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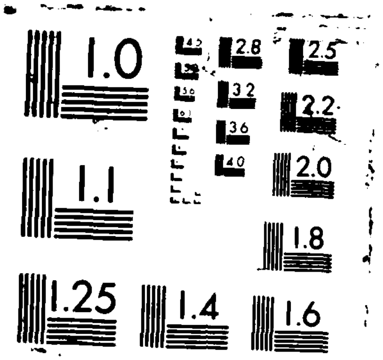
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INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION
STAGE 1

FINAL REPORT
FOR
AIR FORCE PLANT 4
FORT WORTH, TEXAS

VOLUME 1. REPORT TEXT

HEADQUARTERS AERONAUTICAL SYSTEMS DIVISION
FACILITIES MANAGEMENT DIVISION (ASD/PMDA)
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433-6503

AND

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RADIAN
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The Department of Defense's Installation Restoration Program (IRP) is a four-phase program to identify past waste disposal practices, evaluate the environmental impacts, propose mitigation measures, and remediate environmental problems. An IRP investigation is currently underway at AF Plant 4, Texas. Phase I, an initial assessment and records search to locate potential environmental problems associated with waste disposal practices, was completed in 1984. Phase II, a field program to investigate potential environmental contamination, has been under way since 1985 under the direction of the U.S. Air Force Occupational and Environmental Health Laboratory (USAFOEHL). Radian Corporation of Austin, Texas, has performed Stage 1 of the Phase II investigation which is reported in this document. The Phase II investigation has

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EXECUTIVE SUMMARY

INTRODUCTION

The Department of Defense (DOD) is conducting a nation-wide program to evaluate past waste disposal practices on DOD property, to control the migration of hazardous contaminants, and to control hazards that may result from these waste disposal practices. This program, the Installation Restoration Program (IRP), consists of four phases: Phase I, Initial Assessment/Records Search; Phase II, Problem Confirmation/Quantification; Phase III, Technology Base Development; and Phase IV, Operations. The United States Air Force is conducting an IRP investigation at Air Force Plant 4 (AF Plant 4) near Fort Worth, Texas. Radian Corporation has performed this Phase II Stage 1 Field Evaluation under USAF Contract No. F33615-83-D-4001, Delivery Order 27. Authorization to proceed on this study was given on 13 September 1985. Field activities were performed from November 1985 to August 1986.

PURPOSE OF THE INVESTIGATION

The purpose of the AF Plant 4 investigation was to define the presence, magnitude, extent, direction and rate of movement of any identified contaminants. In addition, the body of geological and chemical data developed by General Dynamics, operator of the plant, was to be used in the investigation. Finally, additional investigations required beyond this stage, including an estimate of costs (provided separately) were to be determined.

A contaminant source investigation at AF Plant 4 was conducted to determine: (1) the presence or absence of contamination within the specified areas of the field survey; (2) if contamination exists, the potential for migration in the various environmental media; (3) the extent/magnitude of contamination on AF Plant 4 property; and (4) the potential environmental consequences and health risks of migrating contaminants, based on state or federal standards for these contaminants.

Operations at AF Plant 4 center around the production of military aircraft and associated equipment. Industrial operations have been continuous since AF Plant 4 went into production in 1942. The manufacturing of aircraft and associated equipment generates varying quantities of waste oils (including lubricating oils, hydraulic fluids, and coolants), recoverable fuels, solvents (including degreasers and paint thinners), paint residues (including waste liquid paints and paint booth sludges), and spent process chemicals (including acids, caustics, chromium, and cyanide solutions). The total quantity of these wastes currently ranges from about 5,500 to 6,000 tons/year. However, waste quantities depend on the level of contractor activity, which has varied with time.

ENVIRONMENTAL SETTING

AF Plant 4 is located six miles west of the center of Fort Worth in Tarrant County, Texas (Figure ES-1). The facility is bordered by Lake Worth on the north, Carswell AFB on the east, and the community of White Settlement on the west and south.

AF Plant 4 is situated in an area of primarily residential, recreational, and industrial/commercial land use. The topography of the plant is fairly flat except for areas near the creek parallel to Meandering Road. This creek discharges to Lake Worth, Farmer's Branch, and the Trinity River. Land surface slopes gently northeast toward Lake Worth and east toward the West Fork of the Trinity River. Elevations range from a high of approximately 627 feet MSL at the southwest corner of the plant to a low of approximately 600 feet MSL north of the plant at Lake Worth. Surface drainage at AF Plant 4 is intercepted by storm drains and culverts and is discharged to Lake Worth, the Meandering Road Creek, or a tributary of Farmer's Branch.

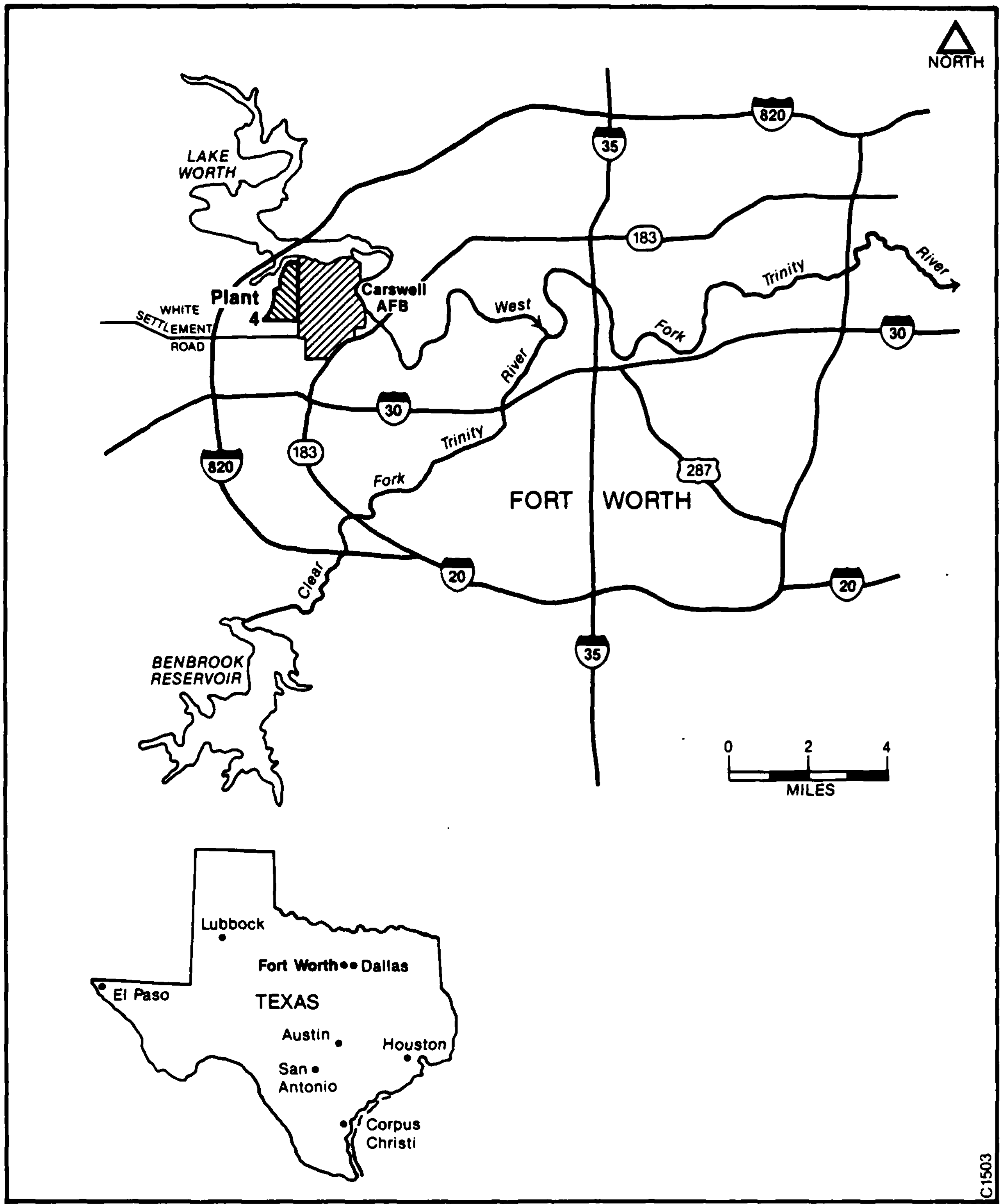

Figure ES-1. General Location of AF Plant 4, Texas

19. Abstract (continued)

focused on closing existing data gaps and evaluating other study topics using the results of previous hydrogeologic investigations sponsored by General Dynamics Corporation, the operating contractor of AF Plant 4.

The Phase II field study was conducted between November 1985 and August 1986. The investigation focused on continued monitoring of existing wells at known waste disposal sites, developing new field data at previously uninvestigated sites, evaluating possible trends in groundwater development and implications for groundwater movement at AF Plant 4, and recommendations concerning future monitoring, additional field programs, and planning for remedial actions. The field program involved terrain conductivity surveys at 3 sites; drilling of 12 soil borings and 6 hand auger holes; installation of 9 shallow monitor wells and 4 Paluxy monitor wells; and the collection and chemical analysis of surface water samples at 11 locations, and groundwater samples at 113 wells.

Results of the Phase II field investigation have confirmed and supported earlier hydrogeologic studies conducted at AF Plant 4. A variety of organic compounds and heavy metals, some at high levels, occur as shallow groundwater contaminants associated with waste disposal sites. Groundwater in the Paluxy aquifer, separated from upper zone contamination by shale and limestone, is generally free of contamination except in a few isolated areas. Water quality in Meandering Road Creek, which forms the western boundary of AF Plant 4 and is a potential receptor of shallow groundwater contamination, has low to non-detectable levels of contamination.

Each of the 21 sites were categorized according to Air Force criteria: 1) no further investigation required (8 sites), 2) additional work needed (1 site), or 3) institute planning for remedial actions (12 sites).

PREFACE

Radian Corporation is the contractor for the Installation Restoration Program (IRP) Phase II, Stage 1 investigation at Air Force Plant 4, Texas. The work was performed for the USAF Occupational and Environmental Health Laboratory (USAFOEHL) under USAF Contract No. F33615-83-D-4001, Delivery Order Number 27.

Field investigation activities included: installation of nine upper zone and four Paluxy aquifer monitor wells; drilling of nine soil borings; completion of six hand-auger borings; conduct of two surface geophysical surveys and a soil gas survey; and collection of soil, groundwater and surface water samples for chemical analysis. Additionally, the effects of continued pumping of water supply wells on the Palauxy aquifer were evaluated and the existing monitor wells were evaluated for inclusion in a long-term monitoring program.

Key Radian project personnel were:

- Francis J. Smith - Contract Program Manager
- Lawrence N. French and William M. Little - Delivery Order Managers
- Tobin K. Walters and Peter A. Waterreus - Supervising Geologists and Report Authors
- Wendy J. Johnson - Groundwater Sampling Team Leader and Report Author
- Ann E. St. Clair - Senior Technical Reviewer
- Fred L. Shore - Senior Chemistry Reviewer

Radian would like to acknowledge the cooperation and assistance of the USAF Plant 4 representative, Maj. Lussier. In addition, Radian acknowledges the assistance of W. C. Rosenthal, G. Long, and M. D. Stuckey of the General Dynamics staff.

The work presented herein was accomplished between November 1985 and September 1986. Maj. George R. New and Capt. Arthur S. Kaminski, Technical Services Division, USAFOEHL, were the Technical Program Managers.

Approved: ______________________
Francis J. Smith, P. E.
Contract Program Manager

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Geologic units underlying AF Plant 4, from youngest to oldest, are as follows: 1) Quaternary Alluvium, 2) Cretaceous Goodland Limestone, 3) Cretaceous Walnut Formation, 4) Cretaceous Paluxy Formation, 5) Cretaceous Glen Rose Formation, and 6) Cretaceous Twin Mountains Formation. Only the first four are exposed at the surface at the plant. Most of the plant is covered by alluvium deposited by the Trinity River during flood stages. The alluvium is composed of gravel, sand, silt, and clay of varying thicknesses and lateral extents.

AF Plant 4 is located in a structurally stable setting. No major faults or fracture zones have been mapped near the base. The regional dip of the rocks beneath AF Plant 4 is between 35 and 40 feet per mile in an easterly to southeasterly direction.

On the basis of their water-bearing properties, the geologic units at AF Plant 4 may be divided into five hydrogeologic units, listed in order of increasing depth: 1) an upper perched-water zone occurring in the alluvial terrace deposits left by the Trinity River; 2) an aquitard of predominantly dry limestone of the Goodland and Walnut Formations; 3) an aquifer in the Paluxy Sand; 4) an aquitard of relatively impermeable limestone in the Glen Rose Formation; and 5) a major aquifer in the sandstone of the Twin Mountains Formation.

Groundwater present in the upper zone occurs as a perched system and, in general, is not hydraulically connected to the underlying aquifers. For the most part, groundwater in the upper zone is not developed because of the water's limited distribution and susceptibility to surface pollution. The perched water present in the upper zone is separated from the aquifers below by the low permeability limestones and shales of the Goodland Limestone and Walnut Formation.

The Paluxy aquifer, the shallowest bedrock aquifer occurring beneath AF Plant 4, is divided into upper and lower water-bearing zones. Most wells are completed in the lower Paluxy. Regional groundwater flow within the

Paluxy is southeastward, in the direction of the regional dip. At Plant 4, groundwater flow is influenced by recharge from Lake Worth, which creates a potentiometric high, and by groundwater withdrawals by the community of White Settlement. This drawdown results locally in a more southerly flow direction within the Paluxy aquifer.

Below the Paluxy aquifer is the Glen Rose Formation, an aquitard restricting water movement between the Paluxy aquifer above and the Twin Mountains aquifer below. The Twin Mountains aquifer is the principal aquifer in Tarrant County.

SITE DESCRIPTIONS

Phase II Stage 1 work at AF Plant 4 has focused on the 21 waste sites and four study topics listed in Table ES-1 and shown in Figure ES-2. Most of the site information was obtained from the Installation Restoration Program Phase I IRP records search report (CH2M Hill, 1984). These IRP sites are described briefly in the following paragraphs.

Site 1, Landfill 1

From 1942 until about 1966, several types of hazardous and nonhazardous wastes were reportedly disposed of in Landfill 1. These wastes included drums of liquid and contents of tanks and bousers loaded with chemical wastes (solvents, thinners, paints, etc.). Contaminated oils, fuels, and hazardous wastes containing metals, chromate sludges, and cyanide are suspected to be present at this site.

