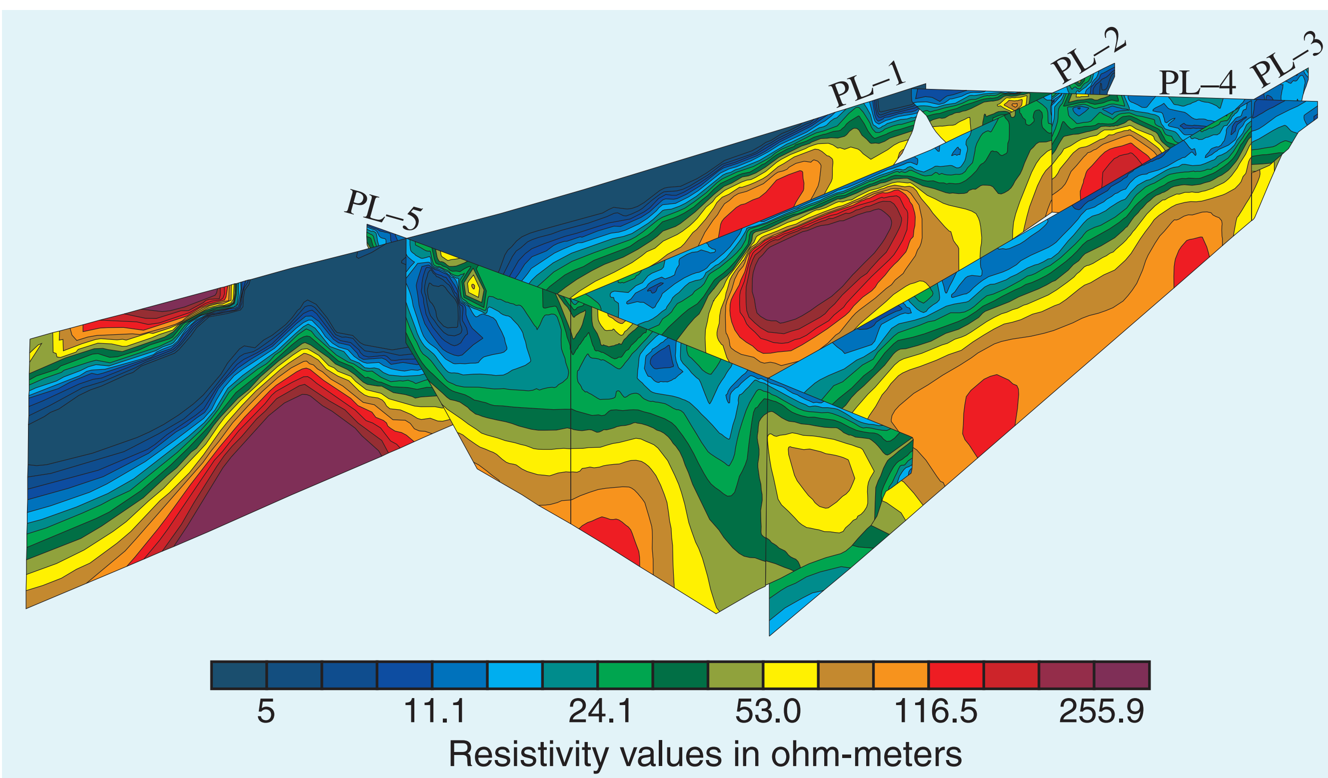
In cooperation with the U.S. Air Force, Aeronautical Systems Center, Environmental Management Directorate, Wright-Patterson Air Force Base, Ohio

Subsurface Evaluation of the West Parking Lot and Landfill 3 Areas of Air Force Plant 4, Fort Worth, Texas, Using Two-Dimensional Direct-Current Resistivity Profiling

Water-Resources Investigations Report 02–4248



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Sea Level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Subsurface Evaluation of the West Parking Lot and Landfill 3 Areas of Air Force Plant 4, Fort Worth, Texas, Using Two-Dimensional Direct-Current Resistivity Profiling

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Abstract

During September 1999, the U.S. Geological Survey made 10 two-dimensional direct-current resistivity profile surveys in the west parking lot and landfill 3 areas of Air Force Plant 4, Fort Worth, Texas, to identify subsurface areas of anomalously high or low resistivity that could indicate potential contamination, contaminant pathways, or anthropogenic structures. Six of the 10 surveys (transects) were in the west parking lot. Each of the inverted sections of these transects had anomalously high resistivities in the terrace alluvium/fill (the surficial subsurface layer) that probably were caused by highly resistive fill material. In addition, each of these transects had anomalously low resistivities in the Walnut Formation (a bedrock layer immediately beneath the alluvium/fill) that could have been caused by saturation of fractures within the Walnut Formation. A high-resistivity anomaly in the central part of the study area probably is associated with pea gravel fill used in construction of a French drain. Another high-resistivity anomaly in the west parking lot, slightly southeast of the French drain, could be caused by dense nonaqueous-phase liquid in the Walnut Formation. The inverted sections of the four transects in the landfill 3 area tended to have slightly higher resistivities in both the alluvium/fill and the Walnut Formation than the transects in the west parking lot. The higher resistivities in the alluvium/fill could have been caused by drier conditions in grassy areas relative to conditions in the west parking lot. Higher resistivities in parts of the Walnut Formation also could be a function of drier conditions or variations in the lithology of the Walnut Formation. In addition to the 10 vertical sections, four horizontal sections at 2-meter-altitude intervals show generally increasing resistivity with decreasing altitude that most likely results from the increased influence of the Walnut Formation, which has a higher resistivity than the terrace alluvium/fill.

