER: J. BUTTS	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 10/1/94; COMPLETED 10/3/94
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING: 97.4 %
9. TOTAL DEPTH OF HOLE: 19'	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		OL	SILTY TOPSOIL, THICK ROOT MAT, VY DK BROWN [10YR 2/2] (0.0-0.4)			3¼" HSA; 3½" DRIVE SPOON
		CL-ML	SILTY CLAY, HARD, FRIABLE, SOME ROOTS, BRNSH YELLOW [10YR 6/6] W/ YELLOWISH BROWN [10YR 5/8] AND LT GRAY [10YR 7/2] MOTTLING (0.4-4.3)	4.3/4.0	S-1	10/1/94 DTW - 6.5' FROM TOP OF GRAVEL THRU 10' AUGER IN 19' HOLE (GRAVEL IS 1.1' THICK); 10/3/94 DTW - 10.78' FROM TOC W/ 3' STICKUP RELATIVE TO THIS LOG (ON COMPLETION)
	4.0	CL-ML	SAME AS ABOVE (4.0-5.0)			
		CL-ML	SANDY SILTY CLAY, STIFF, SAND PREDOM. FINE GR, SUBANGED BUT OCC. MED-CRSE GR, SOME ROOTS, LT GRAY [10YR 7/2] AND YELLOWISH BROWN [10YR 5/8] (5.0-6.8)	4.6/5.0		10/4/94 DTW - 9.30' FROM TOC ECBTO (24 HRS)
		CL	CLAY, STIFF, TR MICA, ROOTS COMMON, GRAY [?] W/ SOME BRNSH YELLOW [10YR 6/8] AND LT BRNSH GRAY [10YR 6/2], SOME FINE GR SAND APPEARING AT VERY BOTTOM OF SAMPLE (6.8-9.6)		S-2	
	9.8	SP	SAND, FINE GR, SUBANGED, WELL SORTED, SAT, V PALE BROWN [10YR 7/4] BECOMING BRNSH YELLOW [10YR 6/6] AT 11.2' (9.0-11.8)	5.0/5.0	S-3	▽ SAT. SAND ENCOUNTERED
		CL	SANDY CLAY, V STIFF, SAND FINE GR, ROOTS, LT GRAY [2.5Y 7/2] (11.8-12.1)			
		SW	SAND, FINE-CRSE GR, ANGULAR-SUBANGED, POORLY SORTED, SAT., REDDISH YELLOW [7.5YR 6/8] (12.1-13.6)		S-4	
		CL	CLAY, HARD, SLIGHTLY MOD GR RAISED SAND, TR MICA, SLIGHTLY LT GRAY [10YR 7/1] AND GRAVEL [?] (13.6-14.0)			
	14.0	CL	CLAY, MED STIFF FOR TOP 0.4', THEN VY STIFF, LIGNITE COMMON TO 17.3', GRAYISH BROWN [10YR 5/2] TO 14.4', THEN GRAY [10YR 5/1] (14.0-18.6)	4.6/5.0	S-5	
	19.0		BOH			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT: RI/FS EDGEWOOD | HOLE NO. WBR-27

Hole No. WBR-28

DRILLING LOG	DIVISION: CENAB-EN-GG	INSTALLATION: APG-EDGEWOOD	SHEET 1 OF 2 SHEETS

1. PROJECT: RI/FS EDGEWOOD	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station): CLUSTER 15	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: COE – MOBILE DIST.	12. MANUFACTURER'S DESIGNATION OF DRILL: CME 75
4. HOLE NO. (As shown on drawing title and file number): WBR-28	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER: J. BUTTS	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED: 9/30/94 — COMPLETED: 10/4/94
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING: 79.7 %
9. TOTAL DEPTH OF HOLE: 34'	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		OL	SILTY CLAY W/ FINE GR SAND, SUBROUNDED, TR. MICA, ROOTS ABUNDANT, VY DARK BROWN [10YR 2/2] (0.0-0.3)			3½" DRIVE SPOON
		CL	SANDY CLAY, SOFT-MED STIFF, SCATTERED ROOTS, SAND FINE-CRSE GR, RNDED, YELLOWISH BRN [10YR 5/6] W/ SCATTERED LT GRAY (10YR 7/1] SPOTS (0.3-3.7)	5.0/5.0	S-1	10/3/94 DTW – 2.9' FROM GROUND THRU 10' AUGERS IN 34' HOLE; 10/4/94 DTW – 4.22' FROM TOC @ 1325 (ON COMPLETION); 10/5/94 DTW – 4.03' FROM TOC @ 0750 (~24 HRS)
		SM	SILTY SAND, SAND PREDOM FINE GR, SUBRNDED, SCATTERED MED. GR, OCC. SUBRNDED-SUBANG GRAVEL UP TO 1.5" IN SIZE, SAT., BRNSH YELLOW [10YR 6/6] (3.7-4.4)			
		SC	CLAYEY SAND, SAND FINE GR, SUBRNDED, WELL SORTED, WET, LT GRAY [10YR 7/1] W/ SOME SAME BRNSH YELLOW (4.4-5.0)			
	5.0	CL	SANDY CLAY, SAND VY FINE GR, SUBRNDED, VY STIFF, COLOR BETWEEN LT GRAY [10YR 7/1] AND WHITE [10YR 8/1] (5.0-7.0)			∇ SAT. SAND ENCOUNTERED
		SM	SILTY SAND, SAND VY FINE GR, SUBRNDED, WELL SORTED, TR HVY MINS, SAT., CLAYEY IN SPOTS, A FEW THIN (<0.1') CLAY LENSES, SAME COLOR AS ABOVE W/ SOME VY PALE BRN [10YR 8/4] (7.0-9.4)	4.4/5.0	S-2	
	10.0	SM	SAME AS ABOVE, LIGNITE STREAKS FROM 11.1-11.4', VY STIFF SILTY CLAY FROM 11.5-11.8' (10.0-12.0)	2.0/2.0	S-3	
	12.0	SM	SAME AS ABOVE, SOME LIGNITE STREAKS, LT YELLOWISH BROWN [10YR 6/4], SAT. & RUNNY (12.0-13.8)	1.8/2.0	S-4	
	14.0	SM	SAME AS ABOVE BUT NO LIGNITE (14.0-15.0)	1.0/1.0	NO SAMPLE TAKEN	
	15.0	SP	SAND, FINE GR, RNDED-SUBRNDED, WELL SORTED, SAT., TR. HVY MINS, VY PALE BROWN [10YR 7/3], BECOMING YELLOW [10YR 7/6] AT 17.8' (15.0-18.7)	5.0/5.0	S-5	
		CL-ML	SILTY CLAY INTERBEDDED W/ SAME SAND AS ABOVE, TR. LIGNITE, SAND & CLAY INTERBEDS ARE 0.2-0.3' THICK, CLAY IS GRAY [10YR 5/1] AND LT GRAY [10YR 7/2], SAND AS ABOVE, CLAY IS STIFF (18.7-20.0)			
	20.0					

Remarks (field screening):

DEPTH	HNU (PPM) BKGRND	HNU (PPM) SAMPLE	RAD (MR/HR) BKGRND	RAD (MR/HR) SAMPLE
9' GRND	6.7	—	0.01	—
0-5'	6.2	6.5	0.01	0.01
5-10'	5.3	6.1	0.01	0.01
10-12'	4.5	6.1	0.01	0.01
12-14'	4.5	5.8	0.01	0.01
8' GRND	3.9	—	0.051	—
14-15'	3.8	4.3	0.01	0.01
15-20'	3.6	4.1	0.01	0.01
20-25'	3.6	4.9	0.01	0.01
25-30'	3.6	4.1	0.01	0.01
30-34'	2.6	5.3	0.01	0.01

10/3/94

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT [illegible] HOLE NO.

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE — Hole No. WBR-28

PROJECT: RI/FS EDGEWOOD — INSTALLATION: APG-EDGEWOOD — SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0	CL-ML	SILTY CLAY, STIFF - V STIFF, DRY-MOIST, DARK GRAY (10YR4/1), VERY THIN SILTY SAND LENSES SCATTERED THRUOUT, SAT. (20.0-21.2')	1.2/5.0	S-6	
	25.0	CL-ML	SAME AS ABOVE, SILTY SAND LENSES UP TO 1" THICK, SAND IS VY FINE GR, ROUND-SUBROUND, SAME DK GRAY (25.0-26.2)			
		SM	SILTY SAND W/ NUMEROUS SILTY CLAY LENSES UP TO 1" THICK, THESE ARE SAME SOILS AS ABOVE, BUT REVERSED ABUNDANCE, SAME DK GRAY (26.2-27.7)	2.7/5.0	S-7	
	30.0	CL-ML	SAME SILTY CLAY W/ SILTY SAND INTERBEDS AS AT TOP OF PREVIOUS SPOON, TR. LIGNITE (30.0-34.0)	4.0/4.0	S-8	DEFINITELY A COMPOSITE SAMPLE; ALTHOUGH ATTEMPTED TO EXCLUDE SANDY LENSES
	34.0		BOH			

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1960 OF-628-603 — PROJECT: RI/FS EDGEWOOD — HOLE NO. WBR-28

Hole No. WBR-31

DRILLING LOG

Field	Entry
DIVISION	CENAB-EN-GG
INSTALLATION	EDGEWOOD
SHEET	1 OF 2 SHEETS
1. PROJECT	RI/FS EDGEWOOD
2. LOCATION (Coordinates or Station)	CLUSTER 15
3. DRILLING AGENCY	COE-MOBILE DISTRICT
4. HOLE NO. (As shown on drawing title and file number)	WBR-31
5. NAME OF DRILLER	J. BUTTS
6. DIRECTION OF HOLE	☑ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	30'
10. SIZE AND TYPE OF BIT	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	CME 75
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED: — UNDISTURBED: —
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED 9/26/94 COMPLETED 9/27/94
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	82.3 %
19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		OL	SILTY CLAY W/ FINE GR SUBANG. SAND, SOFT, ROOTS, BROWN [10YR 4/3] (0.0-0.4)			3½" DRIVE SPOON 3¾" HSA
		ML	SANDY SILT, SAND FINE GR, SUBANG-SUBRNDED, WELL SORTED, BUT OCC. CRSE GR SAND, MOIST-WET, BECOMING SAT AT 3.1', TR. MICA + HVY MINS, LT YELLOWISH BROWN [10YR 6/4] W/ SOME YELLOWISH BROWN AREAS [10YR 5/8], LT GRAY [10YR 7/2] OVER BOTTOM 0.1', CLAYEY IN SPOTS (0.4-3.4)	3.9/5.0	S-1	9/26/94 [illegible] 4.17' [illegible] 5' [illegible] [illegible] 5.72' [illegible] (ON COMPLETION) — H_2O ENCOUNTERED
	5.0	ML-CL	SAME AS ABOVE, BUT CLAYEY (5.0-6.3)			
		CL	CLAY, MED STIFF-SOFT, LT GRAY [10YR 7/2] (6.3-7.5)	3.9/5.0	S-2	∇ SAT. SANDS ENCOUNTERED
		SM	SILTY SAND, SAND FINE GR, SUBRNDED, MOD. WELL SORTED, TR HVY MINS, SAT., VY PALE BROWN [10YR 7/3] (7.5-9.9)			
	10.0	SM	SAME AS ABOVE, BUT SOME AREAS REL. FREE OF SILT (10.0-11.9)			
		CL	SANDY CLAY, SAND PREDOM. FINE-MED GR, SOME CRSE GR, SUBRNDED, VY STIFF, WET-SAT., SAND IS VY ABUNDANT, LT GRAY [10YR 7/1] TO 12.9' THEN PINKISH GRAY [7.5YR 7/2], OCC ¼" RNDED GRAVEL (11.9-13.8)	4.9/5.0	S-3	
		CL-ML	SILTY CLAY, VY STIFF, TR MICA, WET, GRAY [10YR 6/1 AND 5/1] (13.8-14.9)			
	15.0	CL-ML	SAME AS ABOVE (15.0-15.8)			
		ML	SANDY SILT, SAND VY FINE GR, SUBRNDED-RNDED, WELL SORTED, W/ SOME CLAY, SAT., GRAY [10YR 5/1] (15.8-16.5)			
		CL-ML	SILTY CLAY, VY STIFF, TR MICA, SCATTERED LIGNITE, GRAY [10YR 5/1] AND DARK GRAY [10YR 4/1] (16.5-18.5)	3.8/5.0	S-4	
		SM	SILTY SAND, SAND FINE GR, RNDED-SUBRNDED, WELL SORTED, SAT., SOME LIGNITE, GRAY [10YR 5/1] (18.5-18.9)			
	20.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT RI/FS EDGEWOOD | HOLE NO. WBR-31

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | Hole No. WBR-31

PROJECT: RI/FS GAGGWOOD | INSTALLATION: GAGGWOOD | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0	SM	SAME AS ABOVE (20.0–20.8)			
		ML	SANDY SILT ALTERNATING W/ SANDY SILTY CLAY, SAND FINE GR, ROUNDED-SUBROUNDED, WELL SORTED, SILTY CLAY IS MED. STIFF, SANDY AREAS ARE SAT., GRAY (10YR 6/1) (20.8–23.1)	3.8/5.0	S-5	
		CL	CLAY, VY STIFF, GRAY (10YR 5/1) (23.1–23.8)			
	25.0	SM	SILTY SAND, SAND FINE GR, ROUNDED-SUBROUNDED, WELL SORTED, SAT. LT BROWNISH GRAY (10YR 6/2) (25.0–25.4)			
		CL	CLAY, VY STIFF, LT GRAY [10YR 7/1] TO 26.4', THEN LT OLIVE BROWN [2.5Y 5/3], SANDY CLAY OVER TOP 0.4' (25.4–29.4)	4.4/5.0	S-6	
	30.0		BOH			

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1980 OF - 628-603 | PROJECT: RI/FS GAGGWOOD | HOLE NO. WBR-31