Since it was closed during the 1960s, extensive remedial action has been conducted at this site. The major action was the removal of 11,000 cubic yards of earth and the installation of a drain field (French Drain No. 2).

Site 3, Landfill 3

From about 1942 to 1945, this site was reportedly used for the disposal of wastes, including hazardous wastes consisting of mixed oils and solvents. At least one pit (possibly more) in this area was used for holding and burning some of the liquid wastes during the 1940s. Other wastes are suspected to have been disposed of on the ground and later buried. From 1966 until 1967, fill dirt and rubble were used to finish filling and grading this site.

TABLE ES-1. IRP PHASE II STAGE 1 SITES AND STUDY TOPICS AT AF PLANT 4, TEXAS

SITES:

- Site 1, Landfill 1
- Site 3, Landfill 3
- Site 12, Chrome Pit 3
- Site 17, Former Fuel Storage Site
- Site 2, Landfill 2
- Site 4, Landfill 4
- Zone 1 (Site 13, Die Pits; Site 11, Chrome Pit 2; Site 8, Fire Department Training Area 5)
- Site 15, Fuel Saturation Area 2
- Site 20, Wastewater Collection Basins
- Site 16, Fuel Saturation Area 3
- Site 9, Fire Department Training Area 6
- Site 6, Fire Department Training Area 3
- Site 7, Fire Department Training Area 4
- Site 18, Solvent Lines
- Site 10, Chrome Pit 1
- Site 5, Fire Department Training Area 2
- Site 14, Fuel Saturation Area 1
- Site 19, Nuclear Aerospace Research Facility (NARF) Area
- Jet Engine Test Stand, Building 21

ADDITIONAL STUDY TOPICS:

- East Parking Lot
- Fuel Storage Tank
- Lake Worth Monitor Well
- Ambient Monitoring

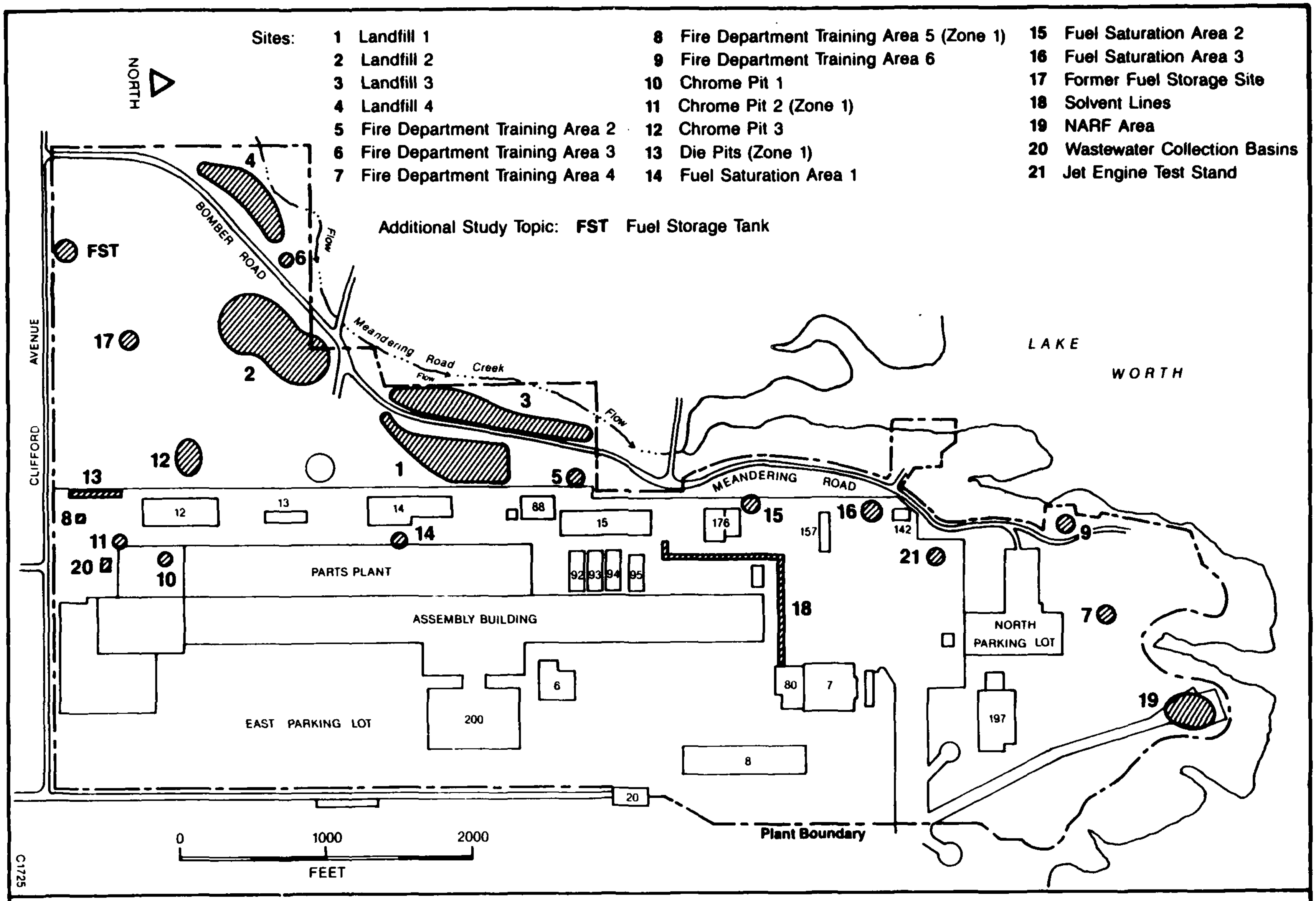

Figure ES-2. Phase II Stage 1 Study Sites, AF Plant 4, Texas

Site 12, Chrome Pit 3

Chrome Pit 3 was used for the disposal of chromate and other chemical wastes from about 1957 until 1973. Barium chromate sludge, dilute metal solutions, and drums of unidentified liquids were disposed of in this pit.

Site 17, Former Fuel Storage Site

A 100,000-gallon above-ground JP-4 storage tank existed at this site from the early 1940s until it was relocated from here in 1962. Sampling at this site in 1982 confirmed that soils and underlying groundwater are contaminated by fuels and other organic compounds.

Site 2, Landfill 2

The site originally consisted of some low areas and a livestock watering hole. Most of this site was reportedly filled with construction rubble, plaster, and fill dirt during the early 1940s. However, 1962 aerial photographs show some unspecified activity at the stock watering hole. This area was reportedly used for the disposal of lumber and tires that were assumed to be periodically burned. No reports exist of hazardous substances being deposited at this site. The Phase I report provided no additional data on the nature of the activity at this site.

Site 4, Landfill 4

Landfill 4 was reportedly used for the disposal of clean construction rubble from 1956 until the early 1980s. Aerial photographs and a 1973 memo indicate that other types of wastes may have been disposed of at this site from 1966 until at least 1973. This evidence suggests that small quantities of hazardous wastes (solvents, oils, fuels, thinners, etc.) are present in this landfill.

Zone 1

Three sites were combined into one zone for study purposes. Descriptions of these sites are given below.

> Site 13, Die Pits: These pits were used for the disposal of chromate sludges, metal solutions, and other chemical wastes until 1962, when the site was graded and the entire die yard was paved. One Phase I interviewee reported that some of the contaminated soils at this site were spread around the die yard during the grading and leveling activities. The site of the original pits was excavated in 1983-84. Soils from other parts of the die yard were not analyzed at that time.
>
> Site 11, Chrome Pit 2: According to the Phase I study, miscellaneous liquid and solid wastes, in addition to chromate solutions, were probably disposed of here. Neither interviews nor aerial photographs could confirm the exact location of this site.

Site 8, Fire Department Training Area (FDTA) 5: This site consisted of a shallow pit in which waste fuels, oils, and chemicals were burned and extinguished for training exercises. This site, which has been graded and paved, is located in the die yard area south of Warehouse 1.

Site 15, Fuel Saturation Area (FSA) 2

This site reportedly became saturated with fuels from leaks in buried fuel lines between the 1970s and early 1980s.

Site 20, Wastewater Collection Basins

Two concrete-lined waste basins, each with a capacity of approximately 85,000 gallons, are used to collect and settle suspended solids from chemical wastewaters before discharge to the City of Fort Worth sanitary sewage system. The basins have been in use since about 1966. Evidence indicates that several spills from the vapor degreaser tanks in the Process Building have occurred since installation of these tanks. Some of the spilled chemicals (primarily trichloroethylene) have flowed to the basins via floor drains. These basins are suspected of being a possible source of organic heavy and metal groundwater contamination.

Site 16, Fuel Saturation Area 3

This site reportedly became saturated with fuels from leaks in buried fuel lines between the mid-1970s and the early 1980s. This site is the subject of current remedial action planning by Intellus.

Site 9, Fire Department Training Area 6

Before 1970, training exercises were conducted twice a year at this site. After 1970, exercises were conducted at monthly intervals. Approximately 250 gallons of waste fuels and oils were reportedly used for each exercise. In addition, the Phase I report indicates that larger quantities of contaminated fuels and oils were probably deposited in the FDTA between exercises.

Site 6, Fire Department Training Area 3

Training exercises at this site also used about 250 gallons of waste fuels and oils per exercise. The location and current condition of FDTA 3 could not be accurately determined because it is not visible on historical aerial photographs.

Site 7, Fire Department Training Area 4

Fire training exercises were reportedly conducted here. Since this site is not visible on historical aerial photographs, its location and current condition are not accurately known. The area is also believed to have received fill material originating from a foundation excavation at the Administration Building.

Site 18, Solvent Lines

These lines reportedly leaked during the 1940s before they were drained, capped and abandoned in 1944. The Phase I study could not determine the actual locations of the leaks. These solvent lines reportedly contained xylene, methyl ethyl ketone, and kerosene.

Site 10, Chrome Pit 1

Miscellaneous liquid and solid chemical wastes, in addition to chrome wastes, were probably disposed of at this site. The actual location of this site is thought to be somewhere beneath the Process Building, but the Phase I report could not accurately confirm this. No monitor wells exist in the immediate vicinity of this site.

Site 5, Fire Department Training Area 2

Exercises were held infrequently (twice a year) at this site. However, disposal of waste oils and fuels and uncontrolled burns may have been more frequent. This site is located under the pavement in the west employee parking area.

Site 14, Fuel Saturation Area 1

The ground at this site, located just west of the Parts Plant, reportedly became saturated by fuels from leaking fuel lines from the mid-1970s to the early 1980s. This site is the subject of Phase IV Remedial Action planning by Intellus.

Site 19, Nuclear Aerospace Research Facility (NARF) Area

The Nuclear Aerospace Research Facility (NARF), formerly located at the north end of AF Plant 4, housed several experimental atomic reactors between 1953 and 1974. The facility was decommissioned and disposed of by contractor in 1974.

Jet Engine Test Stand, Building 21

This site was not identified in Phase I. The jet engine test building is located north of a fuels test area, previously identified as

Site 16, a known area of fuel contamination. The sump downslope of Building 21, constructed in 1975, collects water used for cooling, noise suppression, and clean-up in Building 21. This water is pumped into the industrial waste line. The area immediately south of Building 21 contains two underground tanks once used for fuel storage. These tanks are being investigated as potential sources of contamination under a separate underground tank investigation being conducted as part of IRP activities by the operating contractor, General Dynamics. Outfall 3 is downgradient of Building 21 and is regularly sampled as part of IRP and NPDES monitoring activities.

SCOPE OF PHASE II STAGE 1 INVESTIGATION

Table ES-2 summarizes the field activities performed at each site in the IRP Phase II Stage 1 investigation at AF Plant 4. Table ES-3 is an analytical schedule for all samples, by site.

In addition to the studies associated with the waste sites, additional study topics were identified for inclusion in the Phase II Stage 1 field investigation. These included:

- Ambient monitoring of several wells at AF Plant 4 that are not associated with a particular waste disposal site or suspected spill area;
- Sampling and analysis of five wells located in the vicinity of the East Parking Lot to test for the presence of contaminants in the vicinity of a suspected zone of communication between the upper zone and the Paluxy aquifer;
- Sampling an existing upper zone monitor well for the presence of fuel contamination near an above-ground JP-4 storage tank; and
- Installation, sampling, and analysis of a well in the northern part of AF Plant 4 that borders Lake Worth.

TABLE ES-2. SUMMARY OF IRP PHASE II, STAGE 1 INVESTIGATION ACTIVITIES, AF PLANT 4, TEXAS

Site	Investigation Activities	Purpose	Map Location
Landfill 1	1. Sample surface water at 5 locations on Meandering Road Creek and the creek seep. 2. Sampling French drains 1 and 2 and the drain pipe. 3. Sample groundwater from 6 existing upper zone and 2 Paluxy wells.	1. Evaluate possible impact of landfill leachate on creek. 2. Characterize leachate discharge. 3. Evaluate possible effect of landfill on groundwater.	Figure 3-2.
Landfill 3	1. Conduct a terrain conductivity survey. 2. Install Paluxy monitor well screened in upper sand member. 3. Sample groundwater from 9 existing upper zone wells and 1 new Paluxy well.	1. Determine presence and possible configuration of the landfill. Use data to determine if additional drilling required. 2. Evaluate Paluxy groundwater directly downgradient of landfill. 3. Evaluate possible effect of landfill on groundwater.	Figure 3-2.
Chrome Pit 3	1. Sample groundwater from 8 existing upper zone wells and 1 Paluxy well.	1. Determine post-closure groundwater quality.	Figure 3-4.

(continued)

TABLE ES-2. (Continued)

Site	Investigation Activities	Purpose	Map Location
Former Fuel Storage Site	1. Install 1 upper zone well. 2. Sample groundwater from 2 existing and wells 1 new upper zone well.	1. Provide data on groundwater flow and quality in Radar Range area. 2. Evaluate possible effect of former fuel storage site on groundwater.	Figure 3-5.
Landfill 2	1. Conduct a terrain conductivity survey. 2. Install Paluxy monitor well in upper sand member. 3. Sample groundwater from 7 upper zone wells and 1 new Paluxy well.	1. Determine landfill limits and horizontal extent of contamination, if any. 2. Evaluate Paluxy groundwater directly downgradient of landfill. 3. Evaluate possible effects of landfill on groundwater.	Figure 3-5.
Landfill 4	1. Install 1 upper zone well and 1 Paluxy well screened in middle sand unit (upper unit was dry). 2. Sample groundwater from 3 upper zone wells and 1 Paluxy well.	1,2. Determine possible effects of landfill on groundwater.	Figure 3-5.