INTRODUCTION

U.S. Air Force Plant 4 (AFP4) in Fort Worth, Tex. (fig. 1), has been in operation since 1942. The facility has manufactured aircraft, radar units, missile components, and spare parts. The manufacture and assembly of these products require various types of solvents, paints, metals, oils, fuels, and other chemicals. Some of these chemicals have been detected in the subsurface near the facility (U.S. Army Corps of Engineers, 1986; Jacobs Engineering Group Inc., 1993; Geo-Marine, Inc. 1995; RUST Geotech, 1995a, b, c, d).

A part of the west parking lot currently (2001) overlies landfill 1 (LF1), which was closed in 1966. LF1 was used as a disposal site for general refuse, construction fill, and potentially hazardous waste. Part of the site was excavated in 1983, and the excavated materials were sent to an approved off-site disposal facility. Landfill 3 (LF3), on the west side of Bomber Road and currently unused, was a disposal site for various wastes, including oils and solvents (IT Corporation, 1999).

In summer 1996, during a routine drilling project in the west parking lot, dense nonaqueous-phase liquid (DNAPL) was detected in the Walnut Formation (IT Corporation, 1999). The DNAPL was present in consolidated bedrock below the level of unconsolidated alluvial material that was excavated in 1983.

During September 1999, the U.S. Geological Survey (USGS), in cooperation with the U.S. Air Force, did a surface-geophysical investigation at the site to characterize geophysical anomalies that could indicate potential contamination, contaminant pathways, or anthropogenic structures (buried utility lines, drainage