Hole No. WBR-45

DRILLING LOG	DIVISION CENAB-EN-GG	INSTALLATION EDGEWOOD	SHEET 1 OF 2 SHEETS
1. PROJECT RI/FS EDGEWOOD		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station) CLUSTER 15		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY COE-MOBILE DIST.		12. MANUFACTURER'S DESIGNATION OF DRILL CME 75	
4. HOLE NO. (As shown on drawing title and file number) WBR-45		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER J. BUTTS		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 9/19/94 COMPLETED 9/21/94
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING	70.8 %
9. TOTAL DEPTH OF HOLE 37'		19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		OL	SANDY SILTY TOPSOIL, SAND FINE GR, ANGED-SUBANG, ABUN. ROOTS, BROWN [10YR5/3] (0.0-0.6)			3½" DRIVE SPOON 3¾" HSA
		ML	SANDY SILT, SAND FINE GR, SUBANGED-ANGED, OCC. ROOTS, BRNISH YELLOW [10YR6/6] (0.6-1.4)			9/19/94 DTW-13' THRU AUGERS IN 37' OPEN HOLE
		CL	CLAY, MED. STIFF-SOFT, SOME AREAS SANDY W/ FINE GR ANGED SAND, OTHERS SILTY, WET, BROWN [10YR5/3] BECOMING LT OLIVE BROWN [2.5Y5/3] AT 2', HEAVILY OXIDIZED FRAG'S FROM 1.4-1.8' EMBEDDED IN CLAY (1.4-3.1)	3.1/5.0	S-1	9/20/94 DTW-6.3' THRU AUGERS IN 37' HOLE 9/21/94 DTW 7.72' FROM TOC @ 0955 (ON COMPLETION) 9/22/94 DTW-7.59' FROM TOC @ 0810 (~24 HRS)
	5.0	CL	SAME CLAY, BUT LIGNITE SCATTERED THRUOUT, SOFT-V.SOFT, SAT., GRAYISH BROWN [2.5Y5/2] FINE GR ANGED SAND SCATTERED THRUOUT (5.0-8.5)	3.7/5.0	S-2	
	10.0	CL	SAME AS ABOVE * (10.0-11.3)			* MUCH OF THIS IS PROBABLY FALL IN
		CL	CLAY, MED STIFF LT GRAY [10YR7/1] W/ SOME BRNISH YELLOW [10YR6/6] STREAKS, SCATTERED LIGNITE (11.3-13.4)	5.0/5.0	S-3	
		CL	CLAY, MED STIFF, SOME FINE GR ANGED SAND, LT GRAY [10YR7/1] AND STRONG BROWN [7.5YR5/6] (13.4-15.0)			
	15.0	CL	SAME AS ABOVE, W/ ANGED GRAVEL UP TO 2.5" EMBEDDED (15.0-16.4)			
		CL	CLAY, MED. STIFF, SCATTERED FINE GR ANGED SAND, LT GRAY [10YR5/1] W/ YELLOWISH BROWN [10YR5/8] SPOTS (16.4-17.4)	2.4/5.0	S-4	
	20.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT RI/FS EDGEWOOD | HOLE NO. WBR-45

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | **Hole No.** WBR-45

PROJECT: RI/FS EDGEWOOD | INSTALLATION: EDGEWOOD | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0	SP	SAND, FINE-MED GR, REL. POORLY SORTED, SUBRNDED–SUBANG, TR. HVY MINS, SAT., VY PALE BROWN [10YR 7/4] (20.0-23.0)	4.7/5.0	S-5	SAT SANDS ENCOUNTERED
		CL-ML	SANDY SILTY CLAY, VY STIFF, SAND VY FINE GR, SUBRNDED, SAND OCCURS W/IN CLAY AND ALSO AS DISCRETE, THIN LENSES, MM'S THICK, RARE LIGNITE, DK GRAY [10YR 4/1] (23.0-24.7)			
	25.0	CL-ML	SAME AS ABOVE (25.0-26.6)		S-6	H_2O - 12' UP DRILL ROD IN 30' HOLE
		SM	SILTY SAND, SAND VY FINE GR, SUBRNDED, WELL SORTED, TR. HVY MINS, SAT, GRAY [10YR 6/1] THIN [0.05'] SILTY CLAY LENSES ROUGHLY HALFWAY AND AT BASE (26.6-28.1)	3.1/5.0	S-7	
	30.0	SM	SAME AS ABOVE, ABUNDANT LIGNITE FROM 31.2-31.5' (30.0-31.8')		S-8	
		CL	CLAY, VY STIFF, MULTICOLORED: LT GRAY [10YR 7/1], BRNISH YELLOW [10YR 6/6] W/ DK RED [10R 3/6] STREAKS (31.8-33.3)	3.3/5.0		
	35.0	CL	SAME AS ABOVE, STIFF (35.0-36.1)	1.1/2.0	S-9	
	37.0		BOH			

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1980 OF-628-603 | PROJECT: RI/FS EDGEWOOD | HOLE NO. WBR-45

Hole No. WBR-47

DRILLING LOG	DIVISION CENAB-EN-GG	INSTALLATION EDGEWOOD	SHEET 1 OF 2 SHEETS

1. PROJECT RI/FS EDGEWOOD	10. SIZE AND TYPE OF BIT 3 1/4" 4 5/8" CUTTERHEAD
2. LOCATION (Coordinates or Station) CLUSTER 15	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY COE-MOBILE DIST.	12. MANUFACTURER'S DESIGNATION OF DRILL CME 75
4. HOLE NO. (As shown on drawing title and file number) WBR-47	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 8 — UNDISTURBED
5. NAME OF DRILLER J. BUTTS	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 9/9/94 — COMPLETED 9/9/94
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING 86.0%
9. TOTAL DEPTH OF HOLE 35'	19. SIGNATURE OF INSPECTOR

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
		OL	SILTY TOPSOIL, ABUN. ROOTS, SOME FINE GR SAND (0.0-0.3)			
		CL-ML	SILTY CLAY, VY STIFF, FRIABLE, SCATTERED ROOTS NEAR TOP, VY PALE BROWN [10YR 7/3] TO 1.2', THEN BROWN [10YR 5/3] WITH YELLOWISH RED [5YR 4/6] MOTTLING (0.3-4.2)	4.2/5.0	S-1	9/9/94 DTW-14.3' THRU AUGERS IN 25' HOLE -11.89' FROM TOC @ 1320 (ON COMPLETION) 9/12/94 DTW-11.51' FROM TOC @ 0810 (>24 HRS)
	5.0	CL-ML	SILTY CLAY, VERY SOFT, SAT., SOME FINE GR ROUNDED SAND, TR MICA, 2 FRAGMENTS OF GRAVEL (FROM RAILROAD BED ?), GRAVEL IS FOLIATED METAMORPHIC ROCK, SAME BROWN & YELLOWISH RED AS ABOVE (5.0-7.8)	2.8/5.0	S-2	H2O ENCOUNTERED
	10.0	CL-ML	SAME AS ABOVE (10.0-10.9)			
		ML-CL	CLAYEY SILT, SOFT, SAT, WITH SOME FINE GR SUBROUNDED SAND, HVY MINS COMMON, PALE BROWN [10YR 6/3] w/ SAME YEL RED MOTTLING AS ABOVE (10.9-12.7)	4.1/5.0	S-3	
		CL	CLAY, VERY SOFT, LT GRAY [10YR 7/1] (12.7-14.1)			
	15.0	CL	SAME CLAY (15.0-17.0)		S-4	
		SM	SILTY SAND, SAND FINE GR., WELL SORTED, ROUNDED-SUBROUNDED, HVY MINS COMMON, SAT., VY PALE BROWN [10YR 7/3] FOR TOP 0.4', THEN LT GRAY [10YR 7/2] (17.0-19.8)	4.8/5.0	S-5	SAT. SANDS ENCOUNTERED
	20.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT RI/FS EDGEWOOD HOLE NO. WBR-47

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | **Hole No.** WBR-47

PROJECT RI/FS EDGEWOOD | INSTALLATION | SHEET 2 OF SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0	SM	SAME SILTY SAND, ALTHOUGH SOME AREAS REL. SILT FREE, VY PALE BROWN [10YR7/4], LT YELLOWISH BROWN [10YR6/4] AND BRNISH YELLOW [10YR6/8], 1CM LT GRAY MED STIFF CLAY LENSE AT 22.2', 0.1' LT GRAY SANDY CLAY LENSE AT 23.7' (20.0-24.3)	4.3/5.0	S-6	
	25.0	SP	SAND, FINE GR, WELL SORTED, ANGULAR-SUBROUNDED, VY PALE BROWN [10YR7/3] (25.0-26.7)			
		CL	SANDY CLAY, MED STIFF, SAND FINE GR, SUBRNDED, BRNISH YELLOW FOR TOP HALF, THEN WHITE [10YR8/1] (26.7-27.6)	4.9/5.0	S-7	
		SP	SAME SAND AS AT TOP OF SPOON, VY PALE BROWN [10YR7/3] YELLOWISH BROWN [10YR5/6] AND LT GRAY [10YR7/2] (27.6-29.9)			
	30.0	SP	SAME SAND BRNISH YELLOW [10YR6/6] (30.0-32.2)	5.0/5.0		9/15/94
		CL	CLAY, MED STIFF, GRAYISH BROWN [10YR5/2] W/ A FEW GRAY [10YR6/1] LAYERS, HIGH PLASTICITY, MAY BE CH? (32.2-35.0)		S-8	
	35.0		BOH			

Hole No. WBR-48

DRILLING LOG	DIVISION CENAB-EN-GG	INSTALLATION APG- EDGEWOOD	SHEET 1 OF 4 SHEETS
1. PROJECT RI/FS EDGEWOOD		10. SIZE AND TYPE OF BIT 9 3/4" HAWTHORNE	
2. LOCATION (Coordinates or Station) CLUSTER 15		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY COE- MOBILE DIST.		12. MANUFACTURER'S DESIGNATION OF DRILL CME 75/FAILING 1500/FAILING 314	
4. HOLE NO. (As shown on drawing title and file number) WBR-48		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER J. BOTTS/C.MOON/CARPENTER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
7. THICKNESS OF OVERBURDEN		16. DATE HOLE STARTED 11/2/94 COMPLETED 12/23/94	
8. DEPTH DRILLED INTO ROCK		17. ELEVATION TOP OF HOLE	
9. TOTAL DEPTH OF HOLE		18. TOTAL CORE RECOVERY FOR BORING %	
		19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		CL	CLAYEY TOPSOIL W/ SCATTERED MED. GR SUBANGULAR SAND, MED STIFF, ROOTS COMMON, BRN [10YR5/3] (0.0-0.5)			3 1/2" DRIVE SPOON
		CL	CLAY W/ SOME SILT AND FINE GR SUBROUNDED SAND, VERY STIFF, OCC. ROOTS, BRNSH YELLOW [10YR6/8], YELLOWISH BROWN [10YR5/4], W/ LT BRNISH GRAY [10YR6/2] APPEARING TOWARD BOTTOM (0.5-4.5)	4.5/5.0	S-1	11/3/94 DTW - 10.85' FROM GROUND THRU 37.5' AUGERS; 12/22/94 DTW - 13.47' FROM TOC W/ 3.5' STICKUP - 13.61' FROM TOC W/ 3.5' STICKUP @ 1440; 12/23/94 DTW - 12.45' FROM TOC @ 0905 (ON COMPLETION) 2' STICKUP
	5.0	CL	SAME CLAY AS ABOVE, BUT FINE GR SAND MORE COMMON IN SPOTS, MOIST, COLOR MEASURED LT GRAY [10YR7/2] AND LT BRNISH GRAY [10YR6/2] W/ REDDISH YELLOW [7.5YR6/8] MOTTLING & STREAKS, BECOMES PALE BROWN [10YR6/3] AT 9.4' (5.0-9.8)	4.9/5.0	S-2	
	10.0	CL	CLAY, SOFT-VY SOFT, WET-SAT. IN SPOTS, MED SIZE FINE GR SUBANG SAND LENSES AT 10.5 & 10.8', SAND IS SAT. GRAYISH BROWN [10YR5/2] AND LT GRAY [10YR7/2], SAND LENSES ARE YELLOWISH RED [5YR5/8] (10.0-11.8)	1.8/2.5	S-3	3 1/2" ID WIRE LINE SAMPLER - H_2O ENCOUNTERED
	12.0	CL	SAME CLAY AS ABOVE (12.5-14.1)			
		SM	SILTY SAND, SAND FINE-MED GR, REL. POORLY SORTED, SUBRNDED, SAT., PALE BROWN [10YR6/3] (14.1-14.6)	2.1/5.0	S-4	- SAT. SAND ENCOUNTERED RUNNING SAND
Δ SCALE	17.0	SP	SAND, FINE GR, WELL SORTED, SUBRNDED, SAT., TR. HVY MINS., RUNNY, YELLOW [10YR7/6] (17.5-19.2)	1.7/5.0	S-5	
	22.5					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT RI/FS EDGEWOOD | HOLE NO. WBR-48

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE

Hole No. WBR-48

PROJECT RI/FS EDGEWOOD | INSTALLATION APG- EDGEWOOD | SHEET 2 OF 4 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV-ERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
~~Δ SCALE~~ ↓	~~22.5~~	SP	SAND, VY FINE-FINE GR, WELL SORTED, SUBRNDED, TR. HVY MINS, SAT., RUNNY, VY PALE BROWN [10YR8/3] W/ SPOTS OF YELLOWISH BROWN [10YR5/8] (22.5-24.9)	2.4/5.0	S-6	
Δ SCALE ↓	27.5	SM	SILTY SAND, SAND FINE GR, SUBRNDED, WELL SORTED, TR. HVY MINS, SAT., PALE BROWN [10YR6/3] (27.5-29.6)		S-7	
		CL CL-ML ML	INTERBEDDED CLAY, SILTY CLAY AND SANDY SILT, CLAY IS VY STIFF, SILTY CLAY IS STIFF, SAND IS VY FINE GR, RNDED-SUBRNDED, SILT LAYERS ARE SAT., GRAY [10YR5/1], INDIVIDUAL LAYERS ARE ROUGHLY 0.2-0.4' THICK (29.6-32.4)	4.9/5.0		
	32.5	CL CL-ML ML	SAME AS ABOVE (32.5-34.4)			
		SP	SAND, FINE GR, WELL SORTED, RNDED-SUBRNDED, TR. HVY MINS, SAT., RUNNY, A FEW 0.1' VY STIFF CLAY LENSES THRUOUT, LT GRAY [10YR7/2], TWO PYRITE CEMENTED SAND NODULES, ∠0.5" IN MAX DIMENSION (34.4-35.9)	3.4/5.0	S-8	
Δ SCALE ↓	37.5	SP	SAME SAND AS ABOVE, NO CLAY LENSES, SAT, RUNNY, 1-0.5" NODULE OF PYRITE CEMENTED SAND (37.5-39.6)	2.1/2.5	S-9	
	40.0	SP	SAME SAND, LIGNITE COMMON AT 41.5', 1-2" PIECE OF PYRITE CEMENTED SAND (40.0-42.4)	2.4/2.5	S-10	11/3/94
	42.5	SP	SAME SAND, LIGNITE COMMON AT BASE (42.5-44.1)	1.6/2.5	S-11	
	45.0	SM	SILTY SAND, SAND FINE-MED GR, POORLY SORTED, SUBRNDED, SAT, RUNNY, LIGNITE ABUNDANT AT TOP & SCATTERED THRUOUT ELSEWHERE, GRAY [10YR5/1], OCC 0.5" STIFF CLAY LENSES (45.0-47.5)	2.5/2.5	S-12	
Δ SCALE ↓	47.5	CL & SM	INTERBEDDED SANDY CLAY AND SILTY SAND, LIGNITE ABUNDANT THRUOUT, CLAY SOFT-MED STIFF, SILTY SAND AS ABOVE (47.5-48.9)			
		CL	CLAY, VY STIFF, MULTICOLORED IN SWIRLS: LT GRAY [10YR7/1], DK RED [7.5R3/6] AND LT OLIVE BROWN [2.5Y 5/3], K CLAY? (48.9-50.9)	3.4/5.0	S-13	
Δ SCALE	52.5	CL	SAME CLAY AS ABOVE, BUT VERY LITTLE LT GRAY (52.5-55.5)	3.0/3.0	S-14	
	55.5					