(continued)

TABLE ES-2. (Continued)

Site	Investigation Activities	Purpose	Map Location
Zone 1	1. Drill borehole at FDTA 5. 2. Sample groundwater from 7 existing upper zone wells and 1 Paluxy well.	1. Determine soil conditions and presence of water underlying FDTA 5. 2. Evaluate possible effects of disposal pits and fire training area on groundwater.	Figure 3-4.
Fuel Saturation Area 2	1. Drill 3 boreholes along the length of the buried fuel line. 2. Sample groundwater and measure fuel lens at 1 upper zone well.	1. Determine soil conditions and presence of fuel in the subsurface. 2. Evaluate possible effect of fuel line on groundwater.	Figure 3-6.
Wastewater Collection Basins	1. Install 1 upper zone monitor well (located south of site because of access restrictions). 2. Sample groundwater from 5 upper zone wells. 3. Determine location and depth of buried sanitary and industrial waste lines. Evaluate need for additional sampling and analysis of soil.	1,2. Evaluate possible effects of basins on groundwater. 3. Evaluate effect of lines, if any, on movement of contamination in subsurface.	Figure 3-4.

(continued)

TABLE ES-2. (Continued)

Site	Investigation Activities	Purpose	Map Location
Fuel Saturation Area 3	1. Sample groundwater at 1 upper zone well.	1. Evaluate possible effect of buried fuel line on groundwater.	Figure 3-7.
Fire Department Training Area 6	1. Hand-auger and collect shallow soil samples for analysis. 2. Sample groundwater from 1 Paluxy well.	1. Determine possible effects of fire training exercises on shallow soil. 2. Evaluate groundwater quality of Paluxy upgradient of AF Plant 4.	Figures 3-7, 8.
Fire Department Training Area 3	1. Install 1 upper zone monitor well west of FDTA 3 (monitor well already exists at site). 2. Sample groundwater from 2 upper zone wells.	1. Determine groundwater flow conditions west of *FDTA* 3. 2. Evaluate possible effects of FDTA 3 on groundwater.	Figure 3-5.
Fire Department Training Area 4	1. Conduct a soil-gas survey.	1. Determine location of FDTA 4 and possible effects on shallow soil.	Figure 3-7.
Solvent Lines	1. Install 1 upper zone monitor well. 2. Sample groundwater from 4 upper zone monitor wells.	1. Improve monitoring coverage of groundwater conditions. 2. Evaluate possible effect of solvent lines on groundwater.	Figure 3-6.

(continued)

TABLE ES-2. (Continued)

Site	Investigation Activities	Purpose	Map Location
Chrome Pit 1	1. Install upper zone monitor well east of site (outside of building).	1. Evaluate groundwater conditions east of Chrome Pit 1.	Figure 3-4.
	2. Sample groundwater from 2 upper zone wells.	2. Evaluate possible effect of Chrome Pit 1 on groundwater.	
Fire Department Training Area 2	1. Conduct a terrain conductivity survey.	1. Determine the extent of a hydrocarbon plume, if any.	Figure 3-2.
	2. Sample groundwater from 7 upper zone wells.	2. Evaluate possible effect of FDTA 2 on groundwater.	
Fuel Saturation Area 1	1. Drill 1 borehole near FSA 1.	1. Determine soil conditions and presence of fuel in subsurface.	Figure 3-2.
	2. Sample groundwater from 2 upper zone wells, 1 upper zone borehole, and 2 Paluxy wells.	2. Evaluate effects of FSA 1 on groundwater.	
NARF	1. Drill 4 boreholes in the upper zone.	1. Determine shallow soil conditions and presence of RAM in soil.	Figure 3-7.
	2. Sample groundwater from 3 upper zone wells.	2. Evaluate possible effect of NARF on groundwater.	
	3. Conduct review of NARF and White Settlement records for radionuclide analyses.	3. Determine past operations and exact location of NARF.	

(continued)

TABLE ES-2. (Continued)

Site	Investigation Activities	Purpose	Map Location
Jet Engine Test Stand	1. Install 3 upper zone wells and drill 2 boreholes. 2. Sample groundwater from 3 upper zone monitor wells. 3. Sample surface water at Outfalls 1 and 5.	1. Collect and analyze soil samples and evaluate groundwater flow and chemistry. 2. Evaluate possible effect of Jet Engine Test Stand on groundwater. 3. Evaluate effect of discharge to surface water near facility.	Figure 3-7.
Ambient Monitoring	1. Sample groundwater from 11 upper zone wells and 8 Paluxy wells.	1. Evaluate groundwater quality in areas away from waste disposal spill sites.	Figure 3-9.
East Parking Lot	1. Sample groundwater from 3 upper zone monitor wells and 2 Paluxy wells.	1. Evaluate groundwater quality at east portion of AF Plant 4.	Figure 3-10.
Fuel Storage Tank	1. Sample groundwater from upper zone well HM-23.	1. Evaluate possible effect of the Fuel Storage Tank on groundwater.	Figure 3-5.
Lake Worth Monitor Well	1. Install 1 Paluxy well near Lake Worth.	1. Evaluate groundwater quality of Paluxy aquifer near recharge source, Lake Worth.	Figure 3-9.

TABLE ES-3. ANALYTICAL SCHEDULE FOR SOIL AND WATER SAMPLES, IRP PHASE II, STAGE 1, AF PLANT 4, TEXAS

Site	Location	Sample Type	VOC	BNA	O&G	Heavy Metals	Fuel HC	Xylene	Cr	MEK	RAM
1	Landfill 1	G	X	X		X					
		W	X	X		X					
3	Landfill 3	G	X	X		X					
12	Chrome Pit 3	G	X	X		X					
17	Former Fuel Storage Site	G					X				
		S					X				
2	Landfill 2	G	X	X		X					
4	Landfill 4	G	X	X		X					
		S	X	X		X					
	Zone 1	G	X	X	X	X					
		S	X	X		X					
15	Fuel Saturation Area 2	G	X				X				
		S	X				X				
20	Wastewater Collection Basins	G	X		X	X	X				
		S	X		X	X	X				
16	Fuel Saturation Area 3	G	X				X				
9	Fire Dept. Training Area (FDTA) 6	G	X	X	X		X				
		S	X	X	X		X				
6	FDTA 3	G	X		X		X				
18	Solvent Lines	G			X			X		X	
		S			X			X		X	
10	Chrome Pit 1	G	X						X		
		S	X						X		
5	FDTA 2	G			X		X				
14	Fuel Saturation Area 1	G					X				
		S					X				
19	NARF Area	G	X	X	X	X	X				X
		S									X
	Jet Engine Test Stand, Building 21	G			X		X				
		S			X		X				
		W		X	X		X				
	Ambient Monitoring	G	X	X	X	X	X		X		
	East Parking Lot	G	X	X	X	X	X		X		
	Fuel Storage Tank	G			X		X				
	Lake Worth Monitor Well	G	X	X		X					

Samples: G = Groundwater; W = Surface Water; S = Soil
VOC = Volatile Organic Compounds
BNA = Base Neutral and Acid Extractable Compounds
O&G = Oil and Grease
Fuel HC = Hydrocarbon Fuels
Cr = Chromium
MEK = Methyl Ethyl Ketone
RAM = Radioactive Materials (Alpha, beta, and gamma radionuclides)

In addition to the field activities identified above, the following tasks were performed in this study:

- Evaluation of the long-term effects of pumping by the City of White Settlement on water levels and flow directions in the Paluxy aquifer;
- A literature search of local hydrogeologic conditions;
- Inventory of wells existing on AF Plant 4 at the time of this investigation and categorization of the wells by waste site;
- Review of the existing system of monitor wells at AF Plant 4 and recommendation of an optimal well network for future monitoring efforts; and
- Review and recommendation of available methods of well abandonment.

DISCUSSION OF RESULTS AND SIGNIFICANCE OF FINDINGS

Hydrogeology

The IRP Phase II Stage 1 investigation conducted at AF Plant 4 has been one of several efforts to define the nature and extent of contamination at the facility. The geologic setting and the occurrence and character of the groundwater have been previously described, so that the emphasis of investigation has been to fill in gaps in the data and focus on investigating areas not previously studied. Generally, the results of the IRP Phase II Stage 1 investigation confirm hydrogeologic interpretations of the previous work.

Hydrogeologic data gathered for this investigation consisted of water-level readings at existing and new upper zone and Paluxy monitor wells. Figure ES-3 depicts the potentiometric surface in the upper zone, based on Phase II Stage 1 monitoring. The occurrence and flow of groundwater is

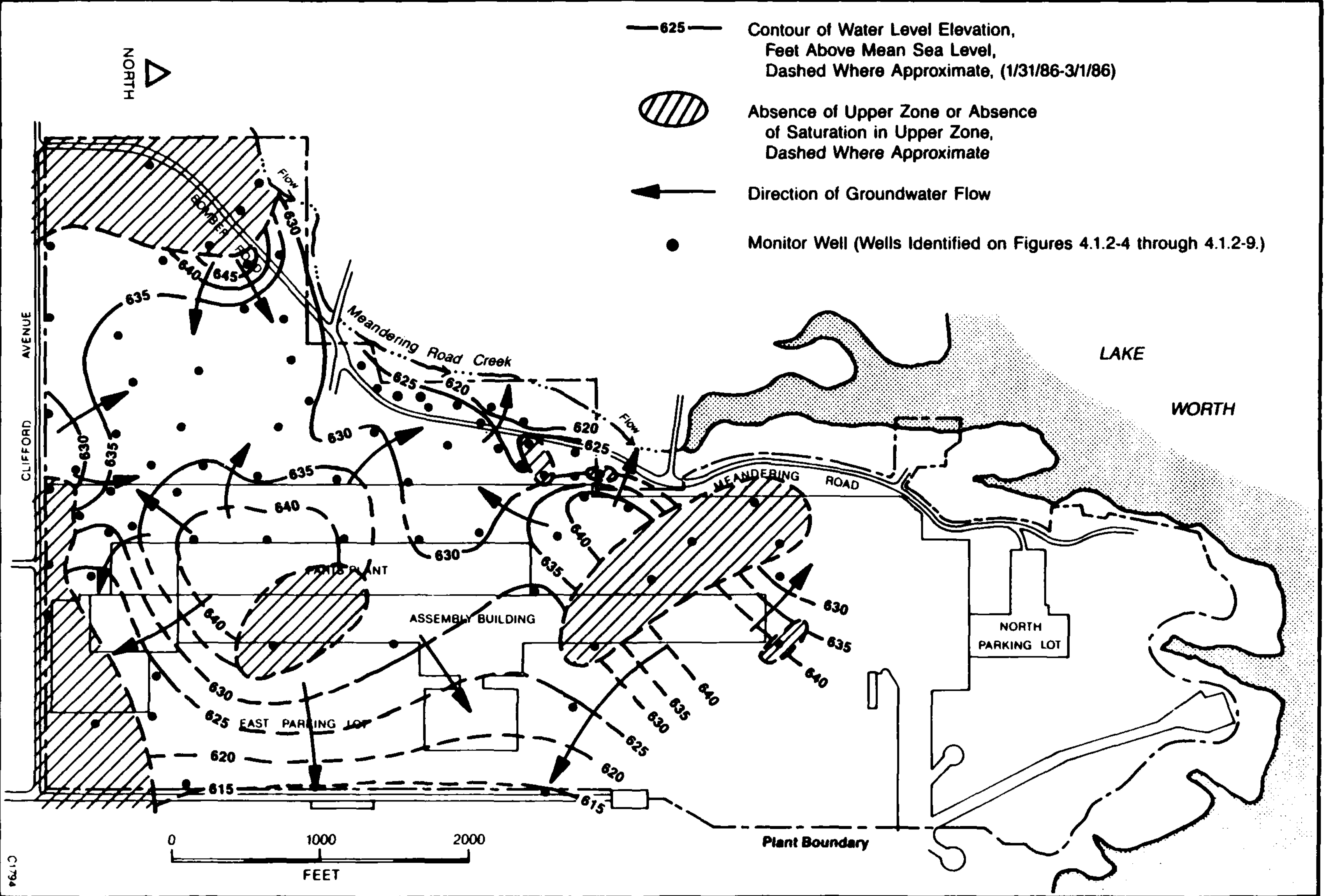

Figure ES-3. Potentiometric Surface Map of the Upper Zone, AF Plant 4, Texas related closely to the distribution and thickness of alluvial material, the bedrock topography, and surface elevations.

Groundwater flow in the Paluxy aquifer is generally to the southeast at AF Plant 4. Potentiometric surface maps of both the upper and middle members of the Paluxy, based on Phase II Stage 1 data, support earlier interpretations of the potentiometric surface and groundwater flow in the Paluxy.

Results and Significance of Chemical Analyses

To determine possible water quality effects on the local groundwater systems, concentrations of organic and inorganic compounds detected in groundwater samples were compared to various water quality criteria. These criteria, from federal drinking water regulations, standards, and guidelines, include final and proposed Maximum Contaminant Levels (MCLs) and proposed Recommended Maximum Contaminant Levels (RMCLs) above zero (0), established by the EPA as part of national drinking water regulations. The RMCLs are nonenforceable health goals set, with an adequate margin of safety, at levels that would result in no known or anticipated adverse health effects. The MCLs are enforceable standards set at levels as close to the RMCLs as feasible.

In the absence of regulatory standards for some compounds, other human health criteria have been used for the interpretation of IRP data. Although these criteria do not now have the force of standards, they do provide a valid means of assessing the relative degree of contamination. Using human health criteria and standards is a stringent way to evaluate groundwater contamination at AF Plant 4. Since the shallow aquifer is not used as a drinking water supply source, contaminants in-situ in this unit have neither human health nor environmental consequences. Groundwater in the Paluxy Formation, however, is used directly as a drinking water source.

No guidelines exist concerning the maximum allowable or recommended pollutant concentrations in soils for protection of human health and the environment.

Tables ES-4 through ES-16 present the results of groundwater and surface water sampling and analysis for sites or study topics where applicable water quality criteria were exceeded in the IRP Phase II Stage 1 program. These include:

- Site 1, Landfill 1;
- Site 3, Landfill 3;
- Site 12, Chrome Pit 3;
- Site 2, Landfill 2;
- Site 4, Landfill 4;
- Zone 1 (Sites 13, 11, and 8);
- Site 20, Wastewater Collection Basins;
- Site 10, Chrome Pit 1;
- Site 16, FSA 3;
- Site 5, FDTA 2;
- Ambient monitor wells; and
- East Parking Lot wells.

The water samples from the following sites or study topics had no concentrations of contaminants detected in excess of applicable water quality criteria:

- Site 17, Former Fuel Storage Site;
- Site 9, FDTA 6;
- Site 6, FDTA 3;
- Site 18, Solvent Lines;
- Jet Engine Test Stand;
- Fuel Storage Tank; and
- Lake Worth monitor well.