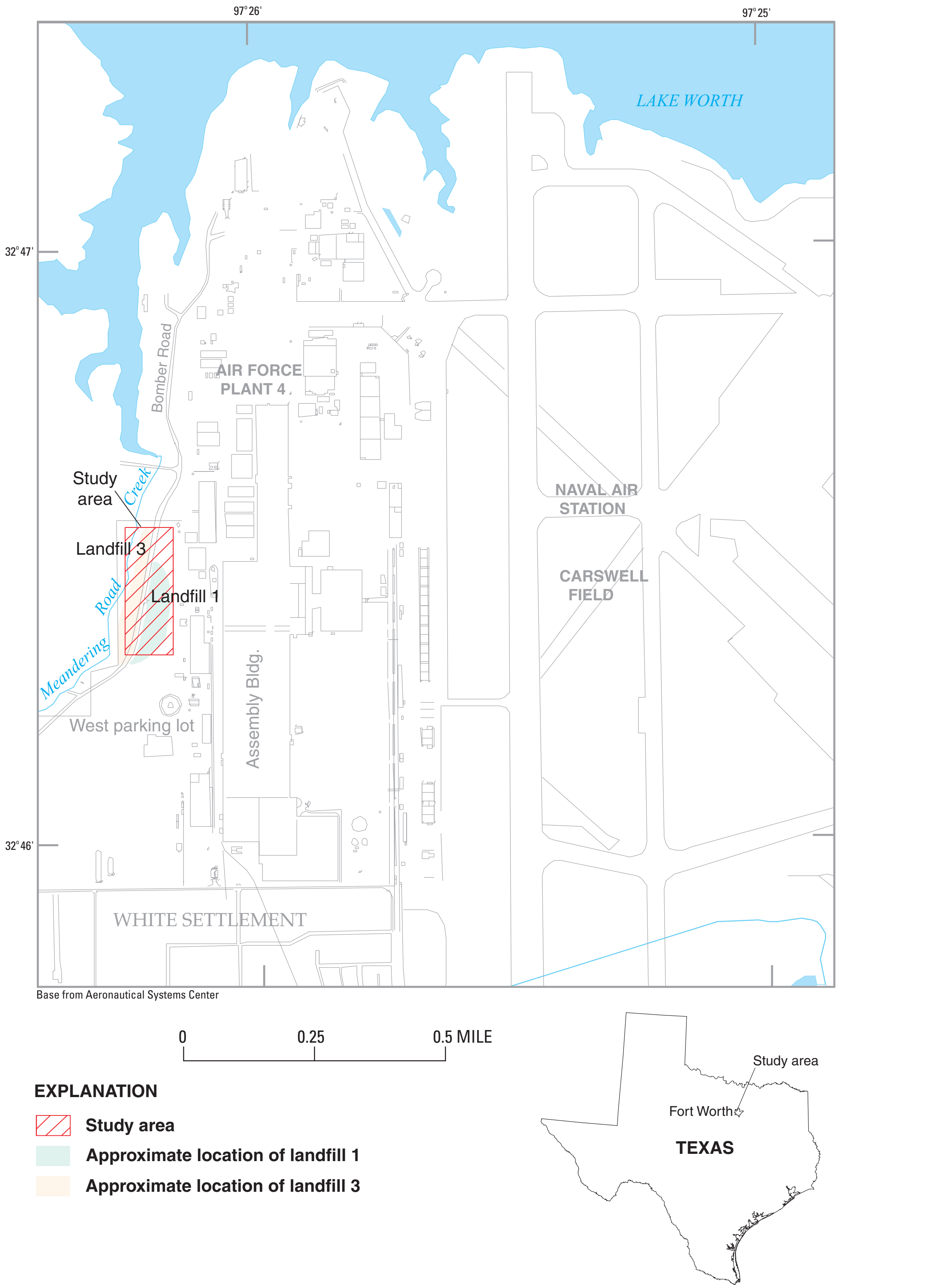

Figure 1. Location of study area.

structures, and so forth). Ten two-dimensional (2D) direct-current (dc) resistivity profile surveys were done in the west parking lot and LF3 areas of AFP4. The profiles ranged in length from 81 to 252 meters (m). Where possible, intersecting lines were used to verify results of the surveys.

Purpose and Scope

This report describes the 2D dc resistivity profiling in the west parking lot and LF3 areas of AFP4; specifically, it describes the methods used to acquire and process the field data, and it describes the use of the profiling results in conjunction with lithologic data to delineate subsurface areas of anomalous (high or low) resistivity that could indicate saturated and unsaturated bedrock zones, DNAPL, or anthropogenic structures.

Description of the Study Area

The study area, located west of the assembly building and east of Meandering Road Creek, mostly includes LF1, LF3, and part of the west parking lot (fig. 1). Location of the 2D dc resistivity transects are shown in plate 1. Quaternary alluvial sediments and fill material, consisting of much construction debris (hereinafter called alluvium/fill), underlie the site. A medium- to dark-gray, interbedded clay and limestone bedrock unit below the alluvial sediments, locally referred to as the Walnut Formation, is considered a confining unit. The Walnut Formation is a fossiliferous limestone with shell conglomerates. It has very low permeability (Kuniansky and others, 1996) and typically is unsaturated. However, there is a saturated zone of unknown extent in the study area (pl. 2); the occurrence and extent of other saturated zones is unknown. Beneath the Walnut Formation is the Paluxy Formation, the lower two-thirds of which is considered an aquifer. The upper one-third (upper zone) of the Paluxy Formation is composed mostly of highly indurated, fine-grained sandstone with shale and claystone interbeds. The upper zone is the zone of interest within the Paluxy Formation for this study because the 2D dc resistivity techniques used do not penetrate either the middle or lower zones of the Paluxy Formation. The Paluxy Formation is used as a water-supply aquifer for the city of White Settlement, which is located directly southwest of AFP4 (fig. 1).

Acknowledgments

The USGS acknowledges the cooperation of IT Corporation for providing field and logistical support in addition to lithologic data. We also thank the Aeronautical Systems Center/Environmental Management Directorate at Wright-Patterson Air Force Base, Ohio, for their financial support of this project.

METHODS

Surface-geophysical methods provide an inexpensive and non-invasive means of defining subsurface properties in a relatively short period of time. These methods can provide information on soil thickness and saturation, location and distribution of conductive fluids, depth to bedrock, and location and orientation of fracture zones. The 2D dc resistivity method was the principal method used to evaluate the subsurface at the site. Ground-penetrating radar was ineffective at the site because of numerous anthropogenic structures and high conductivity of the subsurface. Borehole geophysical methods also were considered, but contamination concerns prevented their use.

Two-Dimensional Direct-Current Resistivity Profiling

The resistivity of a particular soil or rock sample depends on factors such as porosity, degree of saturation, and the concentration of dissolved constituents. According to Loke (2000, table 1), the resistivity of fresh ground water ranges from about 10 to 100 ohm-meters (ohm-m); the resistivity of alluvium ranges from about 10 to 800 ohm-m; the resistivity of limestone ranges from about 50 to 400 ohm-m; the resistivity of sandstone ranges from about 8 to 4,000 ohm-m. For each medium, the lower end of the range corresponds to saturated conditions and the upper end of the range corresponds to unsaturated conditions. Hydrocarbons typically have very high resistivity (Loke, 2000). This characteristic was confirmed at the site when the measured conductivity of a DNAPL sample from the Walnut Formation in well W–5 (near French drain 1, pl. 1) was below the detection level of the conductivity meter (Rick Wice, IT Corporation, oral commun., 2000); low conductivity indicates high resistivity.