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1980 OF - 628-603

PROJECT RI/FS EDGEWOOD | HOLE NO. WBR-48

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | **Hole No.** WBR-48

PROJECT RI/FS EDGEWOOD | INSTALLATION APG-EDGEWOOD | SHEET 3 OF 4 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
Δ SCALE	55.5	CL	CLAY, STIFF-VY STIFF, TR MICA, REDDISH BROWN [2.5YR5/4]; PINKISH WHITE [5YR8/2], WHITE [5YR8/1], AND RED [7.5R4/6] (55.5-56.9)	1.4/0.5	NO SAMPLE	11/19/94 GEO BARREL
Δ SCALE	56.0	CL	CLAY, VY STIFF, SWIRLY WEAK RED [7.5R4/4] AND DK GRAYISH BROWN [2.5Y 4/2] (56.0-57.5)	1.5/3.0	S-15	
Δ SCALE	59.0	CL	SAME AS ABOVE, W/ A 0.1' POCKET OF SANDY SILTY CLAY, SAND IS FINE GR, SUBROUNDED, WHITE [5YR8/1] (59.0-59.8)	0.8/5.0	S-16	THIS RUN PICKED UP PART OF PREVIOUS RUN
Δ SCALE	64.0	CL	SAME CLAY AS ABOVE, W/ SILTY CLAY LENSES AT 64.3-64.6 AND 65.7-66.0, SAME WHITE AS ABOVE, CLAY IS STREAKY LT YEL. BROWN [2.5Y6/4] W/ POCKETS OF RED [10R5/6], SAND DK YEL BROWN [10YR3/4] (62.9-66.0)	3.1/2.0	S-17	
	66.0	CL	SAME CLAY, REDDISH BROWN [2.5YR4/4], BROWN [7.5YR5/4] AND WHITE [5YR8/1] (66.0-67.8)	1.8/2.0	S-18	
Δ SCALE	68.0	CL	SAME CLAY, DK REDDISH BROWN [2.5YR 3/4] W/ SOME LT OLIVE BROWN [2.5Y 5/6] (68.0-72.2)	4.2/5.0	S-19	
	73.0	CL	SAME AS ABOVE (73.0-77.9)	4.9/5.0	S-20	
	78.0	CL-ML	SILTY CLAY, HARD-VY STIFF, ABUNDANT MM-THIN VEINS W/ WHITE CRYSTALLINE INFILLING, DK REDDISH BROWN [2.5YR3/4] W/ LT YELLOWISH BROWN SWIRLS [2.5Y6/4] (78.0-81.1)	3.1/3.5	S-21	11/29/94
	83.0	CL-ML	SAME AS ABOVE, OCC. VUGS W/ ZEOLITE(?) INFILLING, VEINS LESS COMMON (81.5-86.0)	4.5/4.5	S-22	
	88.0	CL-ML	SAME AS ABOVE, VEINS ABUNDANT, PARTICULARLY IN MIDDLE THIRD (86.0-91.3)	5.3/5.0	S-23	
Δ SCALE	91.0	CL-ML	SAME SILTY CLAY, INTERBEDDED W/ SANDY SILT, SAND VY FINE GR, SUBROUNDED, WELL SORTED, TR HVY MINS + MICA, WET, LT GRAY [10YR7/1.5] 91.0-92.4	4.8/5.0	S-24	
	92.4	ML	92.4-92.6			
			92.6-92.9			
		ML	92.9-93.1			
			93.1-93.5			
	93.4	ML	93.5-93.8			
			93.8-94.2			
	94.4	ML	94.2-94.6			
			94.6-95.0			
		ML	95.0-95.7			
			95.7-95.8			
	96.0	CL	CLAY, VY STIFF ~~HARD~~, RED [2.5YR4/6]	3.2/5.0	S-25	
		ML	SANDY SILT, AS IN PREVIOUS SAMPLE			
		CL				
		ML				
Δ SCALE	101.0	CL	CLAY, VY STIFF, TR MICA, BROWN [7.5YR4/3], W/ SANDY-CLAYEY SILT INTERBEDS FROM 0.7-1.4', SIMILAR TO ML ABOVE BUT CLAYEY, CLAY HAS SEVERAL MM THICK SILT LENSES, SAME LT GRAY AS PREVIOUS (101.0-102.5)	1.5/5.0	S-26	
	106.0					

HNU (PPM)

DEPTH	B'GRND	SAMPLE	RAD (mR/hr)
B'GRND	1.9	—	
55.5-56	1.9	1.9	
56-59	2.1	2.1	
59-64	2.1	2.1	
64-66	2.5	2.5	
66-68	2.9	2.9	
68-73	2.9	2.9	
73-78	2.7	2.7	
B'GRND	1.7	—	0.02
81.5-86'	2.2	2.2	0.015
86-91	2.5	2.5	—
91-96	2.4	2.4	—
96-101	2.4	2.4	—
101-106	2.2	2.2	
106-108.5	2.1	2.1	

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1980 OF-628-603 | PROJECT RI/FS EDGEWOOD | HOLE NO. WBR-48

RILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | Hole No. WBR-48

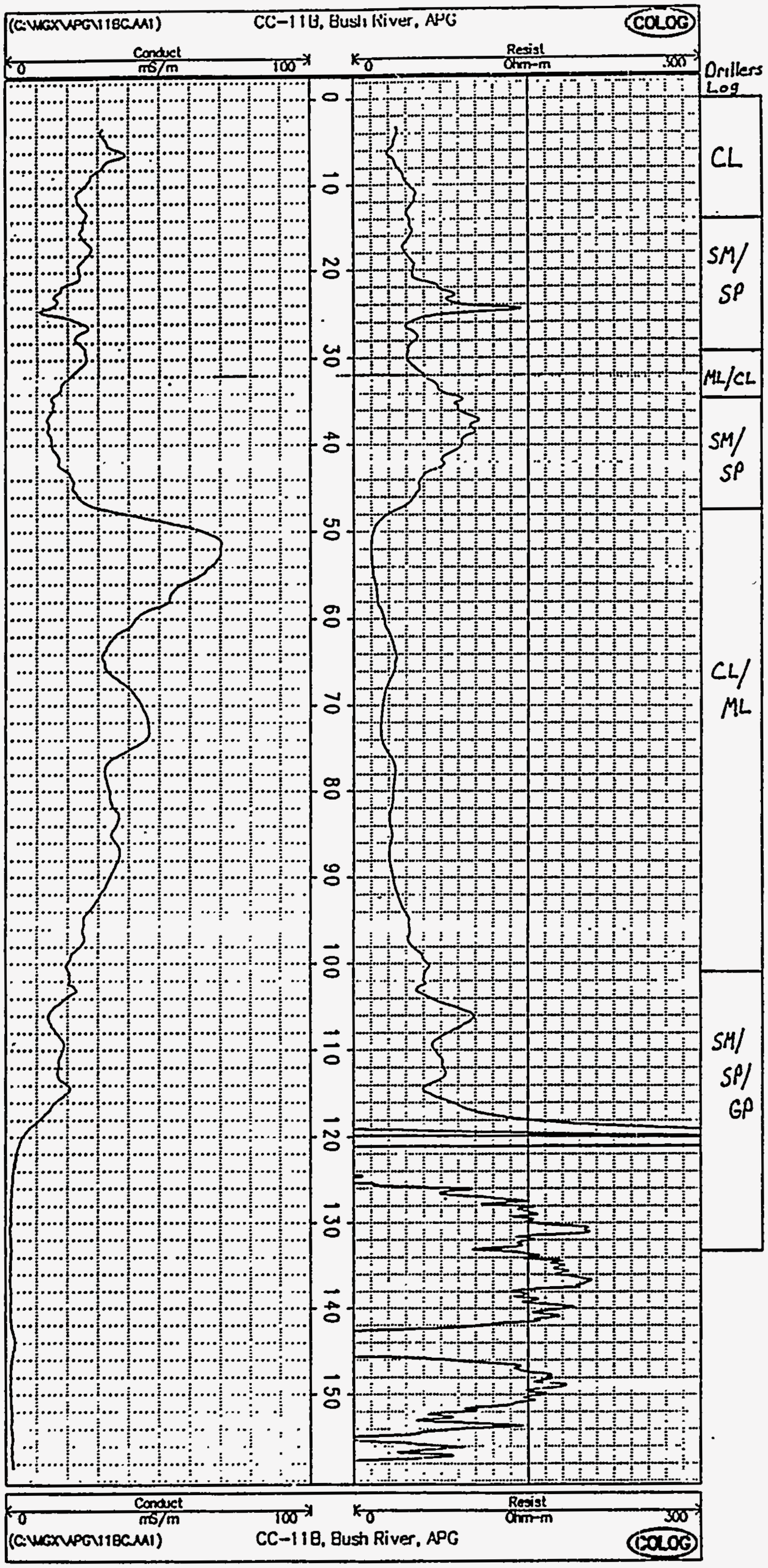
OJECT: RI/FS EDGEWOOD | INSTALLATION: APG-EDGEWOOD | SHEET 4 OF 4 SHEETS

LEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
5 SCALE	106.0	ML	SANDY SILT, SAND FINE-VY FINE GR, SUBRNDED, WELL SORTED, TR. MICA, LIGNITE STREAKS COMMON, WET, LT GRAY [10YR7/1] (106.0-108.3)	0.3/2.2	NO SAMPLE	
	108.0			NO RECOVERY	NO SAMPLE	ERROR MADE IN MEASUREMENT ON 11/29/94
	110.0	CL-ML	CLAY, VY SOFT, YELLOWISH RED [5YR5/6] FOR TOP 0.1'; SANDY SILTY CLAY, SOFT, SAND FINE GR, MICA ABUNDANT, GRAY [10YR6/1], WET, MIDDLE 0.05'; LIGNITE, BOTTOM 0.05' (109.7-109.4)	0.2/4.4	NO SAMPLE	12/10/94 STARTING @ 109.7' FAILING 314
	112.0					
	114.0		(114.1-116.1)	0.0/2.0	NO RECOVERY	Δ TO LONGER SHOE
	116.0	CL-ML	SAME SANDY SILTY CLAY W/ ABUNDANT LIGNITE (116.1-116.4)	0.3/0.3	NO SAMPLE	Δ TO SHORTER SHOE; LONG SHOE NOT CUTTING
			(116.4-118.5)	0.0/2.1	NO RECOVERY	
	118.0	CL-ML ML	SAME SANDY SILTY CLAY W/ ABUNDANT LIGNITE OVER TOP 0.3' THEN SANDY SILT W/ CLAY, SAND VY FINE GR, RNDED, SAT., LT GRAY [10YR7/2] AND LT OLIVE BROWN [2.5Y5/6] (118.5-123.0)	0.5/5.0	NO SAMPLE	BELIEVE IN GRAVEL @ ~119'
	120.0					
	122.0					
	123.0					
Δ SCALE	123.5	SP	GRAVELLY SAND, SAND FINE-MED GR, WELL ROUNDED TO ANGULAR, MOD. WELL SORTED, GRAVEL UP TO 1" IN SIZE, SUBRNDED, SAT., TR. HVY MINS & MICA; 0.05' SILTY CLAY LENSE, MED. STIFF, SAME LT GRAY AS ABOVE. COLOR OF SAND IS INDETERMINATE BECAUSE OF DRILLING MUD (123.5-123.7)	0.2/5.0	NO SAMPLE	
	128.5	SP	SAME GRAVELLY SAND AS ABOVE, RUNNY (128.5-129.5)	1.0/5.0	S-27	
	133.5		BOH			