Results of analyses of soil samples are summarized in Table ES-17. No regulatory criteria exist for comparison of these results. However, the

TABLE ES-4. COMPARISON OF GROUNDWATER QUALITY AT SITE 1, LANDFILL 1, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location				
		HM-7	HM-10	HM-20	HM-62	HM-63
METALS (mg/L)						
Arsenic	0.05					0.075
Chromium	0.05			0.14	0.069	
ORGANIC COMPOUNDS (ug/L)						
Vinyl Chloride	1	56				
1,1,1-Trichloroethane	200			240		
Trichloroethylene	5		37	2300	8	4500
Benzene	5	61				
Acenaphthene	0.028	2				

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

TABLE ES-5. COMPARISON OF SURFACE WATER QUALITY AT SITE 1, LANDFILL 1, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location			
		FRDRN#1	FRDRN#2	CRSEEP	DRNPIPE
METALS (mg/L)					
Chromium	0.05			0.067	
ORGANIC COMPOUNDS (ug/L)					
Vinyl Chloride	1	1200	33		970
Trichloroethylene	5	6700	2300	20	2300
Tetrachloroethylene	8				150
Fluoranthene	0.028				2

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

TABLE ES-6. COMPARISON OF WATER QUALITY AT SITE 3, LANDFILL 3, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location								
		HM-26	HM-27	HM-34	HM-35	HM-36	HM-37	HM-38	HM-39	P-22U
METALS (mg/L)										
Arsenic	0.05			0.062					0.13	
Chromium	0.05		0.13	0.088	0.065	0.055			0.14	
Lead	0.05								0.25	
ORGANIC COMPOUNDS (ug/L)										
Vinyl Chloride	1									20
Methylene Chloride								160000		
1,2-Dichloroethane	5							24000		
trans-1,2-Dichloroethylene	70	300						120000		
Trichloroethylene	5	2000	390				400	450000		46
Tetrachloroethylene	8							19000		
Toluene	2000							6000000		
1,4-Dichlorobenzene	750							4400		
1,2-Dichlorobenzene	620							300000		
Acenaphthene	0.028							250		
Naphthalene	620							1400		
Fluorene	0.028							190		
Phenanthrene	0.028							590		

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

TABLE ES-7. COMPARISON OF WATER QUALITY AT SITE 12, CHROME PIT 3, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location				
		HM-15	HM-16	HM-17	HM-30	HM-45
METALS (mg/L)						
Chromium	0.05		0.21			
Lead	0.05		0.1			
ORGANIC COMPOUNDS (ug/L)						
1,1-Dichloroethylene	7					32
Trichloroethylene	5	5900	10000	15000	180	130

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

TABLE ES-8. COMPARISON OF WATER QUALITY AT SITE 2, LANDFILL 2, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location					
		HM-22	HM-42	HM-43	HM-44	HM-46	P21U
METALS (mg/L)							
Chromium	0.05	0.054	0.069			0.093	
Lead	0.05					0.070	
Selenium	0.01						0.03

* See Table 4.2.1-1 for source of criteria.

TABLE ES-9. COMPARISON OF WATER QUALITY AT SITE 4, LANDFILL 4, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location HM-101
METALS (mg/L)		
Chromium	0.05	0.2
Silver	0.05	0.13

* See Table 4.2.2-1 for source of criteria.

TABLE ES-10. COMPARISON OF WATER QUALITY AT SITES 13, 11, AND 8, (ZONE 1), AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location				
		HM-11	HM-24	HM-25	HM-28	HM-60
METALS (mg/L)						
Arsenic	0.05			0.14		
Chromium	0.05				0.12	
ORGANIC COMPOUNDS (ug/L)						
Vinyl Chloride	1			16		
1,2-Dichloropropane	6		9.6	13		
Trichloroethylene	5	26	7		600	400
Chlorobenzene	60			4700		
Benzene	5			470		
1,4-Dichlorobenzene	750			870		

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

TABLE ES-11. COMPARISON OF WATER QUALITY AT SITE 20, WASTEWATER COLLECTION BASINS, AF PLANT 4, WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location HM-31	HM-47	HM-70
METALS (mg/L)				
Arsenic	0.05			0.062
Chromium	0.05			0.075
Lead	0.05			0.068
ORGANIC COMPOUNDS (ug/L)				
Trichloroethylene	5	2400	12000	11000
Chlorobenzene	60		770	
Tetrachloroethylene	8			6500

* See Tables 4.2.2-1 and 4.2.2-2 for source of criteria.

TABLE ES-12. COMPARISON OF WATER QUALITY AT SITE 16, FUEL SATURATION AREA 3, AF PLANT 4, TEXAS, WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location HM-78
ORGANIC COMPOUNDS (ug/L)		
Benzene	5	8400

*See Tables 4.2.2-1 and 4.2.2-2 for source of criteria.

TABLE ES-13. COMPARISON OF WATER QUALITY AT SITE 10, CHROME PIT 1, AF PLANT 4, TEXAS, WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location	
		HM-48	HM-103
ORGANIC COMPOUNDS (ug/L)			
Trichloroethylene	5	20	5500

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

TABLE ES-14. COMPARISON OF WATER QUALITY AT SITE 5, FDTA 2, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location HM-19	 HM-51	 HM-66
ORGANIC COMPOUNDS (ug/L)				
1,2-Dichloroethane	5		27000	
Trichloroethylene	5	9	420000	29
Toluene	2000		96000	

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

TABLE ES-15. COMPARISON OF WATER QUALITY, AMBIENT MONITORING, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location					
		HM-29	HM-52	HM-54	HM-56	HM-58	HM-59
METALS (mg/L)							
Arsenic	0.05						
Chromium	0.05	0.14				0.075	
Lead	0.05		0.27				
ORGANIC COMPOUNDS (ug/L)							
Trichloroethylene	5	5600		6.4			6.6
Tetrachloroethylene	8						43
Benzene	5				110		

(Continued)

TABLE ES-15. (Continued)

Parameter	Criteria*	Sampling Location HM-61	HM-64	HM-79	HM-81	HM-83	HM-85
METALS (mg/L)							
Arsenic 0.11		0.11				0.28	0.086
Chromium 0.17		0.17			0.05		
Lead 0.08		0.08			0.2	0.05	
ORGANIC COMPOUNDS (ug/L)							
Trichloroethylene	5		75	170		7.4	
Tetrachloroethylene	8			13			
Benzene	5						

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

TABLE ES-16. COMPARISON OF WATER QUALITY, EAST PARKING LOT, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

		Sampling Location			
Parameter	Criteria*	HM-68	HM-71	HM-82	P-8U
METALS (mg/L)					
Chromium	0.05		0.14	0.33	
ORGANIC COMPOUNDS (ug/L)					
Trichloroethylene	5	32	1300	19000	7200
Tetrachloroethylene	8		23		

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

TABLE ES-17. SUMMARY OF ANALYTICAL RESULTS OF SOIL SAMPLE ANALYSES, IRP PHASE II STAGE 1, AF PLANT 4, TEXAS

Site	Parameter	Range of Observed Concentrations
Site 17, Former Fuel Storage Site	Hydrocarbon fuels	ND
Site 15, FSA 2	Hydrocarbon fuels	ND-4600 mg/kg
	1,1-Dichloroethylene	0.012 mg/kg
Site 9, FDTA 6	1,1,1-Trichloroethane	ND-0.022 mg/kg
	Phthalate esters	ND-3.1 mg/kg
	Phenanthrene	ND-0.83 mg/kg
Site 18, Solvent Lines	Oil and grease	ND
	Xylene	ND
	Methyl ethyl ketone	ND
Site 10, Chrome Pit 1	Chromium	7.1-7.4 mg/kg
	trans-1,2-Dichloroethylene	0.039-0.0096 mg/kg
	Trichloroethylene	0.065-0.17 mg/kg
Site 14, FSA 1	Hydrocarbon fuels	ND-59,000 mg/kg
Site 19, NARF Area	alpha radiation	6.7-12.4 pCi/g
	beta radiation	10.0-23.1 pCi/g
	gamma radiation	ND
Jet Engine Test Stand	Hydrocarbon fuels	ND-1700 mg/kg
	Oil and grease	ND-2000 mg/kg

following sites appear to exhibit levels of soil contamination of potential concern:

- Site 15, FSA 2;
- Site 9, FDTA 6; and
- Site 14, FSA 1.

White Settlement Groundwater Pumping Effects

An investigation of the pumpage effects of the City of White Settlement's municipal wells was performed on the groundwater to determine the zone of influence, long-term drawdowns (if any) and the influence on the direction of groundwater flow in the Paluxy aquifer beneath the Plant 4 area. Groundwater flows and drawdowns were determined by reviewing existing geologic and hydrologic information and current pumpage records for the City of White Settlement. These data were supported by comparing actual water level data to simulated results from a simple finite-difference steady-state groundwater model (Koch, 1984). Drawdowns were predicted after years 1, 3, 5, 10, 15 and 20, assuming that wells continue pumping at the current capacity for 20 years.

Results of the simulation, as well as existing information related to groundwater flow in the Paluxy aquifer, indicate that groundwater beneath the Plant 4 area is influenced to some degree by the withdrawal of water by nearby municipal wells. The analysis also suggests that fairly significant drawdowns can be expected near pumping wells, which in turn could direct groundwater to flow from Lake Worth and AF Plant 4 toward these wells. Considering water quality, there appears to be a logical concern about the potential for contaminants originating at AF Plant 4 to migrate toward these wells.

Well Network Selection for Future Monitoring Efforts

The total system of wells at AF Plant 4 was evaluated to design an optimal well network for future monitoring efforts. The objective of designing an optimal monitor well network was to decrease the number of samples needed to adequately represent groundwater quality and the hydrogeologic conditions in the aquifer. The wells evaluated consisted of the 87 upper zone monitor wells installed by Hargis and Montgomery and Hargis and Associates and the nine upper zone wells installed by Radian. In addition to the upper zone monitor wells, the Paluxy Formation monitor wells have been evaluated with respect to future monitoring efforts at AF Plant 4. The selected well network for Plant 4 includes 64 upper zone monitor wells (HM-series) and all of the currently active Paluxy Formation monitor wells.

ALTERNATIVE MEASURES

Alternatives were considered for further IRP activities at each site investigated in the Phase II Stage 1 study. Types of alternatives considered include continued monitoring, additional field investigations, no further action, and advancement to Phase IV Remedial Action planning.

For those sites anticipated to require Phase IV remedial actions, remedial options were identified at a general, conceptual level. However, since General Dynamics is initiating complete, plant-wide remedial action planning at the present time, the examination of alternatives presented in this study should be considered to be a limited and preliminary overview of general alternatives. Recommendations for selection of alternatives should be based on the detailed planning currently underway.

RECOMMENDATIONS

Table ES-18 summarizes the recommendations from the Phase II Stage 1 investigation at AF Plant 4. The sites are categorized as follows:

Category 1 Sites - No Further IRP Activities

The following sites were investigated during this and previous studies and found to currently contain little or no hazardous material. On the basis of this finding, no further action is considered or recommended for:

TABLE ES-18. SUMMARY OF RECOMMENDATIONS FROM IRP PHASE II STAGE 1, AF PLANT 4, TEXAS.

Site	Recommended Action	Rationale
Site 1, Landfill 1	Proceed with Phase IV remedial action planning	Concentrations of organic compounds and metals in upper zone groundwater and surface water exceed applicable water quality criteria.
Site 3, Landfill 3	Proceed with Phase IV remedial action planning	Concentrations of metals, TCE, and other organic compounds exceed applicable water quality criteria in upper zone and upper Paluxy groundwater.
Site 12, Chrome Pit 3	Proceed with Phase IV remedial action planning	Concentrations of Cr, Pb, and organic compounds (primarily TCE) exceed applicable water quality criteria in upper zone groundwater.
Site 17, Former Fuel Storage Site	No further IRP activities recommended	No hydrocarbon fuels detected in soil or groundwater samples.
Site 2, Landfill 2	No further IRP activities recommended	Metals detected at levels slightly above MCLs in shallow groundwater may be from Chrome Pit 3. No organic compounds detected at levels above applicable criteria.
Site 4, Landfill 4	No further IRP activities recommended	Few organic compounds detected and at levels below applicable water quality criteria. Metals only slightly exceed criteria in samples from one well.

(Continued)

TABLE ES-18. SUMMARY OF RECOMMENDATIONS FROM IRP PHASE II STAGE 1, AF PLANT 4, TEXAS. (Continued)

Site	Recommended Action	Rationale
Zone 1, Site 13, Die Pits; Site 11, Chrome Pit 2; Site 8, FDTA 5	Proceed with Phase IV remedial action planning	Concentrations of metals and organic compounds in upper zone groundwater exceed applicable water quality criteria.
Site 15, Fuel Saturation Area 2	Additional Phase II study required. Install 2 upper zone monitor wells downgradient of the site (west and north) to determine quality of upper zone groundwater exiting the site	Soil sample results indicate fuel contamination but existing upper zone wells appear to be upgradient of the site. Therefore, existence and extent of groundwater contamination at the site is unknown.
Site 20, Wastewater Collection Basins	Proceed with Phase IV remedial action planning	Concentrations of metals in upper zone groundwater slightly above MCLs. Concentrations of TCE and chlorobenzene also exceed applicable water quality criteria in upper zone groundwater.
Site 16, Fuel Saturation Area 3	Proceed with Phase IV remedial action planning	Low levels of organic compounds (below proposed MCLs) detected in groundwater. Hydrocarbon fuels detected in soils. Remedial action planning already underway.
Site 9, FDTA 6	Proceed with Phase IV remedial action planning	Hydrocarbon fuels detected at moderate levels in soil samples. No organic compounds detected in groundwater at levels above applicable criteria.

(Continued)

TABLE ES-18. SUMMARY OF RECOMMENDATIONS FROM IRP PHASE II STAGE 1, AF PLANT 4, TEXAS. (Continued)

Site	Recommended Action	Rationale
Site 6, FDTA 3	No further IRP activities recommended	No organic compounds detected in groundwater at levels above applicable criteria.
Site 7, FDTA 4	No further IRP activities recommended	Site could not be located by soil-gas survey. Plant personnel report that no FDTA ever existed at this location.
Site 18, Solvent Lines	No further IRP activities recommended	No organic compounds detected in soil samples or groundwater.
Site 10, Chrome Pit 1	Proceed with Phase IV remedial action planning	TCE in upper zone groundwater exceeds proposed MCL. Volatile organic compounds detected in soil samples.
Site 5, FDTA 2	Proceed with Phase IV remedial action planning	Concentrations of organic compounds in upper zone groundwater exceed applicable water quality criteria.
Site 14, Fuel Saturation Area 1	Proceed with Phase IV remedial action planning	Hydrocarbon fuels detected in soil and in groundwater grab sample from soil boring.
Site 19, NARF Area	No further IRP activities recommended	No radiation detected above acceptable levels in soil samples.