Direct-current resistivity profiling measures the electrical resistivity distribution in the subsurface by transmitting low-frequency direct current into the ground at one pair of electrodes and measuring the potential difference at a second pair of electrodes along a transect. The apparent resistivity of the subsurface can be calculated by applying a geometric correction to Ohm's law. This geometrically corrected value is not the true resistivity of the subsurface, but an apparent value, which is the resistivity of a homogeneous subsurface that will give the same resistance value for the same electrode arrangement (Loke, 2000). A complex relation exists between the "true" resistivity and the "apparent" resistivity. To estimate the true subsurface resistivity, the measured apparent resistivity data are transformed into a 2D distribution of resistivity along a section of the subsurface using the iterative software tool RES2DINV (Loke, 2000; Geometrics, 2001); this process is called inversion. The inverted section is not unique; that is, different subsurface conditions and materials could yield the same distribution of apparent resistivities.

After obtaining the inverted section based on field data, synthetic apparent resistivity data are generated using another software tool, RES2DMOD (Loke, 2000; Geometrics, 2001), and then input to RES2DINV, which results in another 2D model of resistivity along a section of the subsurface. The basis for generating the synthetic apparent resistivity data (that is, the input to RES2DMOD) is a simplified cell-based model of subsurface resistivities for a particular transect obtained (in the case of this study) from much lithologic data compiled from numerous wells, borings, and piezometers at the site. Because the field-data inverted section is not unique, the high density of lithologic data at the site was an invaluable aid in interpreting subsurface conditions represented by the resistivities of the field-data inverted section.

The two inverted resistivity sections—the one from the field data and the one from the synthetic data of simplified resistivity model—are then compared. The resistivity distribution of the synthetic-data inverted section reflects only undisturbed lithology, whereas the resistivity distribution of the field-data inverted section reflects actual subsurface conditions. Thus, qualitatively comparing the two sections is a way to identify locations and orientations of anomalously high or low resistivity, which could be the result of subsurface features such as fill material, zones of saturation, fractured bedrock, buried pipes or utility lines, and DNAPL.

Data Acquisition

The 2D dc resistivity profiling system (Sting R1 memory earth-resistivity meter and Swift automatic smart electrode system manufactured by Advanced Geosciences, Inc.) consisted of 28 steel electrodes, electrode switches, connecting wires, and a measurement control unit. The field measurements of resistivity were made at locations along each profile and at different offsets. Electrodes were oriented in a linear array for the 2D dc resistivity survey. The control unit uses an automated data-collection program to control the location of current and potential electrodes. Resistivity measurements were stored directly in the memory of the measurement control unit. When field measurements were completed, the data were downloaded to a portable computer.

Three types of arrays, each with advantages and disadvantages, were used initially for profiling—dipole-dipole, Wenner, and Wenner-Schlumberger (Loke, 2000). The dipole-dipole array was ineffective at the site because of its small signal strength and noisy conditions at the site. Noisy conditions can be caused by telluric currents, the natural electric currents near the earth's surface (Loke, 1999). These currents are more pronounced in areas with low resistivities, such as landfills (Mats Lagmanson, Advanced Geosciences, Inc., written commun., 2000). Analysis of the Wenner and Wenner-Schlumberger array data for each transect indicated that the Wenner-Schlumberger array data provided better lateral resolution; therefore, only Wenner-Schlumberger data were used for this report.

For this study, ten 2D dc resistivity profiles were run (transects PL–1 through PL–6 and GR–1 through GR–4, pl. 1). The field procedure included setting electrode stakes at 3-m intervals, laying out the Swift cable, and attaching an electrode switch to each of the electrode stakes. To ensure data quality, a test resistor was used to check the accuracy and precision of the Sting/Swift system before data collection along each profile. A contact resistance test was also done to assure a good electrical connection between the electrodes and the ground. Transects longer than 81 m necessitated the movement of some of the electrodes from one end of the line to the other to collect all of the measurements. The order in which data collection proceeded in the west parking lot depended on access to different parts of the parking lot at certain times during the day. For this reason, data for transect PL–1 were collected from south to north rather than north to south as for transects PL–2 and PL–3.

Data Processing

Using land-surface altitude and lithologic data, detailed contour maps were constructed to show topography (pl. 3), thickness of terrace alluvium/fill (base of terrace alluvium/fill represents the top of the Walnut Formation) (pl. 4), and depth to the top of the Paluxy Formation (pl. 5). For each transect, terrace alluvium/fill thickness (pl. 6a, transect PL–4 for example) and depth to the top of the Paluxy Formation (pl. 6b), together with unique resistivities assigned to terrace alluvium/fill and the Walnut and Paluxy Formations, were used to construct a simplified cell-based model of subsurface resistivity assuming homogeneous lithology devoid of resistivity anomalies (pl. 6c). On the basis of data obtained from the borehole resistivity log of a local well, a resistivity of 10 ohm-m was used for the terrace alluvium/fill; a resistivity of 75 ohm-m was used for the Walnut Formation; and a resistivity of 20 ohm-m was used for the Paluxy Formation. Apparent resistivities from selected transects in areas presumed to be devoid of anthropogenic interferences were used to verify these values.