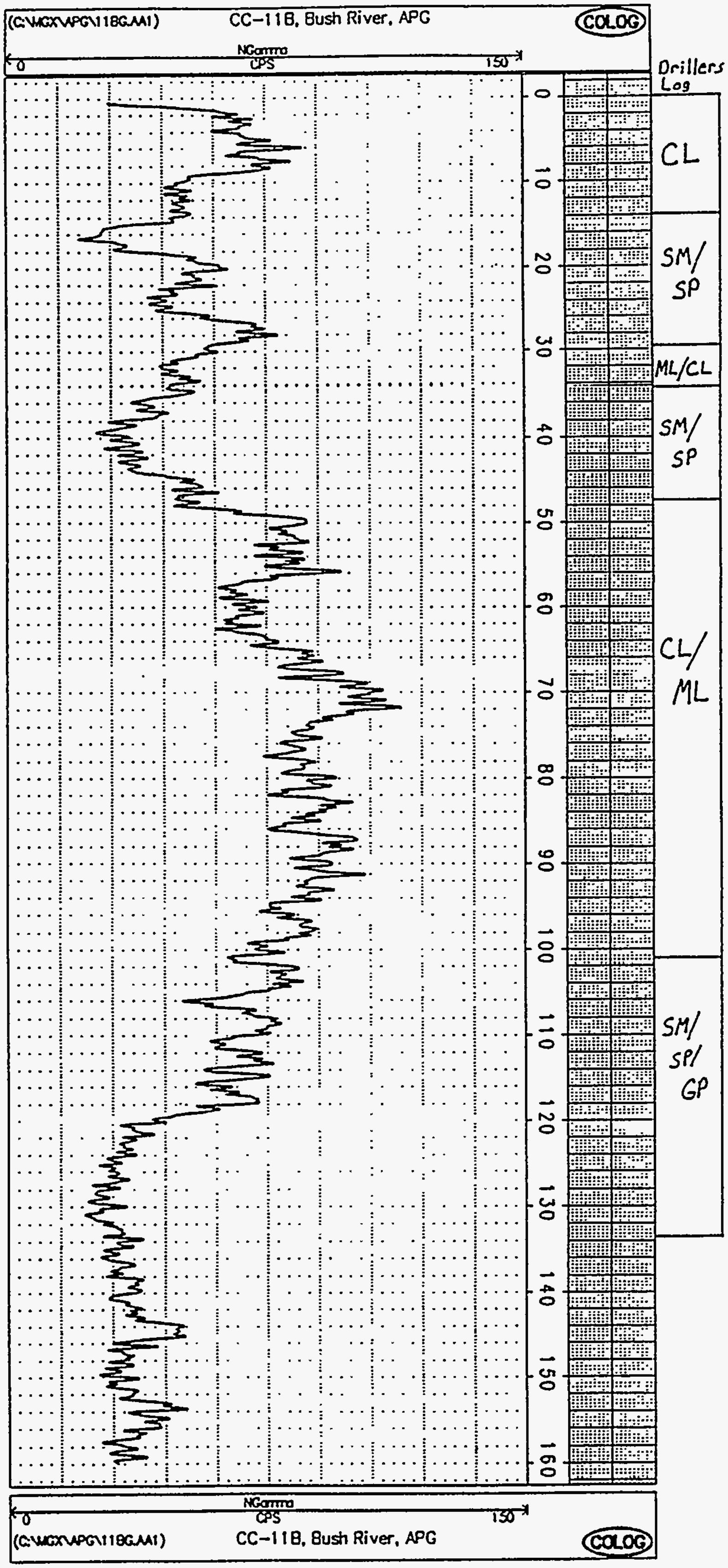
ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1980 OF-628-603 | PROJECT: RI/FS EDGEWOOD | HOLE NO. WBR-48

Appendix B:

Gamma and Induction Logs



(C:\MGX\APG\11BC.AA1)
CC-11B, Bush River, APG
COLOG
Conduct
mS/m
0
100
Resist
Ohm-m
0
300
Drillers Log
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
CL
SM/SP
ML/CL
SM/SP
CL/ML
SM/SP/GP
Conduct
mS/m
0
100
Resist
Ohm-m
0
300
(C:\MGX\APG\11BC.AA1)
CC-11B, Bush River, APG
COLOG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CC-11B, Bush River, APG
COLOG
NGamma
CPS
0
150
Drillers Log
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
CL
SM/ SP
ML/CL
SM/ SP
CL/ ML
SM/ SP/ GP
NGamma
CPS
0
150
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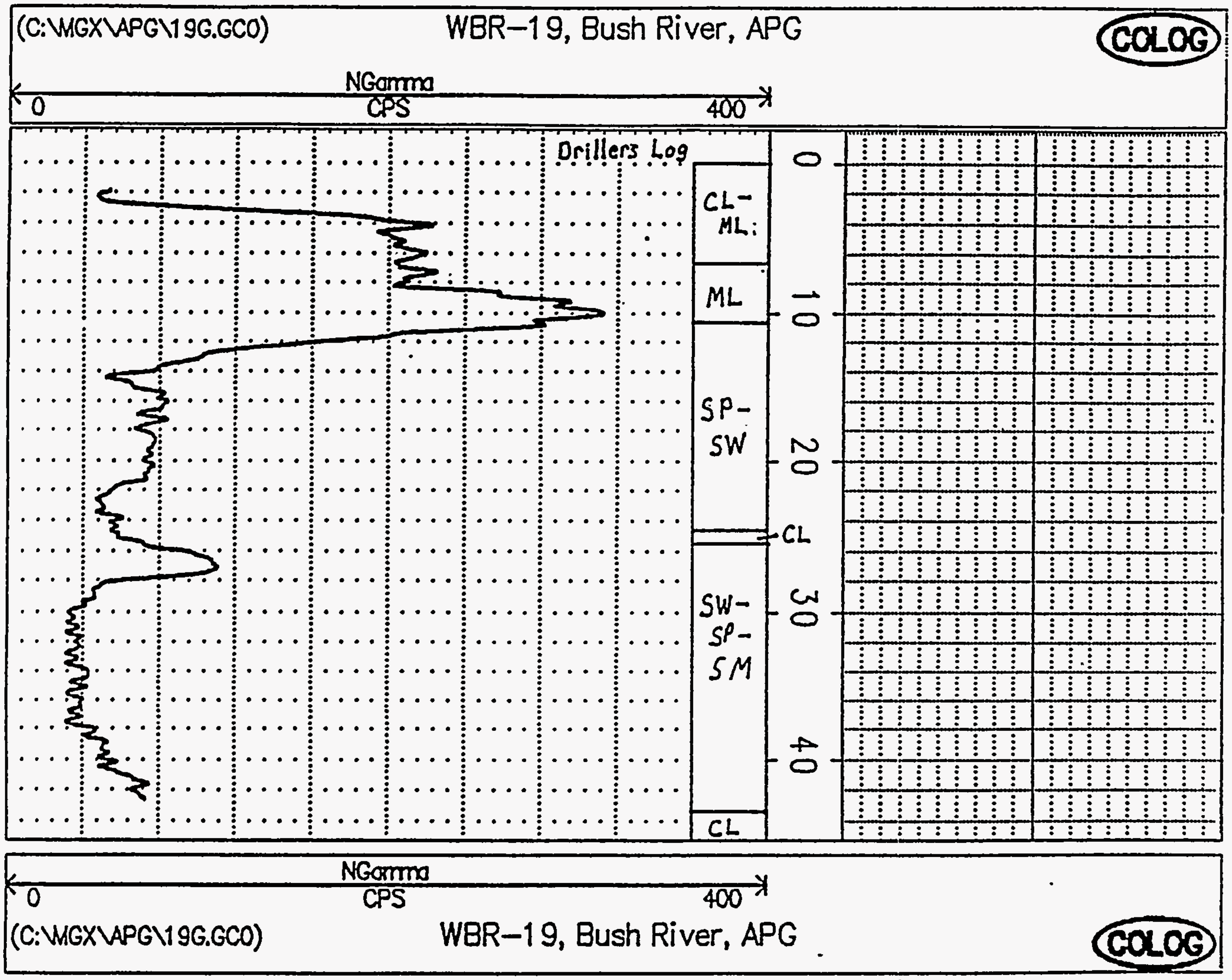
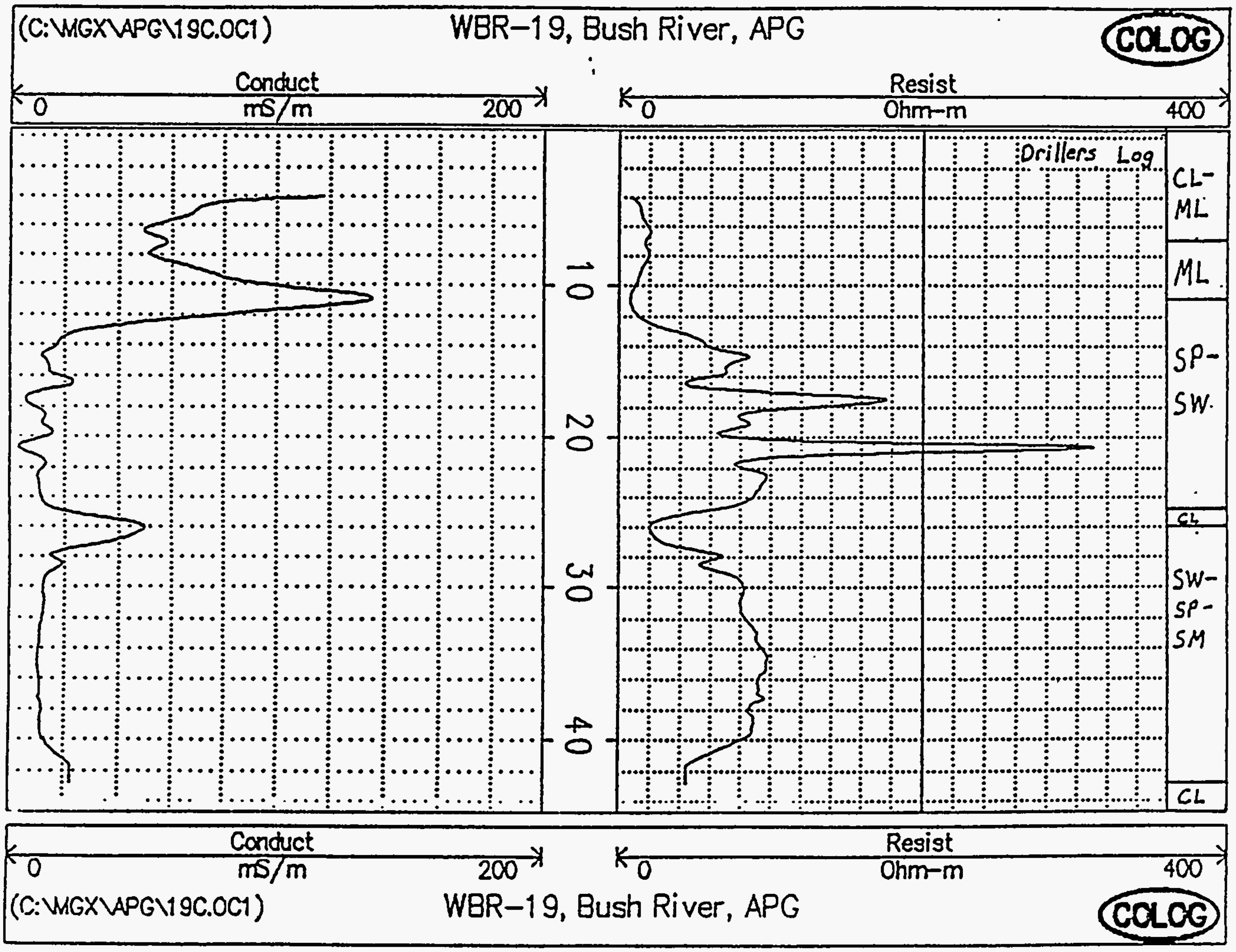
CC-11B, Bush River, APG
COLOG