(Continued)

TABLE ES-18. SUMMARY OF RECOMMENDATIONS FROM IRP PHASE II STAGE 1, AF PLANT 4, TEXAS. (Continued)

Site	Recommended Action	Rationale
Jet Engine Test Stand, Building 21	No further IRP activities recommended	Low levels of hydrocarbon fuels detected in soil samples. No organic compounds detected in surface water at levels above applicable water quality criteria. No hydrocarbons or oil and grease detected in groundwater.

- Site 17, Former Fuel Storage Site;
- Site 2, Landfill 2;
- Site 4, Landfill 4;
- Site 6, FDTA 3;
- Site 7, FDTA 4;
- Site 18, Solvent Lines;
- NARF Area; and
- Jet Engine Test Stand, Building 21.

Individual wells at the various sites should continue to be considered for inclusion in a plant-wide monitoring program.

Category 2 Site - Additional Phase II Effort Required

Site 15, Fuel Saturation Area 2, was studied during this program but insufficient data exist to fully characterize the nature and extent of contamination. Additional Phase II investigations will be required. The following action is recommended.

- Installation of two upper zone monitor wells downgradient (west and north) of the site to determine the character of upper zone groundwater exiting the site.

Category 3 Sites - Ready for Phase IV Actions

The following sites were investigated during this and previous studies and found to contain varying levels of hazardous material. All of these well-characterized sites should be released for Phase IV planning, as appropriate.

- Site 1, Landfill 1;
- Site 3, Landfill 3;
- Site 12, Chrome Pit 3;
- Zone 1 (Sites 13, 11 and 8);

- Site 20, Wastewater Collection Basins;
- Site 10, Chrome Pit 1;
- Site 16, FSA 3;
- Site 9, FDTA 6;
- Site 5, FDTA 2; and
- Site 14, FSA 1.

Individual wells at the various sites should also continue to be considered for a plant-wide monitoring program.

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1.0 INTRODUCTION

The Department of Defense (DOD) is conducting a nation-wide program to evaluate past waste disposal practices on DOD property, to control the migration of hazardous contaminants, and to control hazards that may result from these waste disposal practices. This program, the Installation Restoration Program (IRP), consists of four phases: Phase I, Initial Assessment/Records Search; Phase II, Problem Confirmation/Quantification; Phase III, Technology Base Development and Phase IV, Operations. The United States Air Force is conducting an IRP investigation at Air Force Plant 4 near Fort Worth, Texas. Radian Corporation has performed this Phase II Stage 1 Field Evaluation under USAF Contract No. F33615-83-D-4001, Delivery Order 27.

1.1 Purpose of the Investigation

The purpose of this investigation was to define the presence, magnitude, extent, direction and rate of movement of any identified contaminants. In addition, the body of geologic and chemical data developed by General Dynamics, operator of the plant, was to be used in the investigation. Finally, additional investigations required beyond this stage, including an estimate of costs (provided separately) were to be determined.

A contaminant source investigation at AF Plant 4 was conducted to determine: (1) the presence or absence of contamination within the specified areas of the field survey; (2) if contamination exists, the potential for migration in the various environmental media; (3) the extent/magnitude of contamination on AF Plant 4 property; (4) the potential environmental consequences and health risks of migrating contaminants, based on state or federal standards for these contaminants.

1.2 Duration of the Program

Authorization to proceed on this study was given on 13 September 1985. Field activities began in November 1985. The field work consisted of geophysical surveys, a soil gas survey, coring and sampling of near-surface soil at various locations, installation of upper zone and Paluxy groundwater monitor wells, surface water sampling and sampling of groundwater from completed wells. Field work was completed in August 1986.

1.3 Waste Disposal Practices

The following summation of the waste disposal history of AF Plant 4 is from the USAF Phase I IRP report (CH2M Hill, 1984).

Industrial operations have been continuous since Air Force Plant 4 went into production in 1942. Plant operations center around the production of military aircraft and associated equipment. Manufacturing of aircraft and associated equipment results in the generation of varying quantities of waste oils (including lubricating oils, hydraulic fluids, and coolants), recoverable fuels, solvents (including degreasers and paint thinners), paint residues (including waste liquid paints and paint booth sludges), and spent process chemicals (including acids, caustics, chromium, and cyanide solutions). The total quantity of these wastes currently ranges from about 5,500 to 6,000 tons/year. Development of this information was based on interviews with General Dynamics personnel, previous reports, and Monthly Waste Shipment Reports from 1981 through 1983. Since waste quantities depend on the levels of contractor activity and vary from one time period to the next, the total quantities may have been higher in the past during periods of heavier production.

Past (based on information obtained from files and on the best recollection of interviewees) and present waste disposal practices are summarized below:

- <u>1942-1955</u>: In general, waste oil, solvents, recoverable fuels, paint wastes, and spent process chemicals were disposed of at on-site landfills. Some of these materials, e.g., oils, solvents, and fuels, were burned at the landfill in surface pits. Wastewaters containing process chemicals, including chromium and other metals, were discharged to the sanitary sewer system, which went to the City of Fort Worth treatment system. Washwater from paint booths and water containing residual oils were also discharged to the sanitary sewage system.

- <u>1955-1966</u>: Wastes were handled in the same manner as in the previous period, with few changes. Waste oils, recoverable fuels, and spent solvents were disposed of in the landfills and also burned in fire department training exercises at designated fire department training areas.

- <u>1966-1970</u>: Waste oils and fuels continued to be disposed of at on-site landfills and burned in fire department training exercises. Solvents, waste paints, and process cyanide solutions were disposed of by contractor. Other wastes continued to be discharged to the sanitary sewer system.

- <u>1970-1975</u>: Waste oils and fuels, solvents, process cyanide chemicals, and paint wastes continued to be disposed of in the same manner. Other process chemical solutions, rinse waters, and paint booth wastewater were treated by a newly installed chemical waste treatment system that removed metals and neutralized acids and bases.

- 1975-1983: Waste oils were disposed of by a contractor and, to a lesser extent, by burning with recoverable fuels at fire department training exercises. Solvents, process cyanide chemicals, and paint wastes continued to be disposed of by contractor. Paint booth washwaters and some waters containing residual oils were discharged to the chemical waste treatment system and also to the industrial wastewater collection system, which dishcarged, untreated, to the sanitary sewer system. Other process chemical solutions continued to be discharged to the chemical waste treatment system.

- 1983 to present: Wastes continued to be disposed of in the same manner as in the previous period, except that all waste oils and recoverable fuels were disposed of contractor, and none were burned in fire department training exercises.

1.4 Location and Site Descriptions

AF Plant 4 is located six miles west of the center of Fort Worth in Tarrant County, Texas (Figure 1-1). Lake Worth borders the facility on the north, Carswell AFB on the east, and the community of White Settlement on the west and south.

Phase II Stage 1 work at AF Plant 4 has focused on the 21 waste sites and four study topics listed in Table 1-1. Brief descriptions of the locations and features of the Phase II sites and study topics are provided below. The 21 waste sites (including the three Zone 1 sites) and the fuel storage tank are shown in Figure 1-2. Sites are presented and discussed in the order in which they appear in the Delivery Order. The additional study topics are not plotted because the areas they cover are too large and diverse.

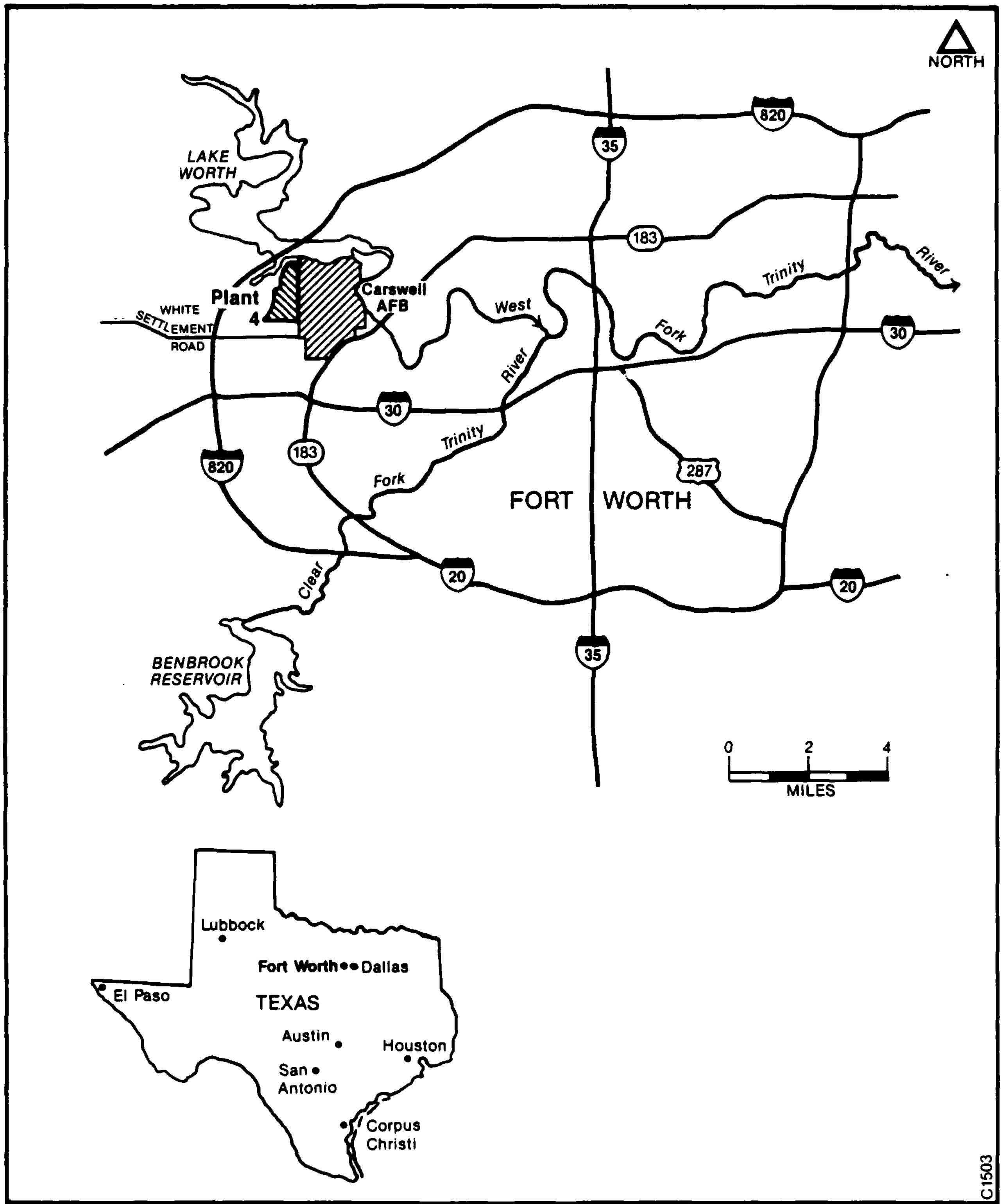

Figure 1-1. General Location of AF Plant 4, Texas

TABLE 1-1. IRP PHASE II STAGE 1 SITES AND STUDY TOPICS AT AF PLANT 4, TEXAS

SITES:

Site 1, Landfill 1
Site 3, Landfill 3
Site 12, Chrome Pit 3
Site 17, Former Fuel Storage Site
Site 2, Landfill 2
Site 4, Landfill 4
Zone 1 (Site 13, Die Pits; Site 11, Chrome Pit 2; Site 8, Fire Department Training Area 5)
Site 15, Fuel Saturation Area 2
Site 20, Wastewater Collection Basins
Site 16, Fuel Saturation Area 3
Site 9, Fire Department Training Area 6
Site 6, Fire Department Training Area 3
Site 7, Fire Department Training Area 4
Site 18, Solvent Lines
Site 10, Chrome Pit 1
Site 5, Fire Department Training Area 2
Site 14, Fuel Saturation Area 1
Site 19, Nuclear Aerospace Research Facility (NARF) Area
Jet Engine Test Stand, Building 21

ADDITIONAL STUDY TOPICS:

East Parking Lot
Fuel Storage Tank
Lake Worth Monitor Well
Ambient Monitoring

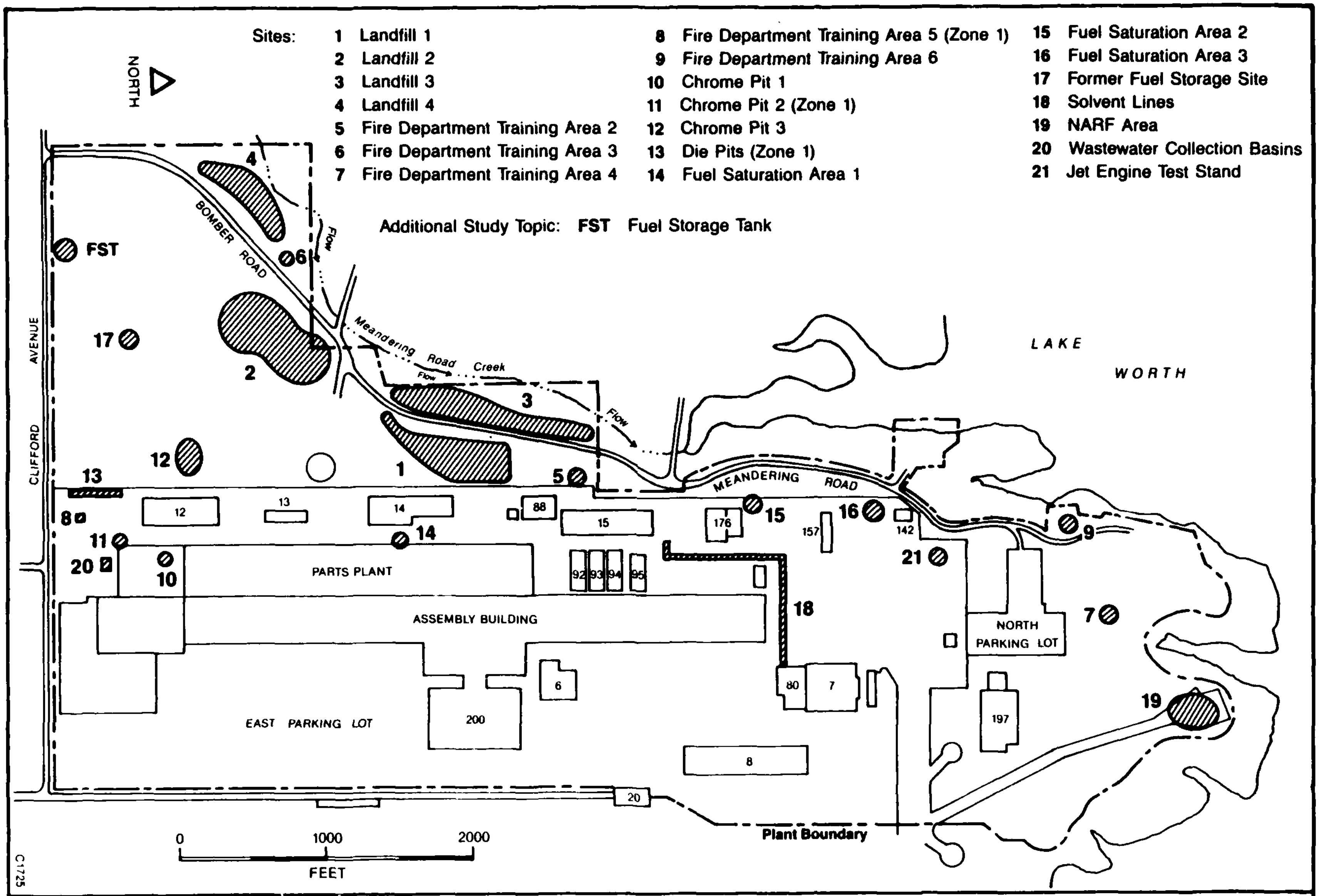

Figure 1-2. Phase II Stage 1 Study Sites, AF Plant 4, Texas

Most of the site information was obtained from the Installation Restoration Program Phase I IRP records search report (CH2M-Hill, 1984).