The field resistivity data for each transect were input to RES2INV to obtain an inverted section that approximates actual subsurface resistivity (pl. 6d). The simplified model resistivities were input to RES2DMOD to generate synthetic apparent resistivity data that were then input to RES2DINV to obtain a synthetic-data inverted section (pl. 6e). The synthetic-data inverted section was then visually compared with the field-data inverted section (pl. 6d). By studying differences between the two apparent-resistivity sections, anomalously high (greater than 150 ohm-m) or low (less than 10 ohm-m) resistivities that might be the result of subsurface features other than lithology were identified (pl. 6f).

Resistivity anomalies can be distorted by adjacent resistivity anomalies, which might result in a misrepresentation of both the size and the extent of a particular resistivity anomaly. Thus the location and extent of all resistivity anomalies are approximate. A map of the possible extent of DNAPL in the Walnut Formation based on DNAPL detections in wells sampled by IT Corporation was generated to facilitate interpretation (pl. 7).

SUBSURFACE EVALUATION

Maps of the altitude of the top of the Walnut Formation (pl. 8) and the altitude of the top of the Paluxy Formation (pl. 9) were used to locate those horizons in the subsurface along the transects to facilitate analysis of the geophysical data.

West Parking Lot Transects

Transects PL–1 through PL–6 (pls. 6, 10) are in the west parking lot. The anomalously high resistivity in area 1 on each of these transects probably is associated with fill material, which, in most cases, is more resistive than the terrace alluvium. The anomalously low resistivity in area 2 on each of these transects could be caused by saturation of the Walnut Formation in those areas.

PL–1

DNAPL was detected in the Walnut Formation in each of the wells located north of soil boring 6 (SB06) (pl. 1) and bound by transects GR–2, PL–5, and PL–1 on the west, north, and east respectively. The cluster of wells in which DNAPL was detected is located west of but adjacent to the anomalously high resistivity in area 3 on transect PL–1; area 3 contains the highest resistivity detected in the west parking lot. This anomaly could be caused by the presence of highly resistive DNAPL in the fractured Walnut Formation (Rick Wice, IT Corporation, oral commun., 2000). The anomalously high resistivity in area 4 probably is associated with pea gravel backfill or other materials used in the construction of French drain 2. The anomalously low resistivity in area 5 could reflect a saturated fracture zone of the Walnut Formation.

PL–2

The anomalously high resistivity in area 3 probably is associated with pea gravel backfill or other materials used in the construction of French drain 2. The anomalously low resistivities in areas 4 and 5 could be the result of a saturated fracture zone of the Walnut Formation.

PL–3

The anomalously high resistivity in area 3 could be caused by DNAPL in the Walnut Formation, despite the fact that the area is slightly south of the projected extent of DNAPL in the Walnut Formation on the basis of IT Corporation field observations (pl. 7). The anomalously low resistivity in area 4 could be caused by a saturated zone of the Walnut Formation, but the disparity between the field-data inverted section and the synthetic-data inverted section in this area is not nearly as pronounced as it is in area 3. Therefore, the anomaly in area 4 could be caused by a variation in the lithology of the Walnut Formation in this area.

PL–4, PL–5, and PL–6

The anomalously high resistivity in area 3 on each of these transects could be caused by DNAPL in the Walnut Formation. The magnitude and extent of this anomaly are minimal along transects PL–5 and PL–6. Accordingly, the anomaly could be caused by a variation in the lithology of the Walnut Formation in this area. The magnitude of the anomalously high resistivity in area 3 along transect PL–4 is such that it could be caused by DNAPL in the Walnut Formation, even though the area is located outside the projected extent of DNAPL in the Walnut Formation on the basis of IT Corporation field observations (pl. 7). The anomalously low resistivity in area 4 on transect PL–6 could be caused by a saturated zone in the Walnut Formation.

Landfill 3 Transects

Transects GR–1, GR–2, and GR–3 (pl. 11) are along Bomber Road, and transect GR–4 (pl. 11) is inside the fenced area of LF3. These four transects tend to have slightly higher resistivities in both the alluvium/fill and the Walnut Formation than the transects in the west parking lot. Higher resistivities in the alluvium/fill could be caused by drier conditions in grassy areas relative to conditions in the west parking lot. Higher resistivities in parts of the Walnut Formation also could be a function of drier conditions or variations in the lithology of the Walnut Formation. For example, clay content in the Walnut Formation beneath LF3 and along Bomber Road could be lower than that in the Walnut Formation beneath the west parking lot.

GR–1

Transect GR–1 indicates no substantial differences between the field-data inverted section and the synthetic-data inverted section. Resistivities in the alluvium/fill are slightly higher in the field-data section than in the synthetic-data section. This difference could be a function of dry sediment conditions or simply a difference in the lithology of the alluvium/fill in this area. The cause of the anomalously high resistivity in area 1 is unknown, but it could be caused by missing geophysical data, as area 1 is along the edge of the transect where data are sparse. The cause of the anomalously high resistivity in area 2 also is unknown, but it could be caused by DNAPL, which was detected in the Walnut Formation at nearby well W–5 (pl. 1).