(C:\MGX\APG\19G.GCO)
WBR-19, Bush River, APG
COLOG
NGamma
CPS
0
400
Drillers Log
CL-
ML.
ML
SP-
SW
CL
SW-
SP-
SM
CL
0
10
20
30
40
NGamma
CPS
0
400
(C:\MGX\APG\19G.GCO)
WBR-19, Bush River, APG
COLOG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WBR-19, Bush River, APG
COLOG
Conduct
0
mS/m
200
Resist
0
Ohm-m
400
Drillers Log
CL-
ML
ML
SP-
SW
CL
SW-
SP-
SM
CL
10
20
30
40
Conduct
0
mS/m
200
Resist
0
Ohm-m
400
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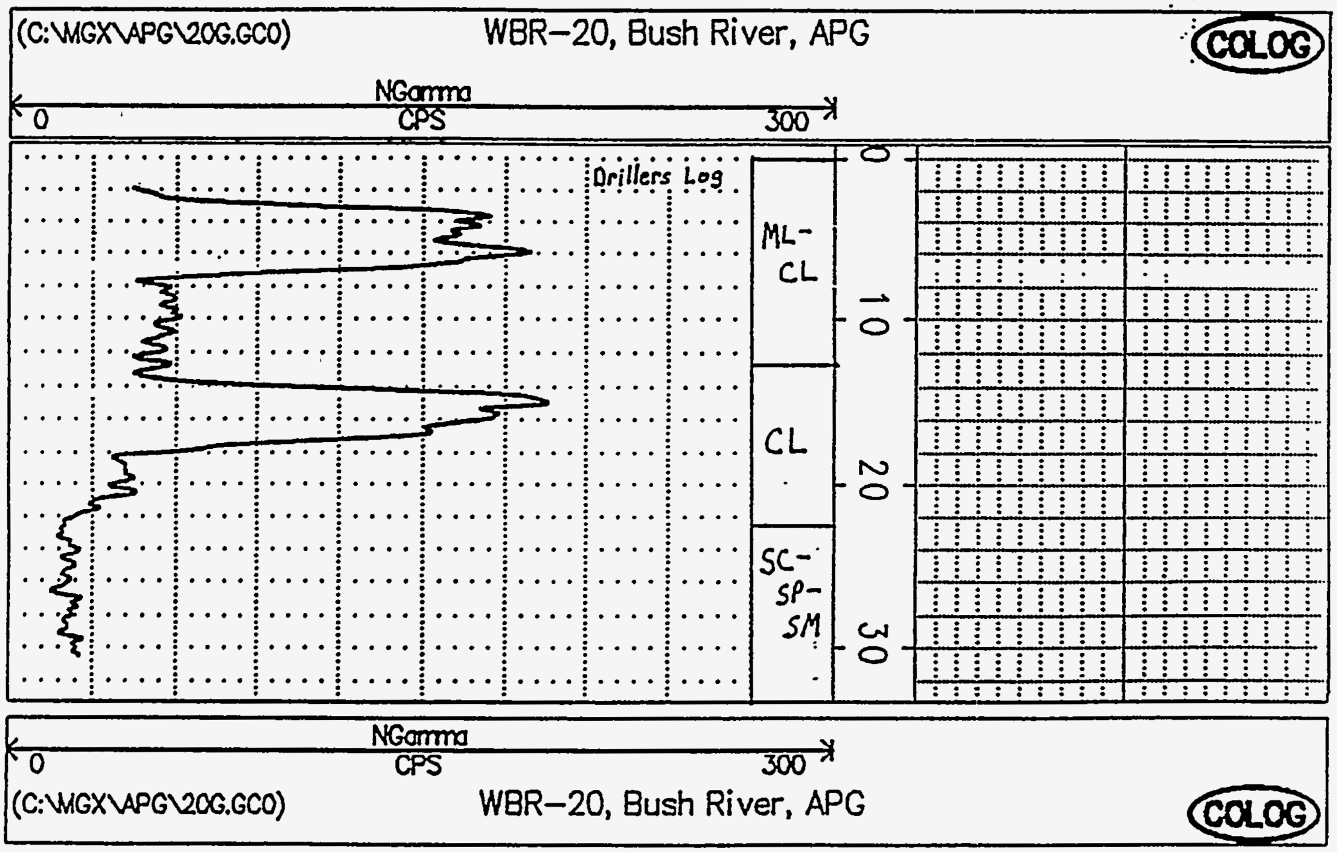
WBR-19, Bush River, APG
COLOG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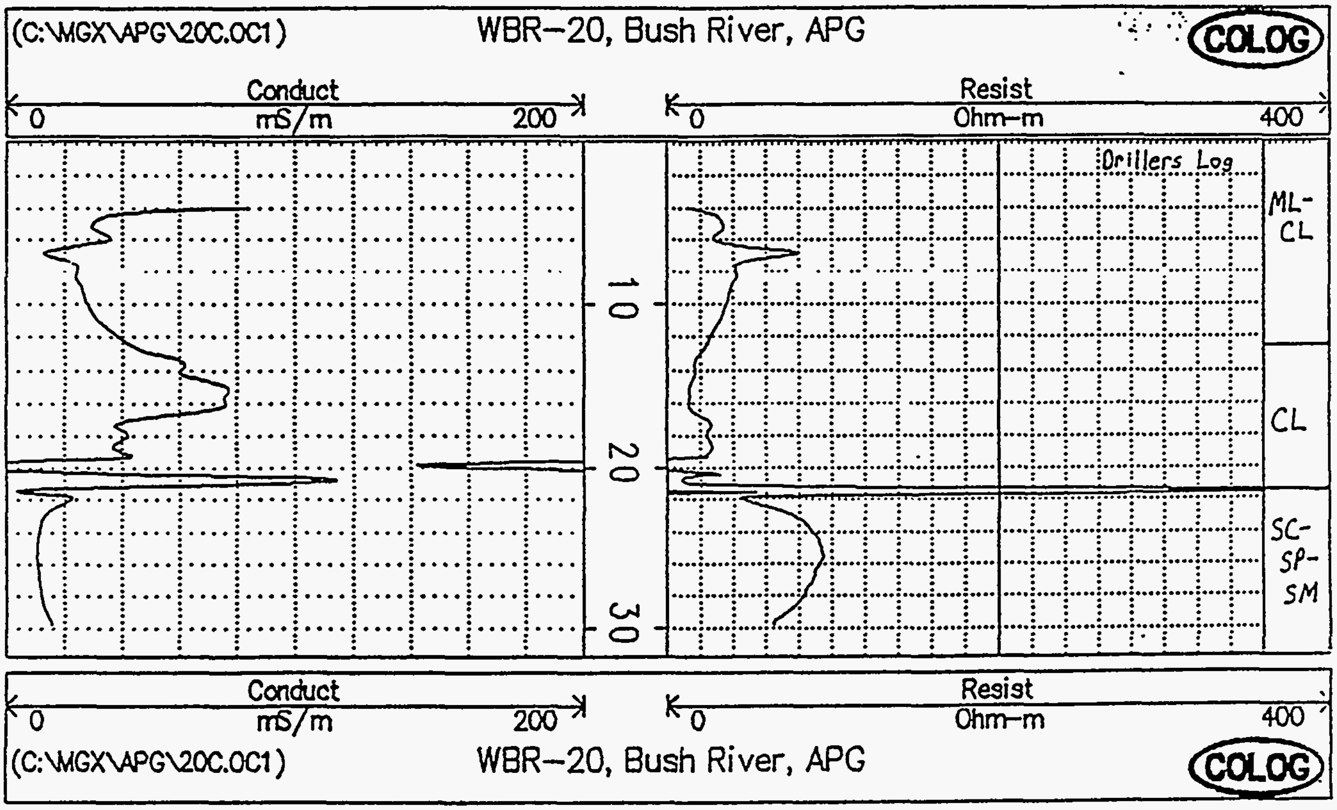
WBR-20, Bush River, APG
COLOG
NGamma
CPS
0
300
Drillers Log
ML-CL
CL
SC-SP-SM
0
10
20
30
NGamma
CPS
0
300
(C:\MGX\APG\20G.GCO)
WBR-20, Bush River, APG
COLOG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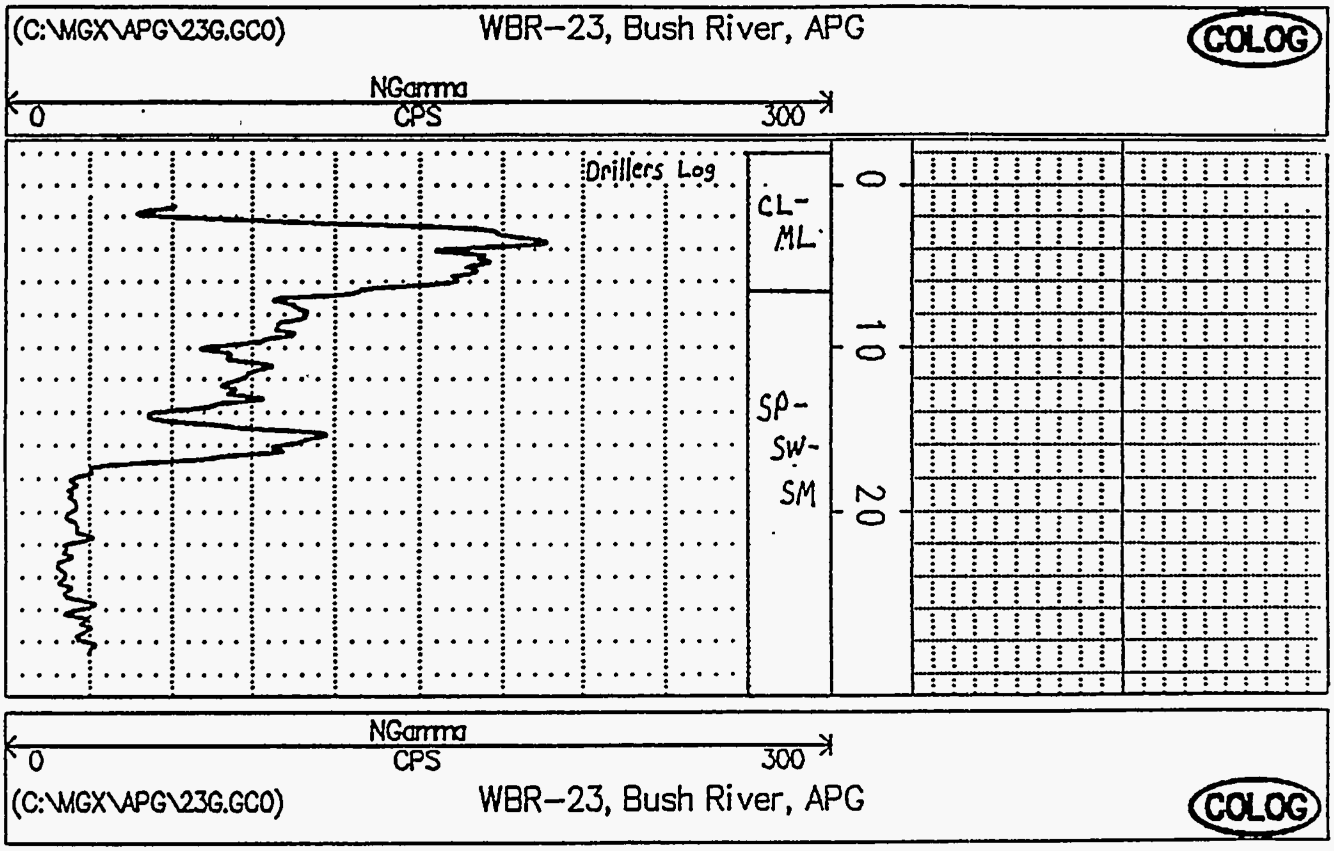
WBR—20, Bush River, APG
COLOG
Conduct
0
mS/m
200
Resist
0
Ohm-m
400
Drillers Log
ML-
CL
CL
SC-
SP-
SM
10
20
30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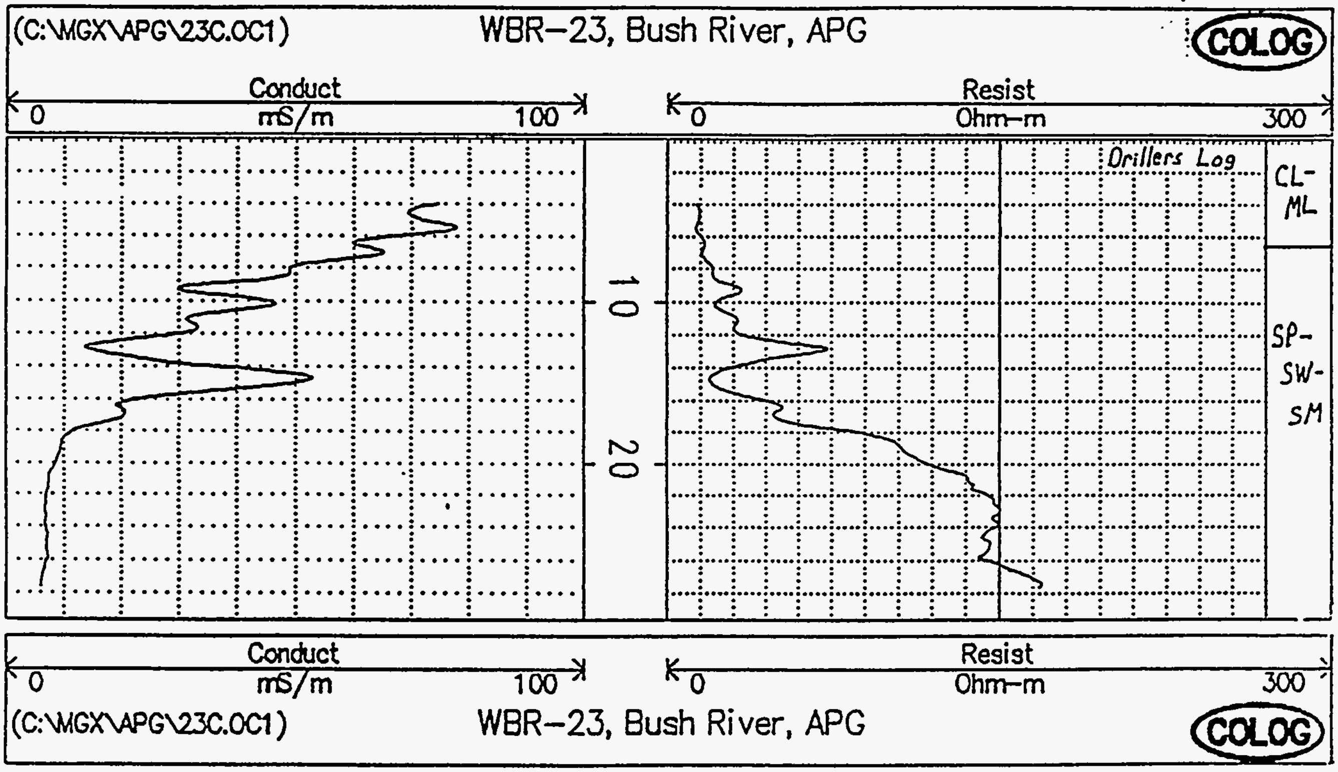
WBR-23, Bush River, APG
COLOG
NGamma
CPS
0
300
Drillers Log
CL-ML
SP-SW-SM
0
10
20
NGamma
CPS
0
300
(C:\MGX\APG\23G.GCO)
WBR-23, Bush River, APG
COLOG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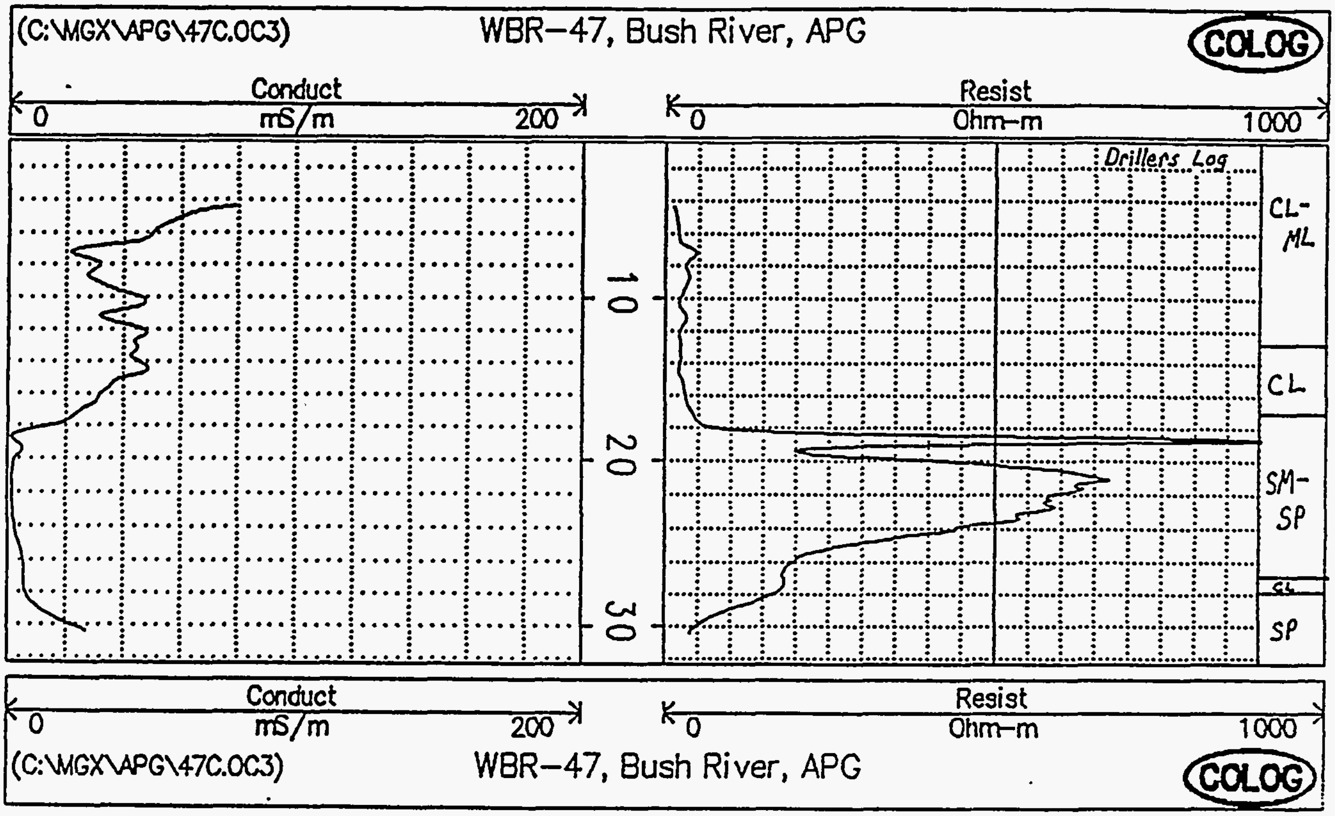
WBR-23, Bush River, APG
COLOG
Conduct
0
mS/m
100
Resist
0
Ohm-m
300
10
20
Drillers Log
CL-ML
SP-SW-SM
Conduct
0
mS/m
100
Resist
0
Ohm-m
300
(C:\MGX\APG\23C.OC1)
WBR-23, Bush River, APG
COLOG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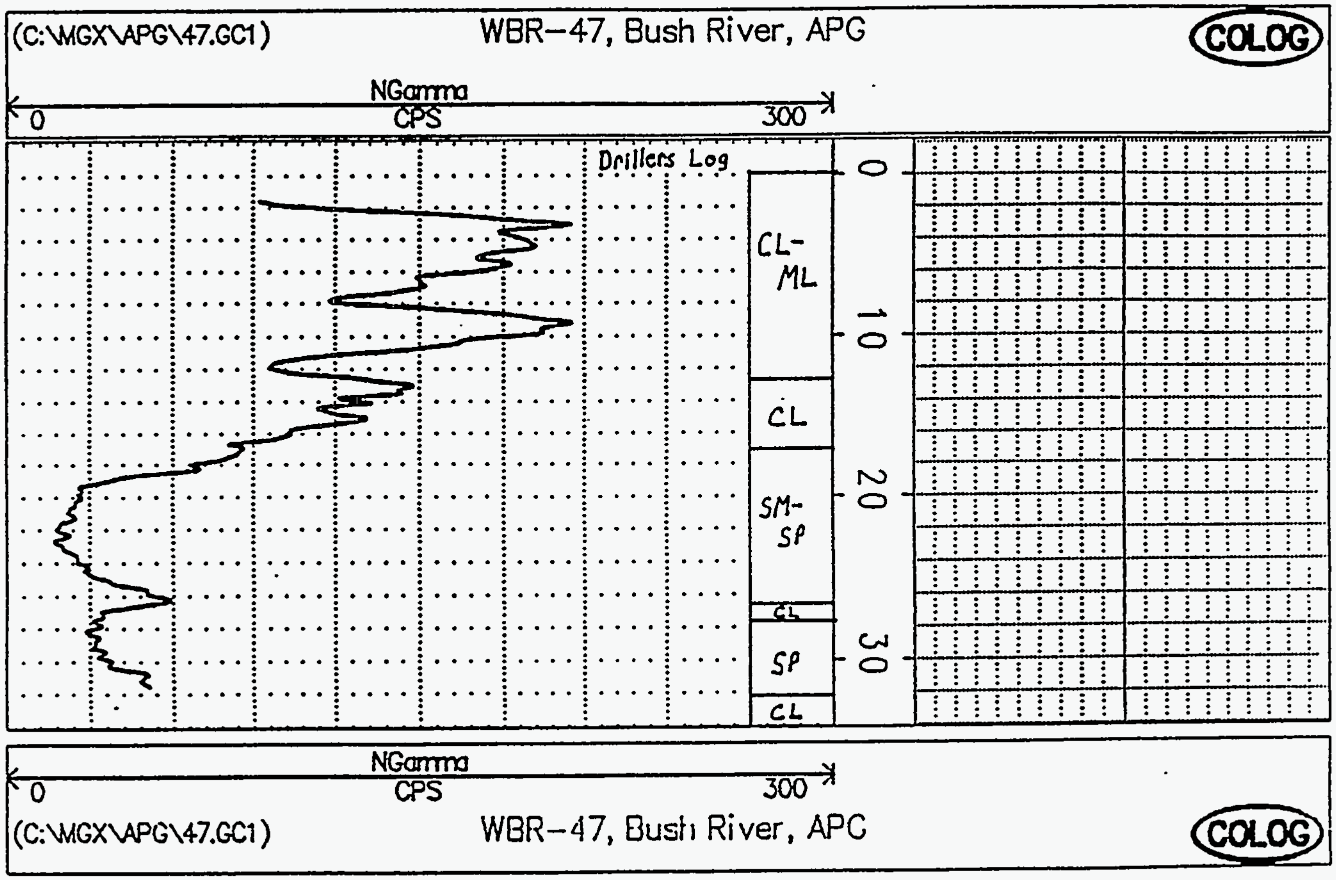
WBR-47, Bush River, APG
COLOG
Conduct
0
mS/m
200
Resist
0
Ohm-m
1000
Drillers Log
CL-ML
CL
SM-SP
SP
10
20
30
Conduct
0
mS/m
200
Resist
0
Ohm-m
1000
(C:\MGX\APG\47C.OC3)
WBR-47, Bush River, APG
COLOG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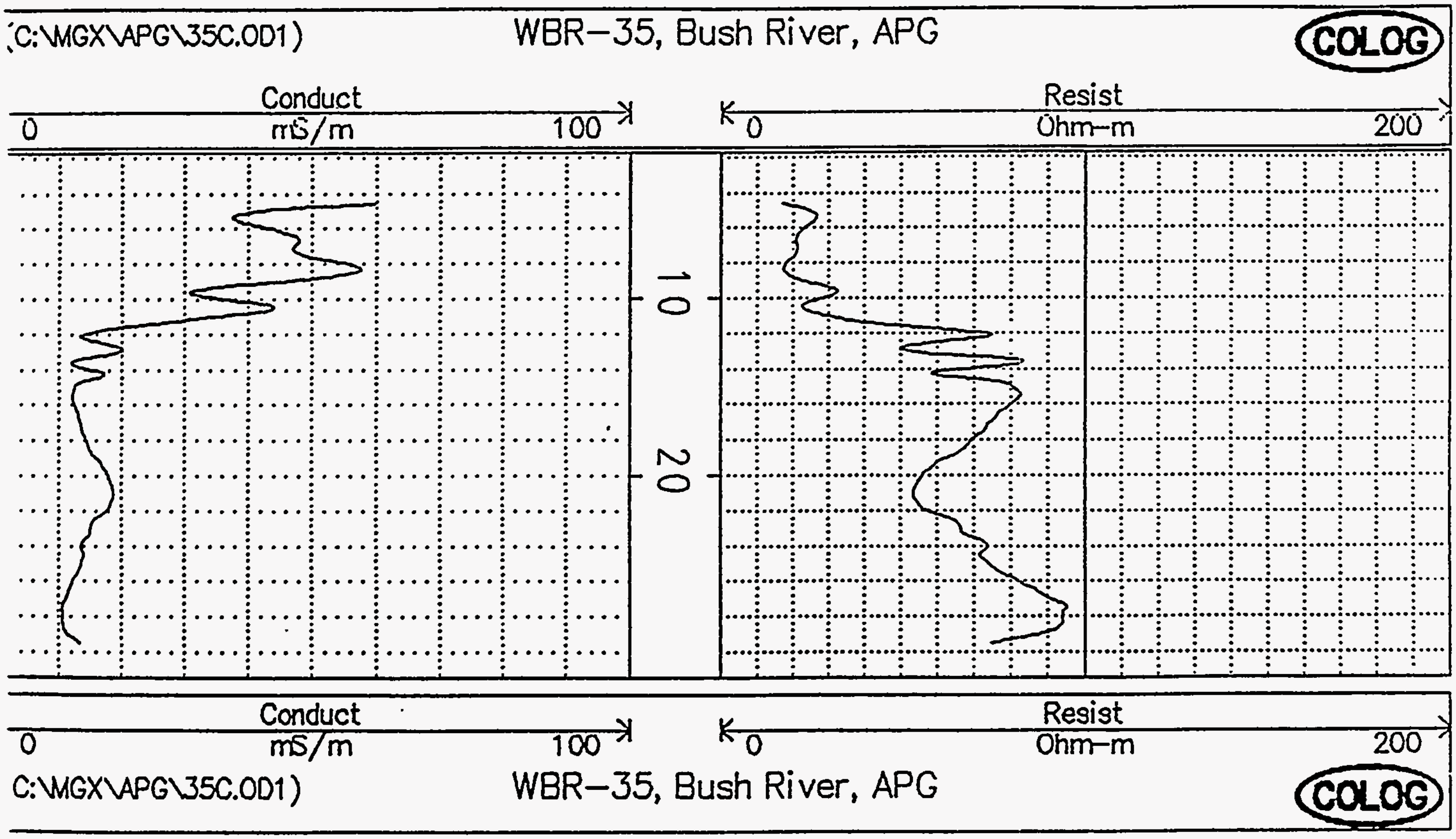
WBR-47, Bush River, APG
COLOG
NGamma
CPS
0
300
Drillers Log
CL-
ML
CL
SM-
SP
CL
SP
CL
0
10
20
30
NGamma
CPS
0
300
(C:\MGX\APG\47.GC1)
WBR-47, Bush River, APG
COLOG