Site 1, Landfill 1

From 1942 until about 1966, several types of hazardous and nonhazardous wastes were reportedly disposed of in Landfill 1. These wastes included drums of liquid and contents of tanks and bousers loaded with chemical wastes (solvents, thinners, paints, etc.). Contaminated oils, fuels, and hazardous wastes containing metals, chromate sludges, and cyanide are suspected to be present at this site.

Since it was closed during the 1960s, extensive remedial action has been conducted at this site. The major action was the removal of 11,000 cubic yards of earth and the installation of a drain field (French Drain No. 2).

Site 3, Landfill 3

From about 1942 to 1945, this site was reportedly was for disposal of wastes, including hazardous wastes consisting of mixed oils and solvents. At least one pit (possibly more) present in this area during the 1940s was used for holding and burning some of the liquid wastes. Other wastes are suspected to have been disposed of on the ground and later buried. From 1966 until 1967, fill dirt and rubble were used to finish filling and grading this site.

Site 12, Chrome Pit 3

Chrome Pit 3 was used for the disposal of chromate and other chemical wastes from about 1957 until 1973. Barium chromate sludge, dilute metal solutions, and drums of unidentified liquids were disposed of in this pit.

Site 17, Former Fuel Storage Site

A 100,000-gallon above-ground JP-4 storage tank from the early 1940s was relocated from here in 1962. Sampling at this site in 1982 confirmed that soils and underlying groundwater are contaminated by fuels and other organic compounds.

Site 2, Landfill 2

The site originally consisted of some low areas and a livestock watering hole. Most of this site was reportedly filled with construction rubble, plaster, and fill dirt during the early 1940s. However, 1962 aerial photographs show some activity at the stock watering hole at this site. This area was reportedly used for the disposal of lumber and tires and was assumed to be periodically burned. No reports exist of hazardous substances being deposited at this site.

Site 4, Landfill 4

Landfill 4 was reportedly used for the disposal of clean construction rubble from 1956 until the early 1980s. Aerial photographs and a 1973 memo indicate that other types of wastes may have been disposed of at this site from 1966 until at least 1973. This evidence seems to show that small quantities of hazardous wastes (solvents, oils, fuels, thinners, etc.) are present in this landfill.

Zone 1

Three sites were combined into one zone for study purposes. Descriptions of these sites are given below.

Site 13, Die Pits: These pits were used for the disposal of chromate sludges, metal solutions, and other chemical wastes until 1962, when the site was graded and the entire die yard was paved. One Phase I interviewee reported that some of the contaminated soils at this site were spread around the die yard during the grading and leveling activities. The site of the original pits was excavated in 1983-84. Soils from other parts of the die yard were not analyzed at that time.

Site 11, Chrome Pit 2: According to the Phase I study, miscellaneous liquid and solid wastes, in addition to chromate solutions, were probably disposed of here. Neither interviews nor aerial photographs could confirm the exact location of this site.

Site 8, Fire Department Training Area (FDTA) 5: This site consisted of a shallow pit in which waste fuels, oils, or chemicals were deposited for training exercises. This site, which has been graded and paved, is located in the die yard area south of Warehouse 1.

Site 15, Fuel Saturation Area 2

This site reportedly became saturated with fuels from leaks in buried fuel lines between the 1970s and early 1980s.

Site 20, Wastewater Collection Basins

Two concrete-lined waste basins, each with a capacity of approximately 85,000 gallons, are used to collect and settle suspended solids from chemical wastewaters before discharge to the City of Fort Worth sanitary sewage system. The basins have been in use since about 1966. Evidence indicated that several spills of vapor degreaser tanks in the Process Building have occurred since installation of these tanks. Some of the spilled chemicals (primarily trichloroethylene) have flowed to the basins via floor drains. These basins are suspected of being a possible source of organic chemical and metal groundwater contamination.

Site 16, Fuel Saturation Area 3

This site reportedly became saturated with fuels from leaks in buried fuel lines between the mid-1970s and the early 1980s. This site is the subject of current remedial action planning by Intellus.

Site 9, Fire Department Training Area 6

Before 1970, training exercises were conducted twice a year at this site. After 1970, exercises were conducted at monthly intervals. Approximately 250 gallons of waste fuels and oils were reportedly used for each exercise. In addition, the Phase I report indicated that larger quantities of contaminated fuels and oils were probably deposited in the FDTA between exercises.

Site 6, Fire Department Training Area 3

Training exercises at this site also used about 250 gallons of waste fuels and oils per exercise. Its location and current condition could not be accurately determined because it is not visible on historical aerial photographs.

Site 7, Fire Department Training Area 4

The same type of training exercises were conducted here. This site is not visible on historical aerial photographs, so that its location and current condition are not accurately known. The area is also believed to have received fill material originating from a foundation excavation at the Administration Building.

Site 18, Solvent Lines

These lines reportedly leaked during the 1940s before they were drained, capped and abandoned in 1944. The Phase I study could not determine the actual locations of the leaks. These solvent lines reportedly contained xylene, methyl ethyl ketone, and kerosene.

Site 10, Chrome Pit 1

Miscellaneous liquid and solid chemical wastes, in addition to chrome wastes, were probably disposed of at this site. The actual location of this site is thought to be somewhere beneath the Process Building, but the Phase I report could not accurately confirm this. No monitor wells exist in the immediate vicinity of this site.

Site 5, Fire Department Training Area 2

Exercises were held infrequently (twice a year) at this site. However, disposal of waste oils and fuels and uncontrolled burns may have been more frequent. This site is located under the pavement in the west employee parking area.

Site 14, Fuel Saturation Area 1

The ground at this site, located just west of the Parts Plant, reportedly became saturated by fuels from leaking fuel lines from the mid-1970s to the early 1980s. This site is the subject of Phase IV Remedial Action planning by Intellus.

Site 19, Nuclear Aerospace Research Facility (NARF) Area

The Nuclear Aerospace Research Facility (NARF), formerly located at the north end of AF Plant 4, housed several experimental atomic reactors between 1953 and 1974. The facility was decommissioned and disposed of by contractor in 1974.

Jet Engine Test Stand, Building 21

This site was not previously identified in Phase I. The jet engine test building is located north of a fuels test area, previously identified as Site 16, a known area of fuel contamination. The sump downslope of Building 21 was constructed in 1975 and collects water used for cooling, noise suppression, and clean-up in Building 21. This water is pumped into the industrial waste line. The area immediately south of Building 21 contains two underground tanks that were once used for fuel storage. These tanks are being investigated as potential sources of contamination under a separate underground tank investigation being conducted as part of IRP activities by the operating contractor, General Dynamics. Outfall 3 is downgradient of Building 21, and is regularly sampled as part of IRP and NPDES monitoring activities.

1.5 Additional Study Topics

In addition to the studies associated with the waste sites discussed above, additional study topics were identified for inclusion in the Phase II investigation. These topics are discussed below.

Ambient Monitoring

Several wells installed and distributed throughout the plant area of AF Plant 4 are not associated with a particular waste disposal site or suspected spill area. Groundwater from these wells was sampled and analyzed to gain a complete view of groundwater quality at AF Plant 4.

East Parking Lot

Five wells located in the vicinity of the East Parking lot were sampled during the Phase II Stage 1 investigation. The purpose of this investigation was to test for the presence of contaminants in the vicinity of a suspected zone of communication between the upper zone and the Paluxy aquifer.

Fuel Storage Tank

This area is the location of a 100,000-gallon above-ground JP-4 storage tank created in 1962. An existing upper zone monitor well was sampled for the presence of fuel contamination.

Lake Worth Monitor Well

This area is in the northern part of AF Plant 4 that borders Lake Worth. The well was sampled to determine the character of the groundwater in the vicinity of Lake Worth.

White Settlement Groundwater Pumping Effects

This study evaluated the long-term effects of pumping by the city of White Settlement on water levels and flow directions in the Paluxy aquifer. The purpose of the evaluation was to predict the likely direction of movement of any contaminants in the Paluxy aquifer, as well as the effects of pumping on this movement.

Literature Search

A literature search of local hydrogeologic conditions was conducted and documented in the report. The results of that search are contained in Section 2.

Well Inventory

All of the wells existing on AF Plant 4 at the time of this investigation were inventoried and grouped into subsets associated with a particular site, zone, or ambient area.

Well Network Selection

The total system of wells was evaluated, and an optimal well network redesign was recommended for future monitoring efforts at AF Plant 4. This recommendation can be found in Section 4.3.27. Wells not considered necessary to the integrity of the chemical and hydrogeologic data base were identified as candidates for abandonment.

Well Abandonment Procedures

As part of this investigation, available methods of well abandonment were evaluated and a candidate method or technique was recommended. This recommendation can be found in Section 4.3.25.

1.6 Sampling and Analytical Program

The sampling program at AF Plant 4 involved collecting soils, surface water, and groundwater. Soil samples were collected with a Shelby tube or split-spoon sampler during drilling activities or by use of a hand auger. All soil samples were placed in individual glass jars and frozen. Surface water was collected as grab samples. Permanently installed electric pumps were used to collect groundwater from the Paluxy monitor wells. The remaining wells were sampled using a "Tri-loc" portable submersible pump or a Teflon bailer.

All water samples were chilled to 4°C. In addition, samples collected for purgeable aromatics and xylene analysis were preserved with hydrochloric acid (HCl) to pH<2. Samples collected for oil and grease and hydrocarbon fuels analysis were preserved with sulfuric acid (H_2SO_4) to pH<2. Samples for metals analysis were preserved with nitric acid (HNO_3) to pH<2. All samples were shipped to Radian Analytical Services for analysis. The schedule of analyses is summarized in Table 1-2.

1.7 Investigative Personnel

The AF Plant 4 Phase II (Stage 1) investigation was conducted by staff from the Austin, McLean and Sacramento offices of Radian Corporation. Francis J. Smith, Contract Program Manager, was responsible for the contractual administration of the program. The overall technical program was directed by Lawrence N. French, Senior Geologist and Certified Professional Geological Scientist. Mr. French directed all activities of the program and participated directly with USAF personnel.

The geophysical surveys and soil gas investigations were supervised by Mr. Peter A. Waterreus. Soil sampling activities and monitor well installation were supervised by Mr. French, Mr. Waterreus, and Tobin K. Walters. Monitor well sampling activities were conducted by Neil A. Robinson, Arthur H. Morrill, Fred R. Snyder, Wendy J. Johnson, Wallace J. Hise, and Mr. Walters. Mr. Walters evaluated the effects of White Settlement pumpage and Gary D. Henderson evaluated the long-term monitor well network. Mr. French and Ms. Johnson were the principal authors of the draft report. Cartographic and technical illustrations were prepared by Jill P. Rossi. Ann E. St.Clair and William M. Little provided senior technical staff review and editing. Dr. F. L. Shore provided review of chemistry data and interpretation. Table 1-3 summarizes the project individuals and their functions/roles. Appendix J contains resumes for the primary individuals.

TABLE 1-2. ANALYTICAL SCHEDULE FOR SOIL AND WATER SAMPLES, IRP PHASE II, STAGE 1, AF PLANT 4, TEXAS

Site	Location	Sample Type	VOC	BNA	O&G	Heavy Metals	Fuel HC	Xylene	Cr	MEK	RAM
1	Landfill 1	G	X	X		X					
		W	X	X		X					
3	Landfill 3	G	X	X		X					
12	Chrome Pit 3	G	X	X		X					
17	Former Fuel Storage Site	G					X				
		S					X				
2	Landfill 2	G	X	X		X					
4	Landfill 4	G	X	X		X					
		S	X	X		X					
	Zone 1	G	X	X	X	X					
		S	X	X		X					
15	Fuel Saturation Area 2	G	X				X				
		S	X				X				
20	Wastewater Collection Basins	G	X		X	X	X				
		S	X		X	X	X				
16	Fuel Saturation Area 3	G	X				X				
9	Fire Dept. Training Area (FDTA) 6	G	X	X	X		X				
		S	X	X	X		X				
6	FDTA 3	G	X		X		X				
18	Solvent Lines	G			X			X		X	
		S			X			X		X	
10	Chrome Pit 1	G	X						X		
		S	X						X		
5	FDTA 2	G			X		X				
14	Fuel Saturation Area 1	G					X				
		S					X				
19	NARF Area	G	X	X	X	X	X				X
		S									X
	Jet Engine Test Stand, Building 21	G			X		X				
		S			X		X				
		W		X	X		X				
	Ambient Monitoring	G	X	X	X	X	X		X		
	East Parking Lot	G	X	X	X	X	X		X		
	Fuel Storage Tank	G			X		X				
	Lake Worth Monitor Well	G	X	X		X					

Samples: G = Groundwater; W = Surface Water; S = Soil
VOC = Volatile Organic Compounds
BNA = Base Neutral and Acid Extractable Compounds
O&G = Oil and Grease
Fuel HC = Hydrocarbon Fuels
Cr = Chromium
MEK - Methyl Ethyl Ketone
RAM = Radioactive Materials (Alpha, beta, and gamma radionuclides)

TABLE 1-3. AF PLANT 4 IRP PHASE II STUDY TEAM

Individual	Function/Role
F. J. Smith	Contract Program Manager
L. N. French	Technical Director
P. A. Waterreus	Geophysical and soil gas surveys, monitor well installation, soil sampling, report preparation
T. K. Walters	Monitor well installation, White Settlement pumping effects
N. A. Robinson	Water sampling
A. H. Morrill	Water sampling
F. R. Snyder	Water sampling
W. J. Johnson	Water sampling, report preparation
W. J. Hise	Water sampling
G. D. Henderson	Long-term monitor well evaluation
J. P. Rossi	Cartography, technical illustrations
F. L. Shore	Chemistry review
W. M. Little	Technical review
A. E. St. Clair	Technical review

Subcontractors:

Delta Geophysical Services - Geophysical survey

Tracer Research Corporation - Soil gas study

Southwestern Laboratories - Upper zone monitor well installation and soil sampling

Underground Resources Management, Inc. - Paluxy monitor well installation

Sempco, Inc. - Well location and elevation surveying

2.0 ENVIRONMENTAL SETTING

The following discussion of the basic features and history of the AF Plant 4 environmental setting, which sets the context for evaluating the results of the current study, is derived primarily from the USAF Installation Restoration Program Phase I Records Search Report (CH2M Hill, 1984). Information from that report is supplemented by information from the literature, from the general findings of this study, and by other information supplied by the USAF. Section 4 contains a detailed discussion of the results of the current study.