GR–2

The field-data inverted section and the synthetic-data inverted section are substantially different. Anomalously high resistivities appear in areas 1–4. The cause of the anomalously high resistivities in areas 1 and 2 is unknown; the high resistivities could be the result of buried utilities or fill. The anomalously high resistivity in area 3 could be caused by DNAPL, which was detected in the Walnut Formation at nearby well W–21 (pl. 1), or it could be a function of variations in the lithology of the Walnut Formation. The anomalously high resistivity in area 4 is substantially higher than any of the other resistivities; this anomaly could be caused by DNAPL in the Walnut Formation.

GR–3

Similar to transect GR–1, transect GR–3 shows little variation between the field-data inverted section and the synthetic-data inverted section. Resistivities in the alluvium/fill are slightly higher in the field-data section than in the synthetic-data section. The anomalously low resistivity in area 1 could be caused by saturation of the Walnut Formation in this area. Anomalously high resistivities in areas 2–4 could be caused by a variation in the lithology of the Walnut Formation; the Walnut Formation might contain less clay in those areas.

GR–4

The inverted field data and the inverted lithologic model are substantially different. The differences could be caused by lithologic variations or invalid field data. The root-mean-square (RMS) error was higher in this transect than in any of the other transects, which indicates that the field data could be deficient. The anomalously high resistivities in areas 1 and 2 could be caused by anthropogenic structures, such as wells, or by fill material. The anomalously high resistivities in areas 3 and 4 could be caused by variations in the character of the Walnut Formation or possibly DNAPL in the Walnut Formation.

Horizontal Sections

Arranging the 2D dc resistivity transects in an intersecting, grid-like fashion in the west parking lot during data collection made it possible to obtain quasi-three-dimensional (3D) data. In addition to the 10 vertical (x-z plane) sections shown in plates 6, 10, and 11, a series of four horizontal sections (x-y plane) also were constructed. Point-resistivity data collected in the field by the Sting/Swift system are located at specific x-y-z locations. The resulting dataset can be inverted using RES2DINV to yield data from which horizontal sections at specified depths (or altitudes) can be constructed. To generate horizontal sections, the data from transects PL–1 through PL–6 were output from RES2DINV as x-y-z point values. Altitudes along transects were not uniform because of land-surface topographic variations. To compensate, a linear weighted average of resistivities derived from points above and below the target altitude were computed over the length of each transect. The resulting set of point values for each transect at the target altitude then was plotted on a geographically referenced map of the site. The values then were hand-contoured using the same intervals as those of the field-data inverted vertical sections.

Contouring areas predominantly composed of fill tends to be misleading because the character of fill material can be highly variable over a small area. As a result, horizontal sections above an altitude of 192 m above sea level were not considered because of their increased contact with the fill material of LF1.

Four horizontal sections through the west parking lot were generated at altitudes of 192, 190, 188, and 186 m above sea level (pls. 12, 13, 14, 15, respectively). Transects at altitudes below 186 m also were not considered because data typically are collected in a triangular or trapezoidal fashion (pl. 6d). As a result, data become increasingly sparse at depth, making generation of a horizontal section at altitudes below 186 m impractical. Land-surface altitudes in the rectangular area selected for horizontal sections (pl. 1) range from slightly less than 197 m in the southeastern corner to slightly more than 194 m in the northwestern corner.

The resistivity recorded at each point in a survey actually is a weighted average of resistivities over a hemispherical area surrounding that point. These hemispheres become larger with depth; therefore, small features that would be distinguishable near the top of an inverted vertical section are masked at depth, resulting in a decrease of detail with depth. A 2-m spacing between horizontal sections was used because the variation between sections at a 1-m spacing was negligible in many places.

Figure 2 shows a 3D representation of all four horizontal sections. The sections show generally increasing resistivity with decreasing altitude that most likely results from the increased influence of the Walnut Formation, which has a higher resistivity than the terrace alluvium/fill.

Section 192

In general, resistivities are low in this horizontal section (pl. 12), but there is a high degree of variability in resistivity in small areas. The resistive properties of the fill material used in the west parking lot probably are responsible for these resistivity anomalies. On the basis of data from lithologic logs prepared by IT Corporation, the resistivity of the fill material has the potential for high variability over short distances.

The area of low resistivity near the intersection of PL–1 and PL–5 could be caused by wet sediment conditions, possibly in conjunction with conductive contaminants in the ground water. Metal debris, as described in the lithologic log for well W–17 (pl. 1), also could be responsible. The high-resistivity area centered near the 90-m mark of transect PL–2 most likely is associated with highly resistive pea gravel used in the construction of French drain 2. The cause of the high resistivity at 140 m on transect PL–3 is unknown, but it probably is not deep enough to be caused by DNAPL in the Walnut Formation.