(C:\MGX\APG\35C.OD1)
WBR-35, Bush River, APG
COLOG
Conduct
0
mS/m
100
Resist
0
Ohm-m
200
10
20
Conduct
0
mS/m
100
Resist
0
Ohm-m
200
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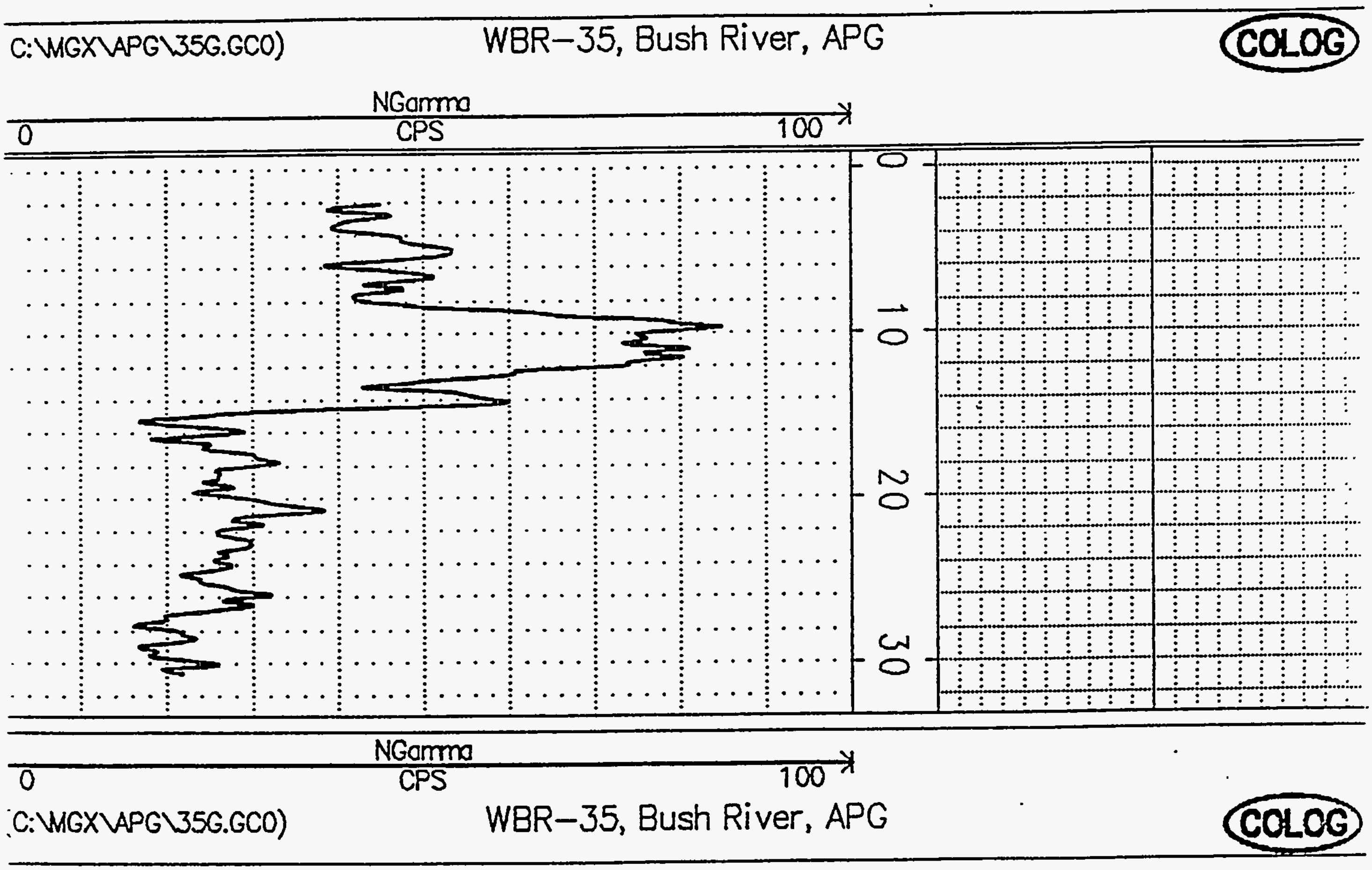
WBR-35, Bush River, APG
COLOG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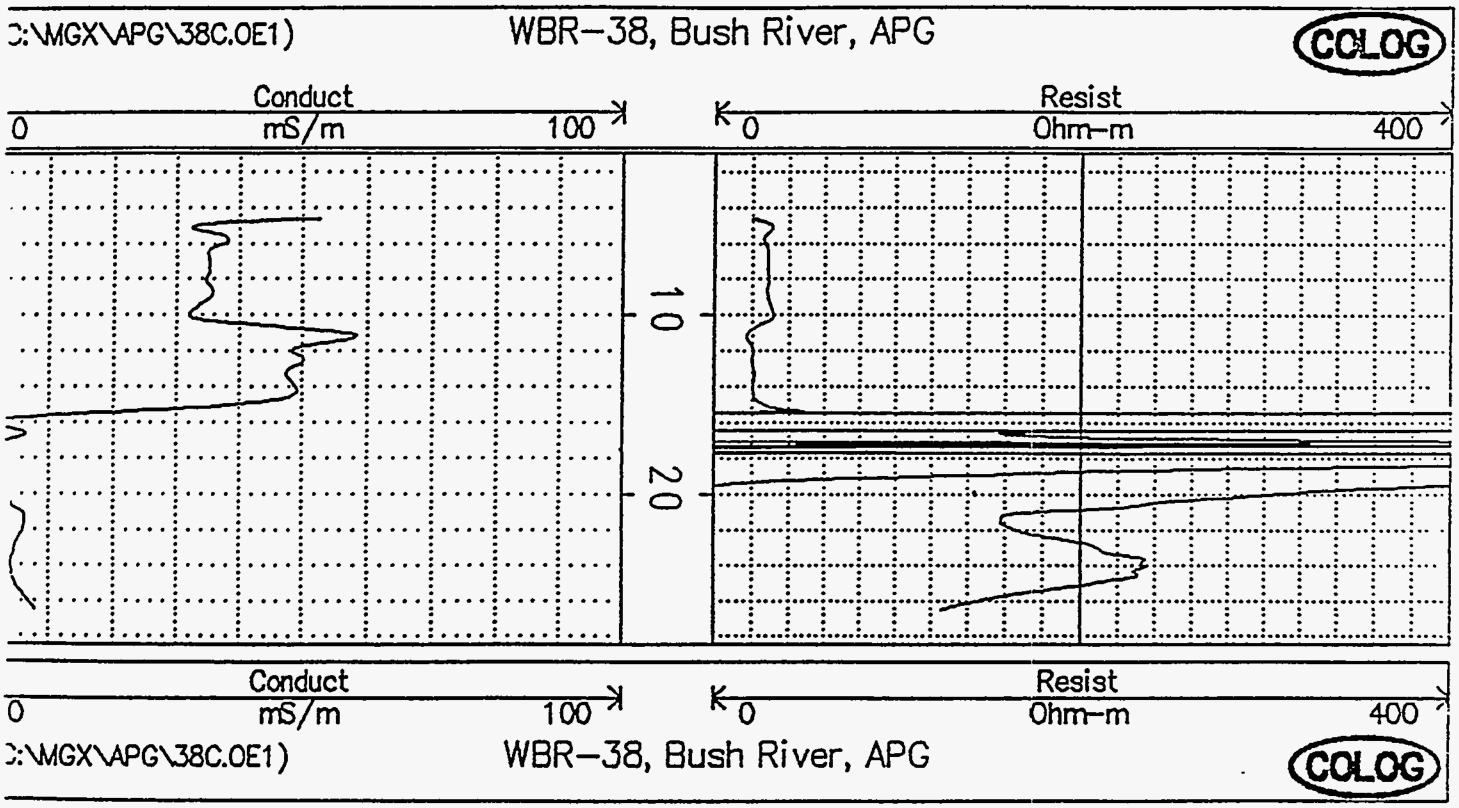
WBR-35, Bush River, APG
COLOG
NGamma
CPS
0
100
0
10
20
30
NGamma
CPS
0
100
(C:\MGX\APG\35G.GC0)
WBR-35, Bush River, APG
COLOG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WBR-38, Bush River, APG
COLOG
Conduct
0
mS/m
100
Resist
0
Ohm-m
400
10
20
Conduct
0
mS/m
100
Resist
0
Ohm-m
400
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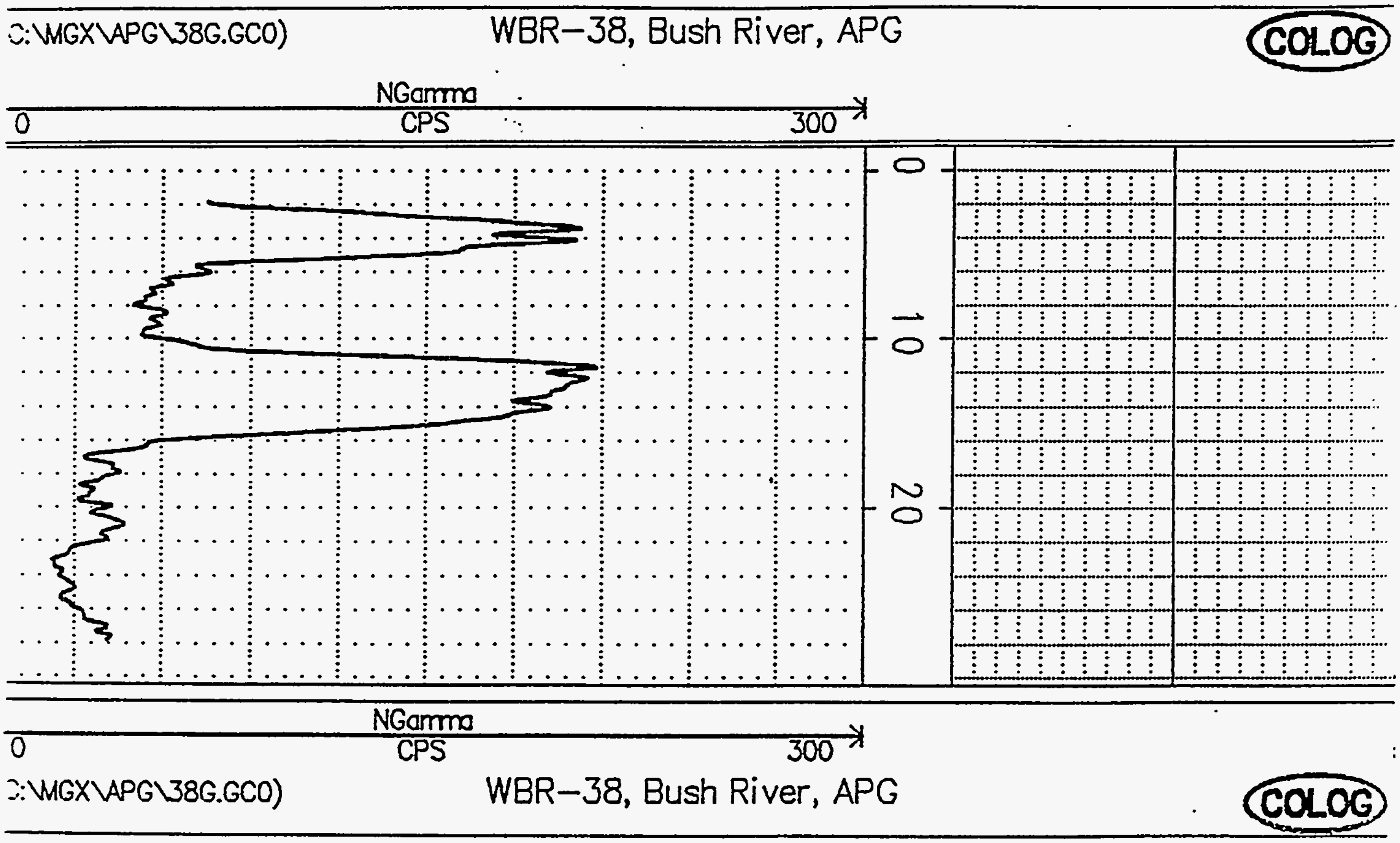
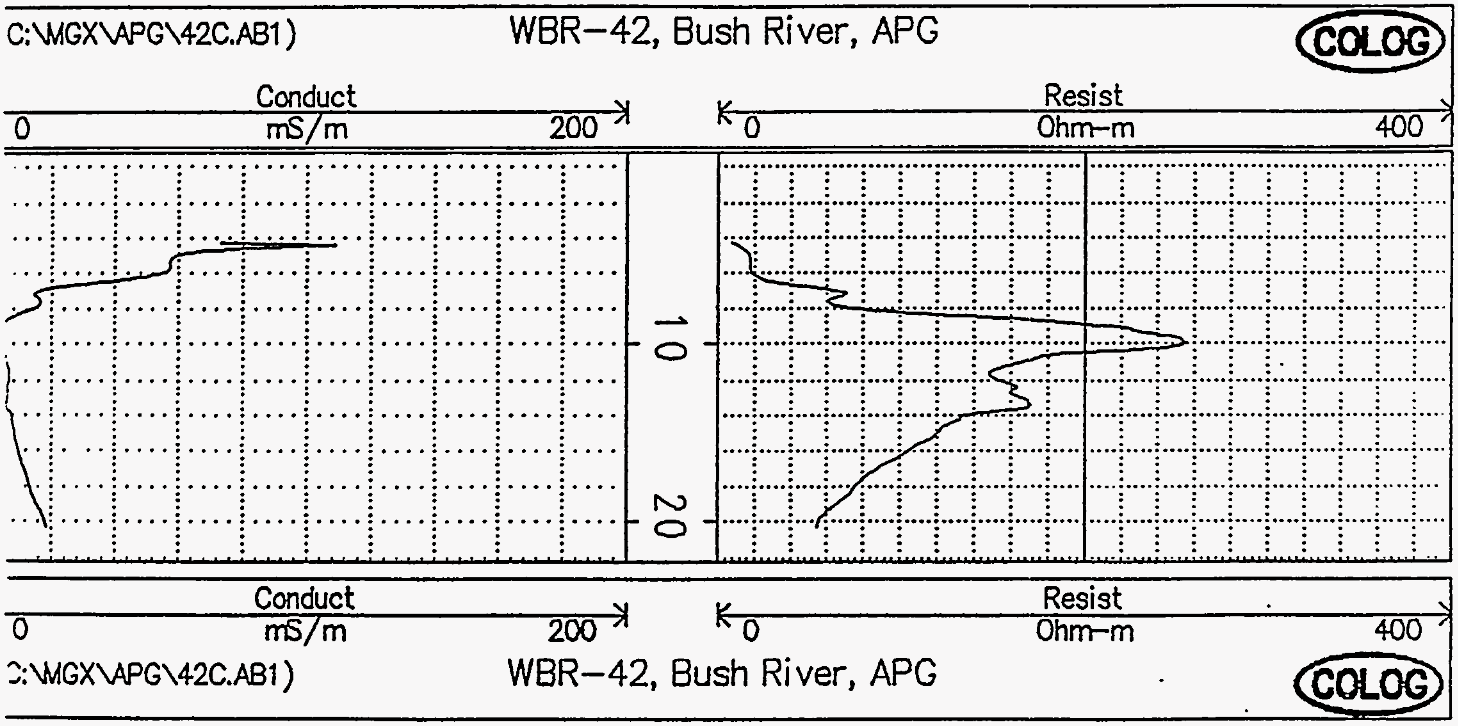
WBR-38, Bush River, APG
COLOG