2.1 General Geographic Setting and Land Use

AF Plant 4 is located six miles west of the center of Fort Worth in Tarrant County, Texas (Figure 2-1). The plant is bordered by Lake Worth on the north, the community of White Settlement on the south and west and Carswell AFB on the east. The major facilities and physical features of the AF Plant 4 site are shown in Figure 2-2.

The plant is situated in an area of primarily residential, recreational, and industrial/commercial land use. AF Plant 4 is the principal industrial user of the area. Recreational land use includes the Y.M.C.A.'s Camp Carter and various parks on the shores of Lake Worth.

2.2 Physiographic and Topographic Features

AF Plant 4 is located within the Grand Prairie section of the Central Lowlands Physiographic Province. This area is characterized by broad terrace surfaces sloping gently eastward, interrupted by westward-facing escarpments. The land is typically grass-covered and barren of trees, except for isolated stands of upland timber. The northwestern part of AF Plant 4 is within the Western Cross Timbers Physiographic Province, which is

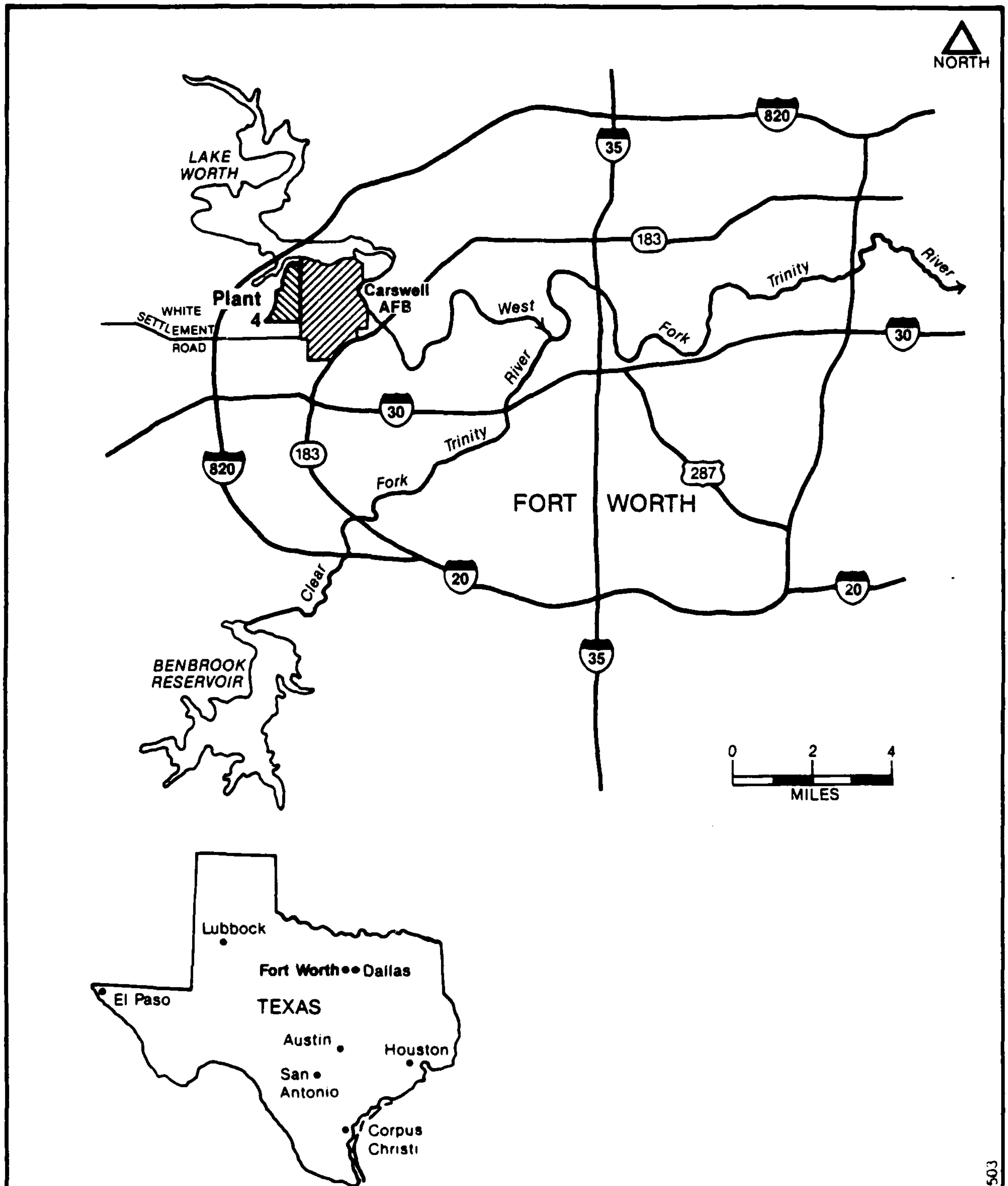

Figure 2-1. Location Map of AF Plant 4, Texas

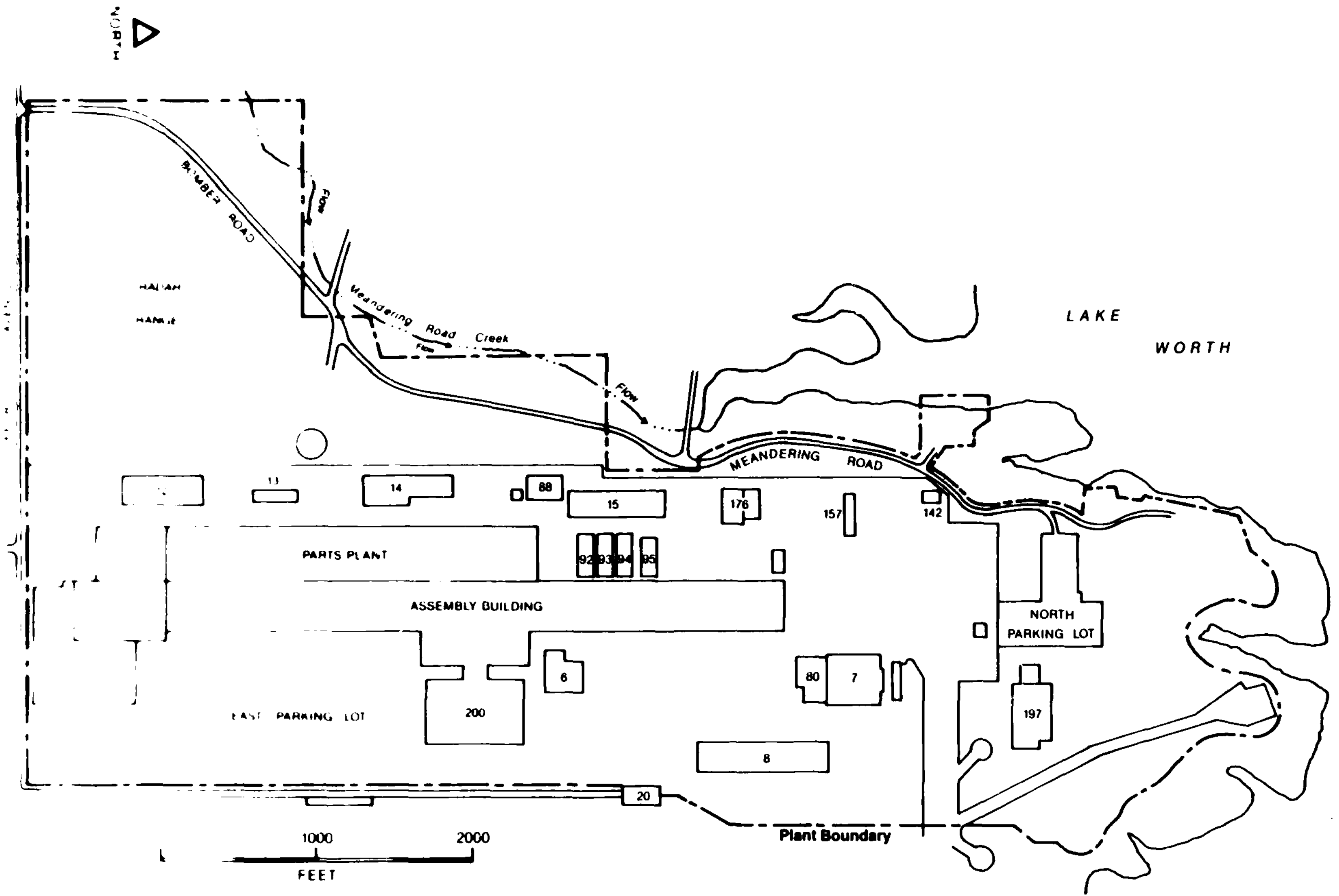

Figure 2-2. General Layout and Physical Features of AF Plant 4, Texas

characterized by rolling topography and a heavy growth of post and blackjack oaks.

The topography of the plant is fairly flat except for areas near the creek parallel to Meandering Road, which discharges to Lake Worth, Farmer's Branch and the Trinity River. Land surface slopes gently northeast toward Lake Worth and east toward the West Fork of the Trinity River. Elevations range from a high of approximately 627 feet MSL at the southwest corner of the plant to a low of approximately 600 feet MSL north of the plant at Lake Worth.

Surface drainage at AF Plant 4 is intercepted by storm drains and culverts and is discharged to Lake Worth, the Meandering Road Creek, or a tributary of Farmer's Branch. AF Plant 4 is partially drained by Farmer's Branch, which in turn discharges into the West Fork Trinity River east of Carswell Air Force Base. Figure 2-3 shows the direction of surface water flow at AF Plant 4.

2.3 Geologic and Hydrogeologic Conditions

Surficial Soils

The U.S.D.A. Soil Conservation Service has identified two similar soil associations at AF Plant 4. Most of the surficial soils of the installation area are nearly level or gently sloping clay soils of the Sanger-Purves-Slidell and Aledo-Bolar-Sanger associations. Soils of the Sanger-Purves-Slidell association occupy most of the area at AF Plant 4. The Aledo-Bolar-Sanger association exists only in a thin strip along the northern boundary of the plant. These soils are described in Table 2-1 and shown on Figure 2-4.

Lithology

A geologic section showing the geologic formations beneath AF Plant 4 is presented in Figure 2-[illegible]. Descriptions and properties of units pertinent

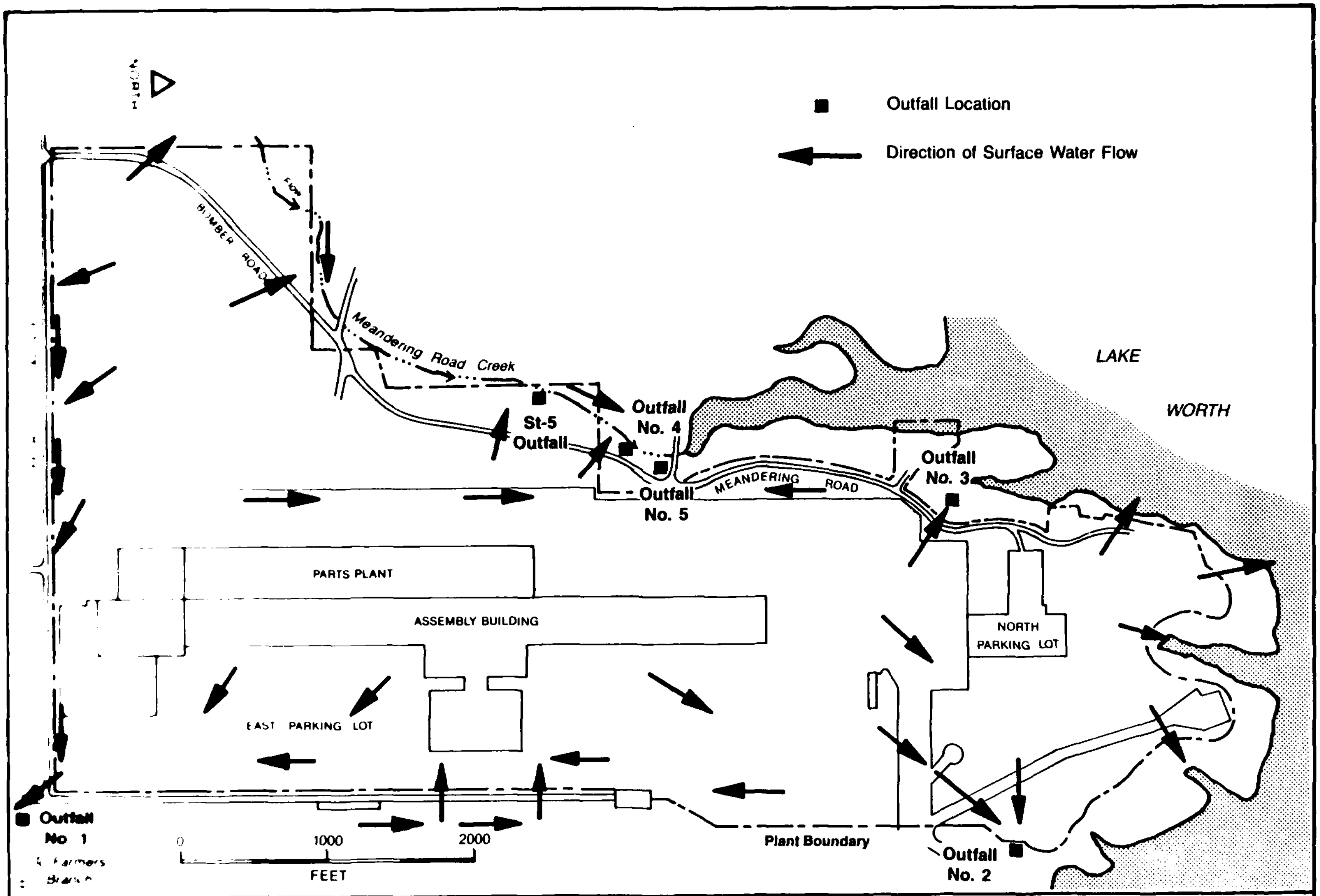

Figure 2-3. Surface Drainage at AF Plant 4, Texas

TABLE 2-1. SOIL ASSOCIATIONS FOR AF PLANT 4, TEXAS

Association	Description	Thickness (inches)	Permeability (cm/sec)
Sanger-Purves-Slidell: Clay soils of nearly level to gently sloping uplands.	Clay loam Clay over bedrock Silty clay	8-80	$<4.2 \times 10^{-5}$ to 3×10^{-4}
Aledo-Bolar-Sanger: Loamy and clayey soils of gently sloping to moderately steep uplands.	Clay loam over bedrock Clay loam	8-70	$<4.2 \times 10^{-5}$ to 9×10^{-4}

SOURCE: U.S. Department of Agriculture, 1981, Soil Survey of Tarrant County: Soil Conservation Service, 218 pp.