Section 190

Resistivities over most of horizontal section 190 (pl. 13) are slightly higher than those in section 192. The higher resistivities probably are a function of increased influence of the Walnut Formation, which has a higher resistivity than the terrace alluvium/fill. The area of low resistivity in section 192 near the intersection of PL–1 and PL–5 is still present in section 190, but it is less salient. The decrease in resistivity there could be a lithologic transition from the highly resistive fill to the less resistive terrace alluvium or could be caused by the masking effects of a high-resistivity area between the 120- and 130-m marks of PL–1. This high-resistivity area could be caused by DNAPL in the Walnut Formation. The high-resistivity area centered near the 90-m mark of transect PL–2 has increased in extent and

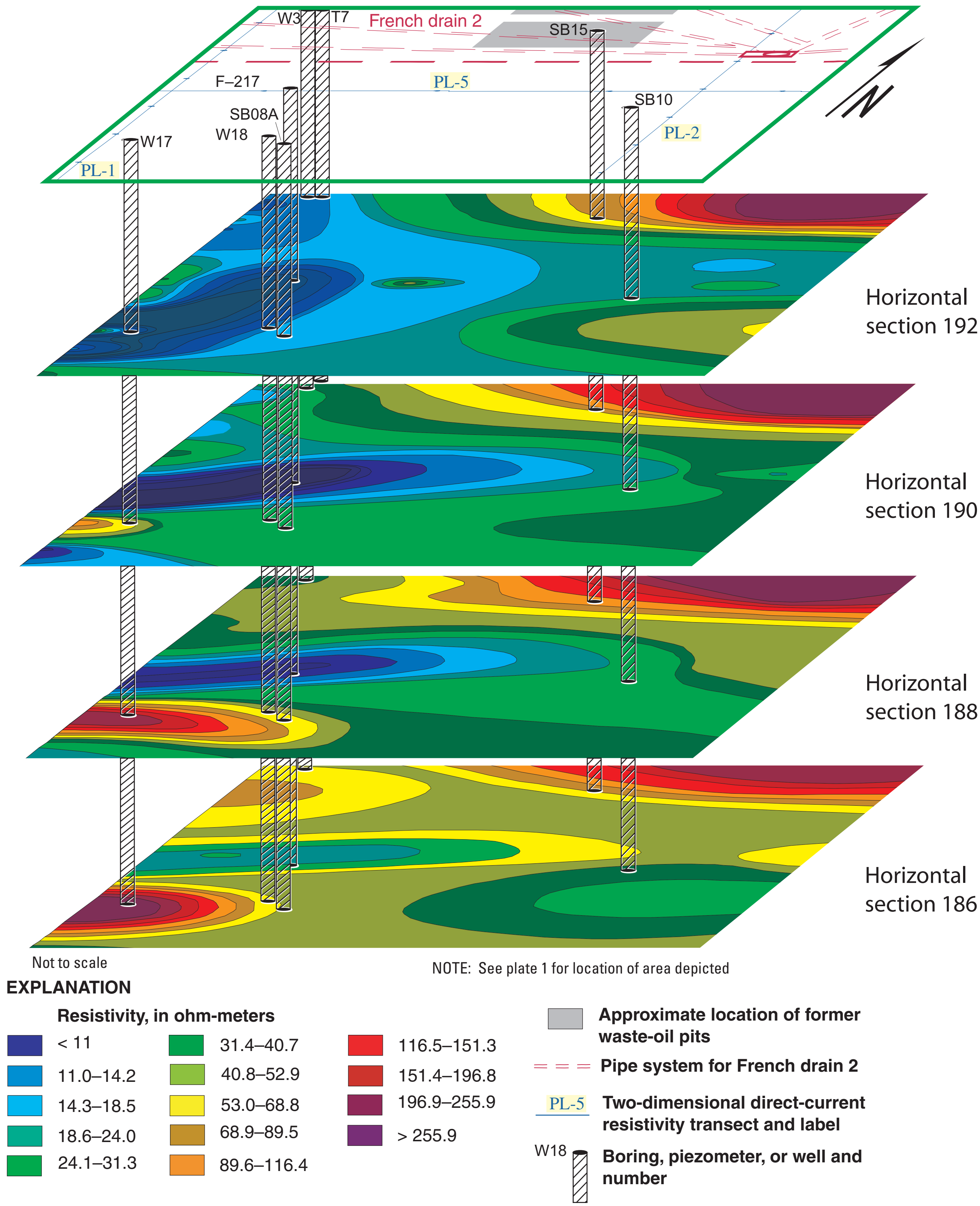

Figure 2. Three-dimensional representation of inverted resistivity from field data along four horizontal sections at altitudes of 192, 190, 188, and 186 meters above sea level in the west parking lot of Air Force Plant 4, Fort Worth, Texas.

magnitude over that feature in section 192 most likely because this section is closer to the center of the backfill area for French drain 2. The high resistivity at 140 m in transect PL–3 is decreasing in magnitude as a function of depth, which indicates that the source of the anomaly probably is closer to an altitude of 192 m. This decrease with depth supports the supposition that the anomaly is not caused by DNAPL in the Walnut Formation. An additional anomalous high near the 45-m mark of transect PL–4 also is present in this section. The cause of this anomaly is unknown, but it might be DNAPL in the Walnut Formation, even though this anomaly is outside the projected extent of DNAPL in the Walnut Formation on the basis of IT Corporation field observations.