C:\MGX\APG\38G.GC0)
WBR-38, Bush River, APG
COLOG
NGamma
CPS
0
300
0
10
20
NGamma
CPS
0
300
C:\MGX\APG\38G.GC0)
WBR-38, Bush River, APG
COLOG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WBR-42, Bush River, APG
COLOG
Conduct
0
mS/m
200
Resist
0
Ohm-m
400
10
20
Conduct
0
mS/m
200
Resist
0
Ohm-m
400
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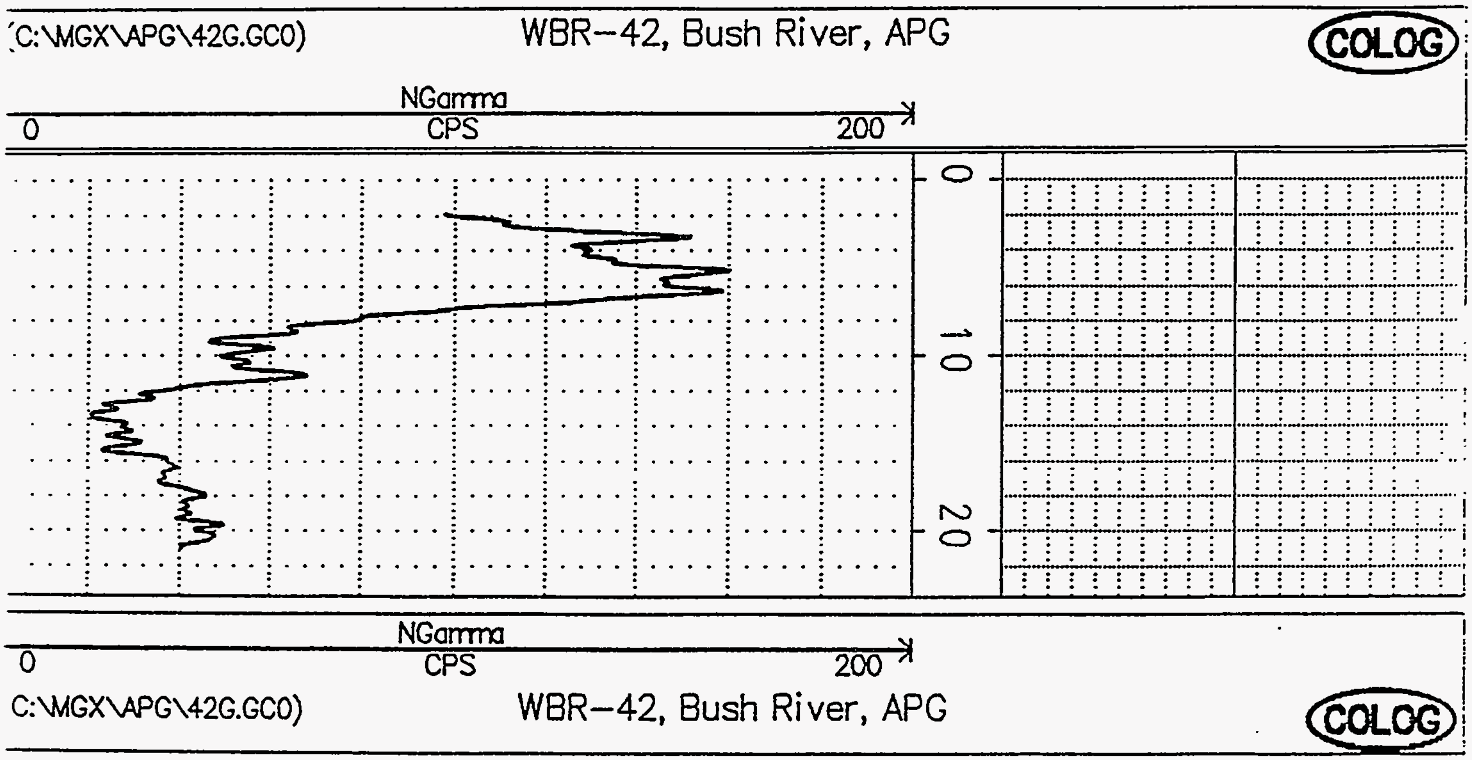
WBR-42, Bush River, APG
COLOG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WBR-42, Bush River, APG
COLOG
NGamma
0
CPS
200
0
10
20
NGamma
0
CPS
200
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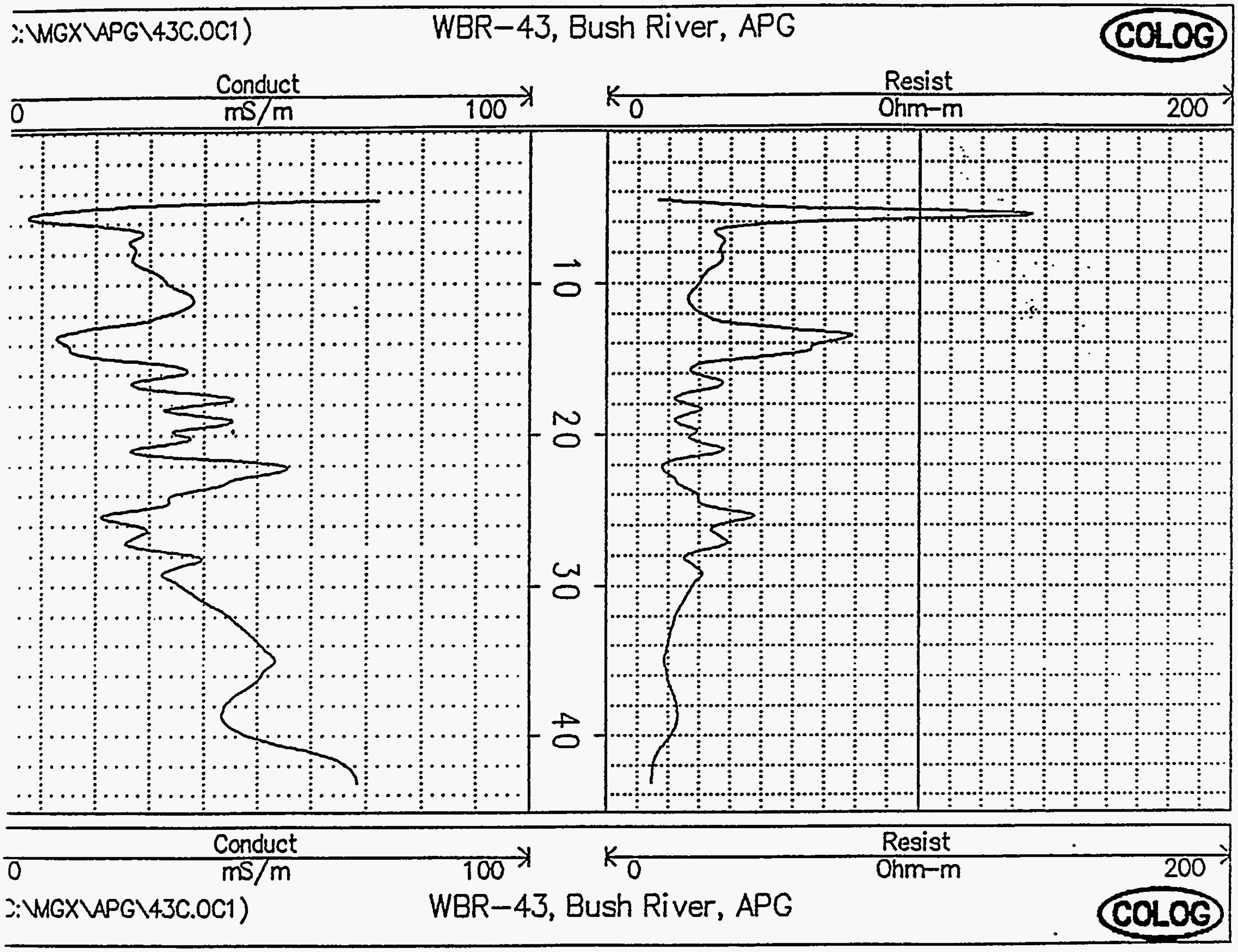
WBR-42, Bush River, APG
COLOG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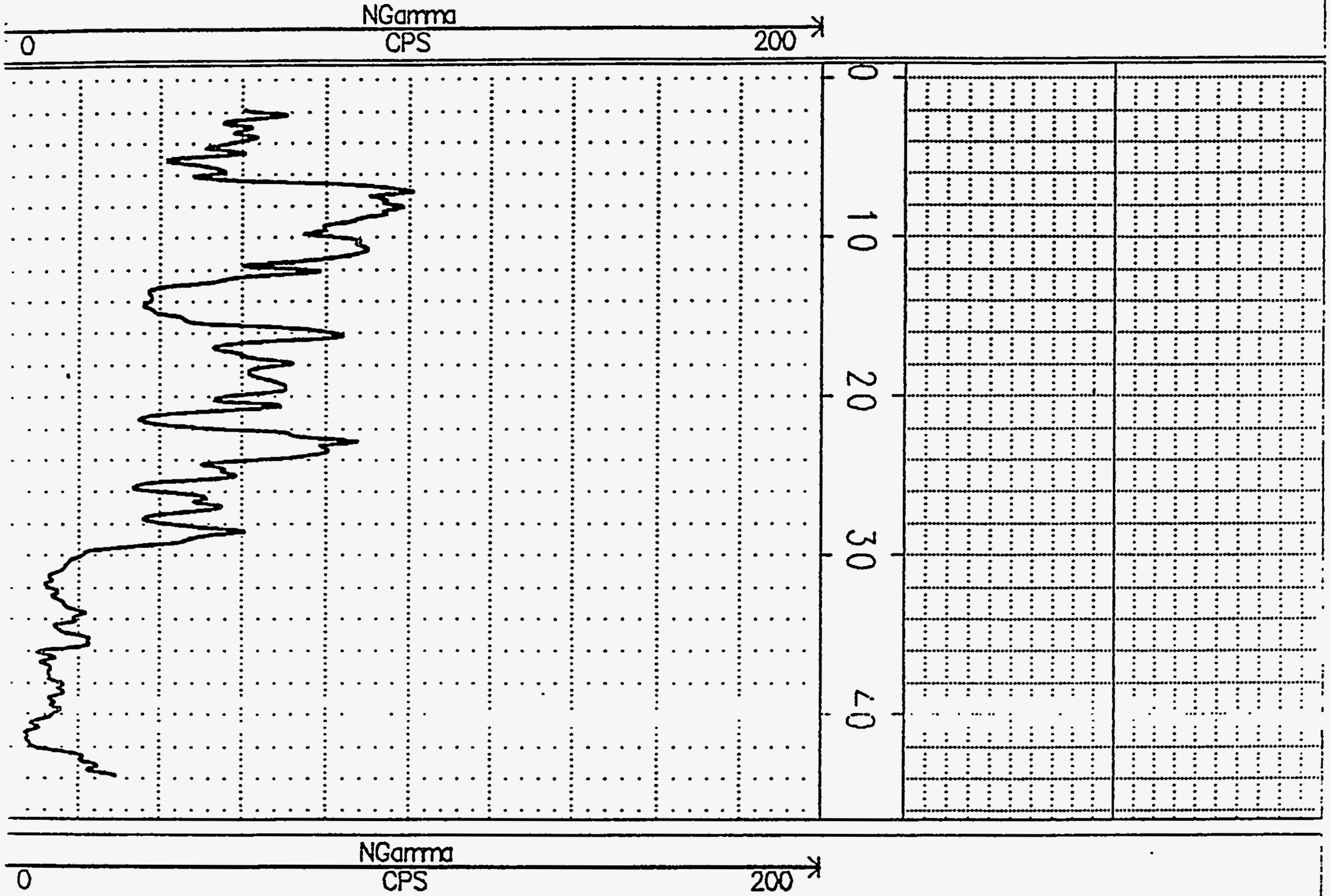
WBR–43, Bush River, APG
COLOG
Conduct
0
mS/m
100
Resist
0
Ohm-m
200
10
20
30
40
Conduct
0
mS/m
100
Resist
0
Ohm-m
200
:\MGX\APG\43C.OC1)
WBR–43, Bush River, APG
COLOG