Section 188

This horizontal section (pl. 14) looks similar to section 190, but with slightly higher resistivities over most of the area. The probable reason for higher resistivities is the increased influence of the Walnut Formation, which has a higher resistivity than the terrace alluvium/fill. Resistivity is substantially higher near the 130-m mark of transect PL–1 than that in section 190. The high resistivity could be caused by proximity to DNAPL in the Walnut Formation. Resistivities near the 90-m mark of transect PL–2 are slightly less than those in section 190, most likely because this section intersects the Walnut Formation there and is not in contact with the more resistive pea gravel backfill. The high-resistivity area centered near the 45-m mark of transect PL–4 has greater magnitude than its counterpart in section 190, which supports the supposition that it could be caused by the presence of DNAPL in the Walnut Formation.

Section 186

Resistivities are greater in this horizontal section (pl. 15), which is entirely in the Walnut Formation, than in the three higher altitude sections. The anomalously high resistivity centered near the 130-m mark of transect PL–1 continues to increase in magnitude compared with this feature in the section above as the (probable) influence of DNAPL in the Walnut Formation continues to increase. A low-resistivity area between the 150- and 180-m marks of transect PL–3 also is becoming more prominent as depth increases. This increased prominence could be caused by saturation of the Walnut Formation in this area.

SUMMARY

During September 1999, the USGS made ten 2D dc resistivity profile surveys in the west parking lot and LF3 areas of AFP4 to characterize geophysical anomalies that could indicate potential contamination, contaminant pathways, or anthropogenic structures. Alluvial sediments and fill material (alluvium/fill) immediately underlie the site. The fill consists of much construction debris. Below the alluvial sediments and fill is the Walnut Formation, a bedrock unit that is considered a confining unit. Beneath the Walnut Formation is the Paluxy Formation, which is used as a water-supply aquifer for the city of White Settlement, located directly southwest of AFP4.

Direct-current resistivity profiling measures the electrical resistivity distribution in the subsurface by transmitting low-frequency direct current into the ground at one pair of electrodes and measuring the potential difference at a second pair of electrodes along a transect. To estimate the true subsurface resistivity, measured apparent resistivity data were transformed into a 2D distribution of resistivity along a section of the subsurface using the iterative software tool RES2DINV; this process is called inversion. After obtaining the inverted section based on field data, synthetic apparent resistivity data based (in the case of this study) on lithologic data are generated using another software tool, RES2DMOD, and then input to RES2DINV, which results in another 2D model of resistivity along a section of the subsurface. The two inverted resistivity sections—one from the field data and one from the synthetic data—then are compared. The resistivity distribution of the synthetic-data inverted section reflects only undisturbed lithology, whereas the resistivity distribution of the field-data inverted section reflects actual subsurface conditions. Thus, qualitatively comparing the two sections is a way to identify locations and orientations of anomalously high or low resistivity.

Six of the 10 surveys done (transects PL–1 through PL–6) were in the west parking lot. Each of the inverted sections of these transects had anomalously high resistivities in the terrace alluvium/fill that probably were caused by the highly resistive fill material. In addition, each of these transects had anomalously low resistivities in the Walnut Formation that could have been caused by saturation of fractures within the Walnut Formation. A high-resistivity anomaly in the central part of the study area (northern part on the west parking lot immediately east of Bomber Road) probably

is associated with pea gravel fill used in construction of French drain 2. Another high-resistivity anomaly in the west parking lot slightly southeast of French drain 2 could be caused by DNAPL in the Walnut Formation.

Three of the four remaining surveys (transects GR–1 through GR–3) were along Bomber Road, and one (transect GR–4) was inside the fenced area of LF3. The inverted sections of these four transects tended to have slightly higher resistivities in both the alluvium/fill and the Walnut Formation than the transects in the west parking lot. The higher resistivities in the alluvium/fill could have been caused by drier conditions in grassy areas relative to conditions in the west parking lot. Higher resistivities in parts of the Walnut Formation also could be a function of drier conditions or variations in the lithology (such as clay content) of the Walnut Formation.

In addition to the 10 vertical (x-z plane) sections, four horizontal sections (x-y plane) were constructed for a rectangular area in the west parking lot that ranged in land-surface altitude from slightly less than 197 m above sea level to slightly more than 194 m. The horizontal sections, at altitudes of 192, 190, 188, and 186 m, were constructed to support visualization of lateral as well as vertical resistivity variations. The sections show generally increasing resistivity with decreasing altitude that most likely results from the increased influence of the Walnut Formation, which has a higher resistivity than the terrace alluvium/fill.

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