(C:\MGX\APG\43G.GCO) WBR-43, Bush River, APG COLOG



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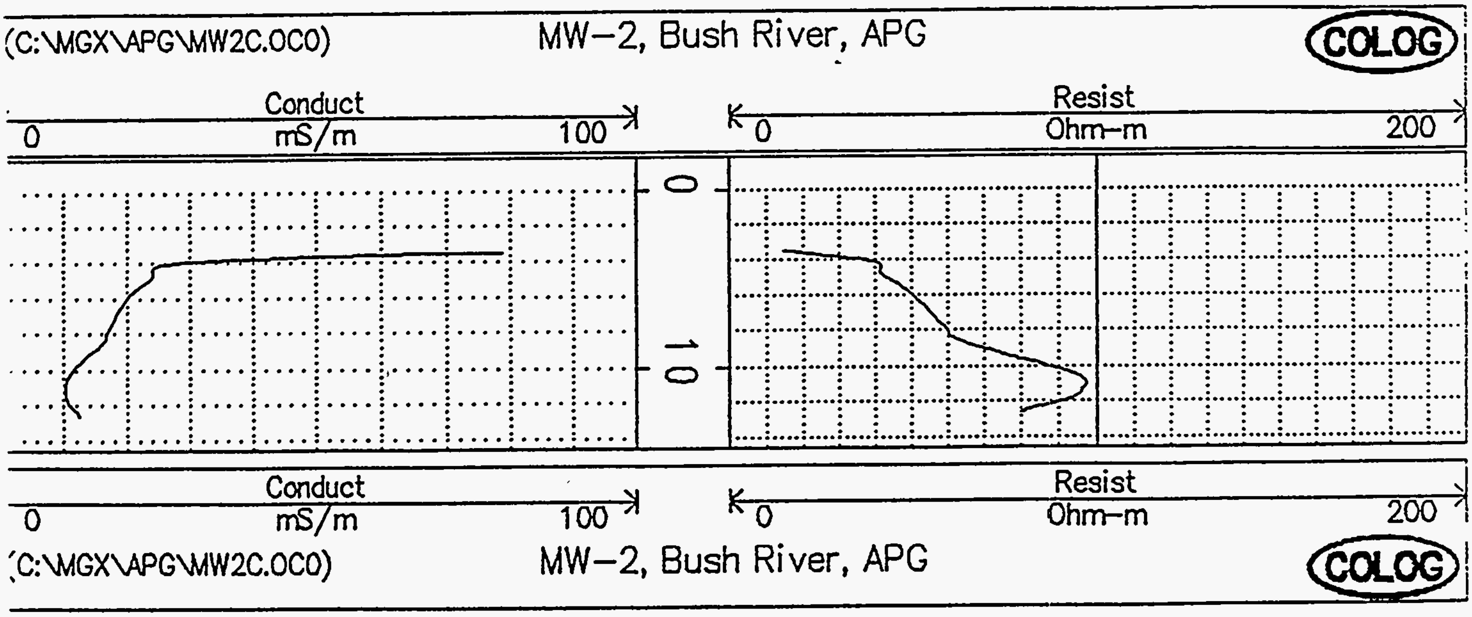
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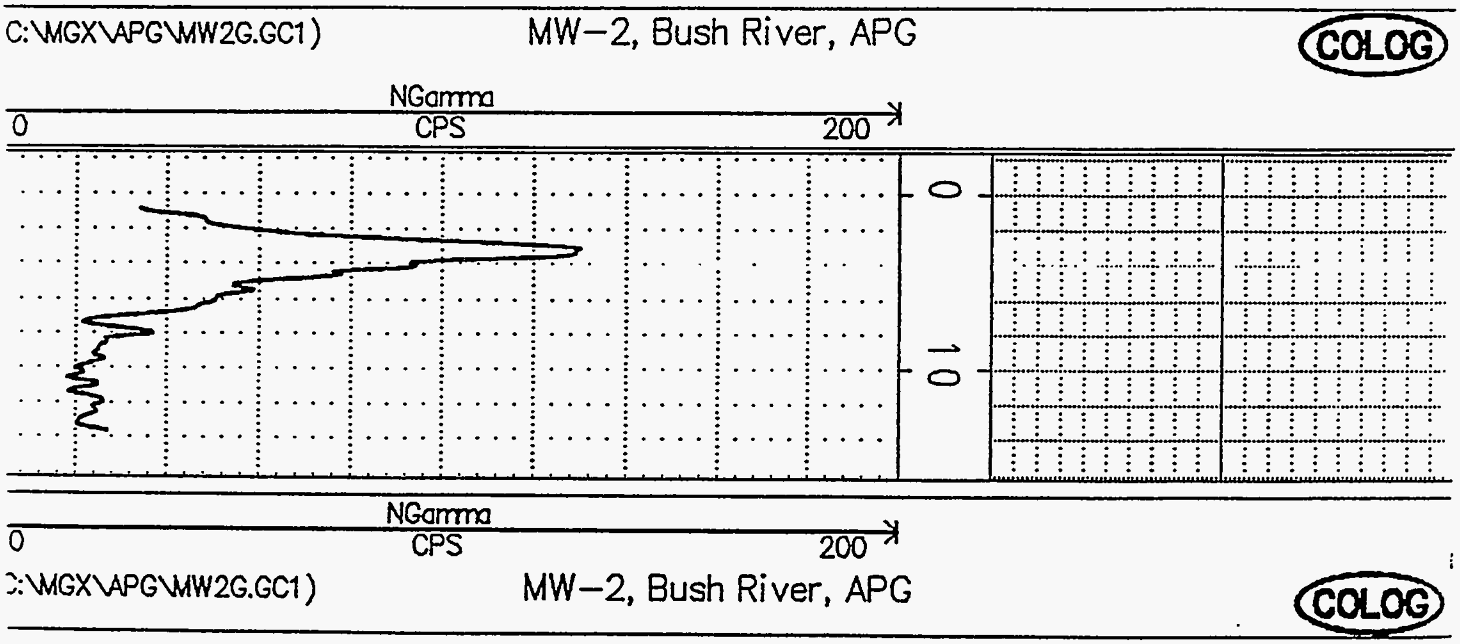
MW-2, Bush River, APG
COLOG
Conduct
0
mS/m
100
Resist
0
Ohm-m
200
0
10
Conduct
0
mS/m
100
Resist
0
Ohm-m
200
(C:\MGX\APG\MW2C.OCO)
MW-2, Bush River, APG
COLOG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MW-2, Bush River, APG
COLOG
NGamma
0
CPS
200
0
10
NGamma
0
CPS
200
:\MGX\APG\MW2G.GC1)
MW-2, Bush River, APG
COLOG