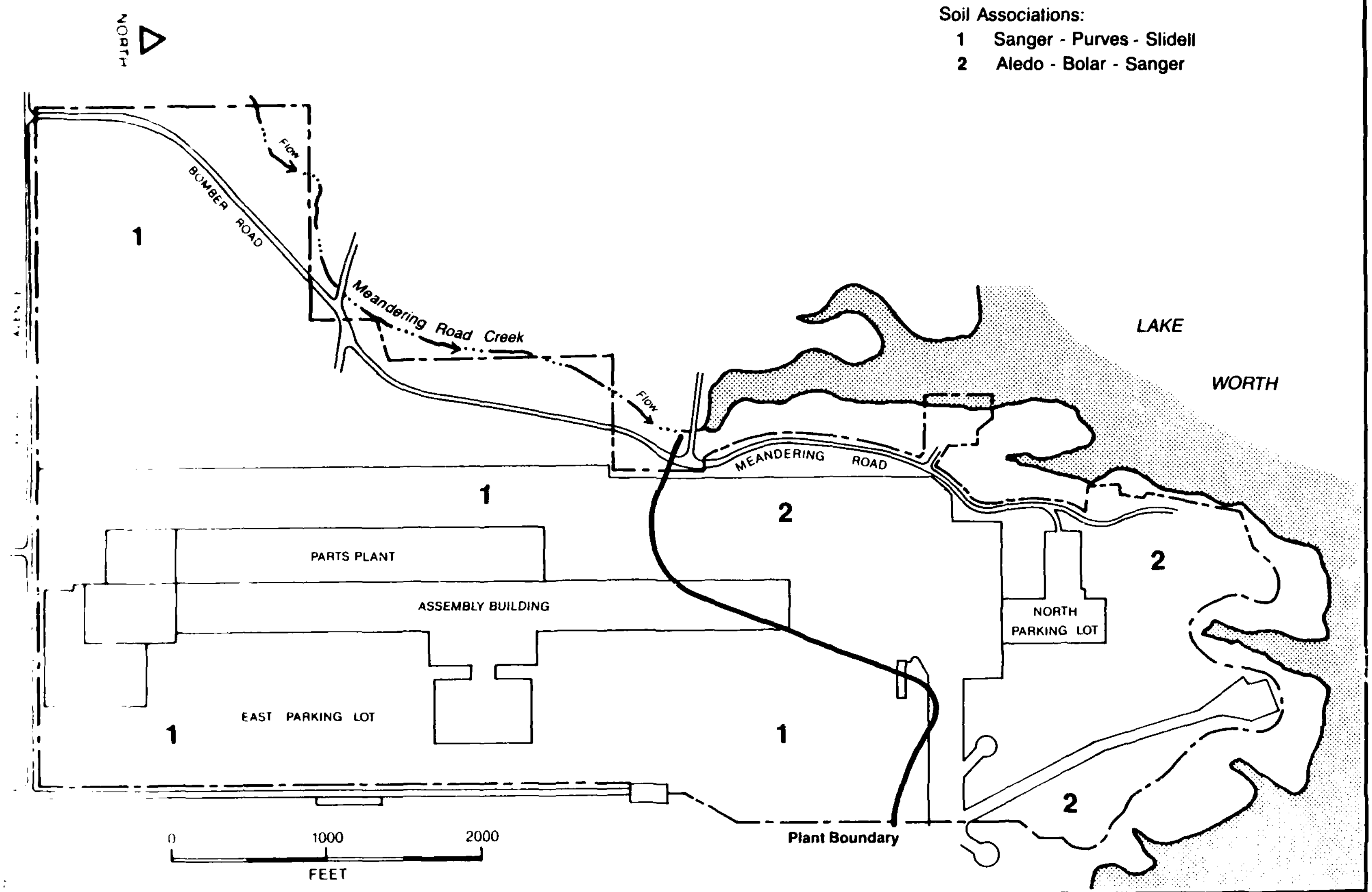

Figure 2-4. General Soil Association Map, AF Plant 4, Texas

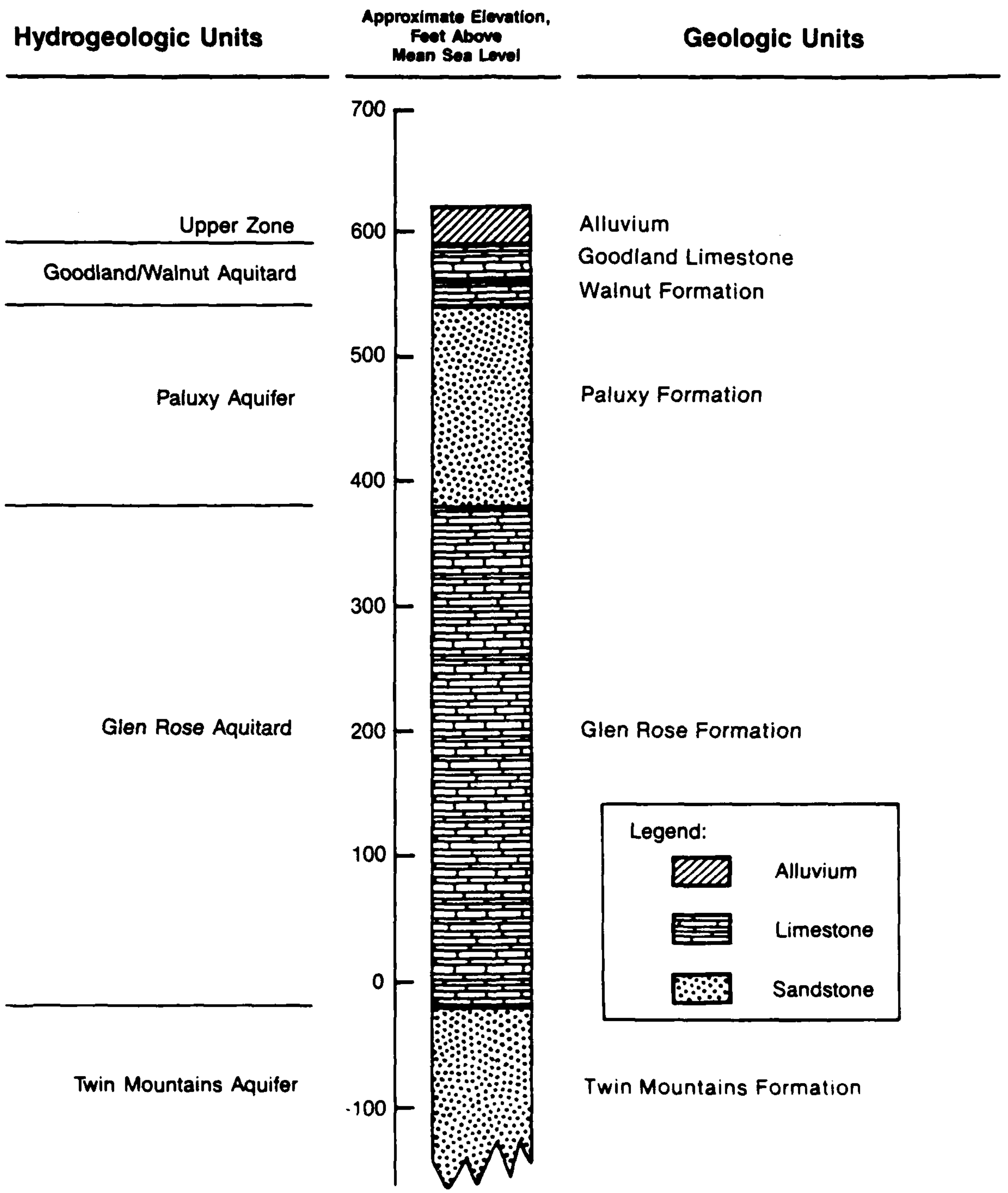

Figure 2-[illegible]. Generalized stratigraphic column at AF Plant 4, Texas

to this study are summarized in Table 2-2. From youngest to oldest, the geologic units of interest to AF Plant 4 are as follows: 1) Quaternary Alluvium, 2) Cretaceous Goodland Limestone, 3) Cretaceous Walnut Formation, 4) Cretaceous Paluxy Formation, 5) Cretaceous Glen Rose Formation, and 6) Cretaceous Twin Mountains Formation. Only the first four are exposed at the surface at Plant 4. Except for a thin strip along Meandering Road Creek and Lake Worth, the surface is blanketed with alluvium and man-made fill. The locations and extent of the bedrock units at the plant are shown on a geologic map, Figure 2-6.

The majority of the plant is covered by alluvium deposited by the Trinity River during flood stages. The alluvium is composed of gravel, sand, silt, and clay of varying thicknesses and lateral extents.

The Goodland Limestone and Paluxy Formation are exposed in very small sections along the north and northwest boundary of the AF Plant 4, along Meandering Road Creek and Lake Worth. The Goodland is a chalky-white, fossiliferous limestone and marl. The Walnut Formation is a shell-agglomerate limestone with varying amounts of clay and shale. Although the Glen Rose Limestone and sandstones of the Twin Mountains Formation are not exposed at AF Plant 4, these formations are important in understanding the hydrogeology of the AF Plant 4 area.

Structure

AF Plant 4 is located in a structurally stable setting (the Texas craton), west of the faults that lie along the Ouachita Structural Belt. No major faults or fracture zones have been mapped near the base. The regional dip of the rocks beneath AF Plant 4 is between 35 and 40 feet per mile in an easterly to southeasterly direction. The stratigraphic and structural relationships of the uppermost geologic units at AF Plant 4 are illustrated in Figure 2-6, which shows a cross-section from south to north across the plant site. The location of the cross section, taken from Hargis and Associates

TABLE 2-2. GEOLOGIC FORMATIONS BENEATH AF PLANT 4, TEXAS

System	Series and Group	Formation and Member	Thickness (ft)	Character of Rocks	Topographic Expression	Water-Bearing Properties
Quaternary	Recent and Pleistocene	Alluvium	0-45	Sand, gravel, clay, and silt.	Terrace and flood-plain deposits.	Small to moderate yields. Water unsatisfactory for use unless treated.
Cretaceous	Comanche Series Washita Group	Duck Creek Formation	0-80	Impure limestone and marl, which is blue when fresh and straw-colored when weathered. Fossiliferous with distinctive ammonites.	Bench topography produced by lower limestone unit. Upper marl forms slope separating the Duck Creek from Fort Worth limestone.	Small to moderate yields. Water unsatisfactory for use unless treated.
	Comanche Series Fredericksburg Group	Kiamichi Formation	0-40	Blue and brownish-yellow marl, thin limestone and sandstone flags.	Grassy slope separating scarps of Goodland and Duck Creek formations.	Small to moderate yields. Water unsatisfactory for use unless treated.
		Goodland Limestone	0-130	Chalky-white fossiliferous limestone, and blue to yellowish brown marl.	Prominent glaring-white escarpment along streams.	Small to moderate yields. Water unsatisfactory for use unless treated.
		Walnut Clay	0-28	Shell agglomerate fossiliferous clay and limestone, sandy clay, and black shale.	Forms conspicuous escarpment and waterfalls in western Cross Timbers belt.	Not known to yield water to wells in Tarrant County.
				UNCONFORMITY		
Cretaceous	Comanche Series Trinity Group	Paluxy Sand	140-190	Fine-grained sand, shale, sandy shale, lignite and pyrite.	Sandy soil, hummocky topography, heavily wooded with oaks.	Source of supply for most households, smaller cities, and some industries.
		Glen Rose Limestone	250-450	Fine-grained limestone, shale, marl, and sandstone.	Not exposed in Tarrant County.	Sands yield small supplies to wells in Fort Worth and western Tarrant County. Water too highly mineralized east of Fort Worth.
		Twin Mountains Formation (Formerly Travis Peak Formation)	250-450	Coarse to fine-grained sandstone, red shale, red and yellow clay at base.	Not exposed in Tarrant County.	Principal aquifer in Tarrant County. Yields large supplies for municipal and industrial purposes. Water in upper sands east of Fort Worth may be highly mineralized.
				MAJOR UNCONFORMITY		
Pennsylvanian	Undifferentiated		6,000-7,000	Gray, sandy shale, tight quartzitic sandstone, black limestone. Probably represents Strawn formation.	Not exposed in Tarrant County.	Not tested. Probably would not yield fresh water.

Source: E.R. Legget.

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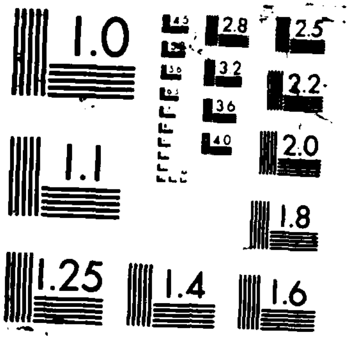
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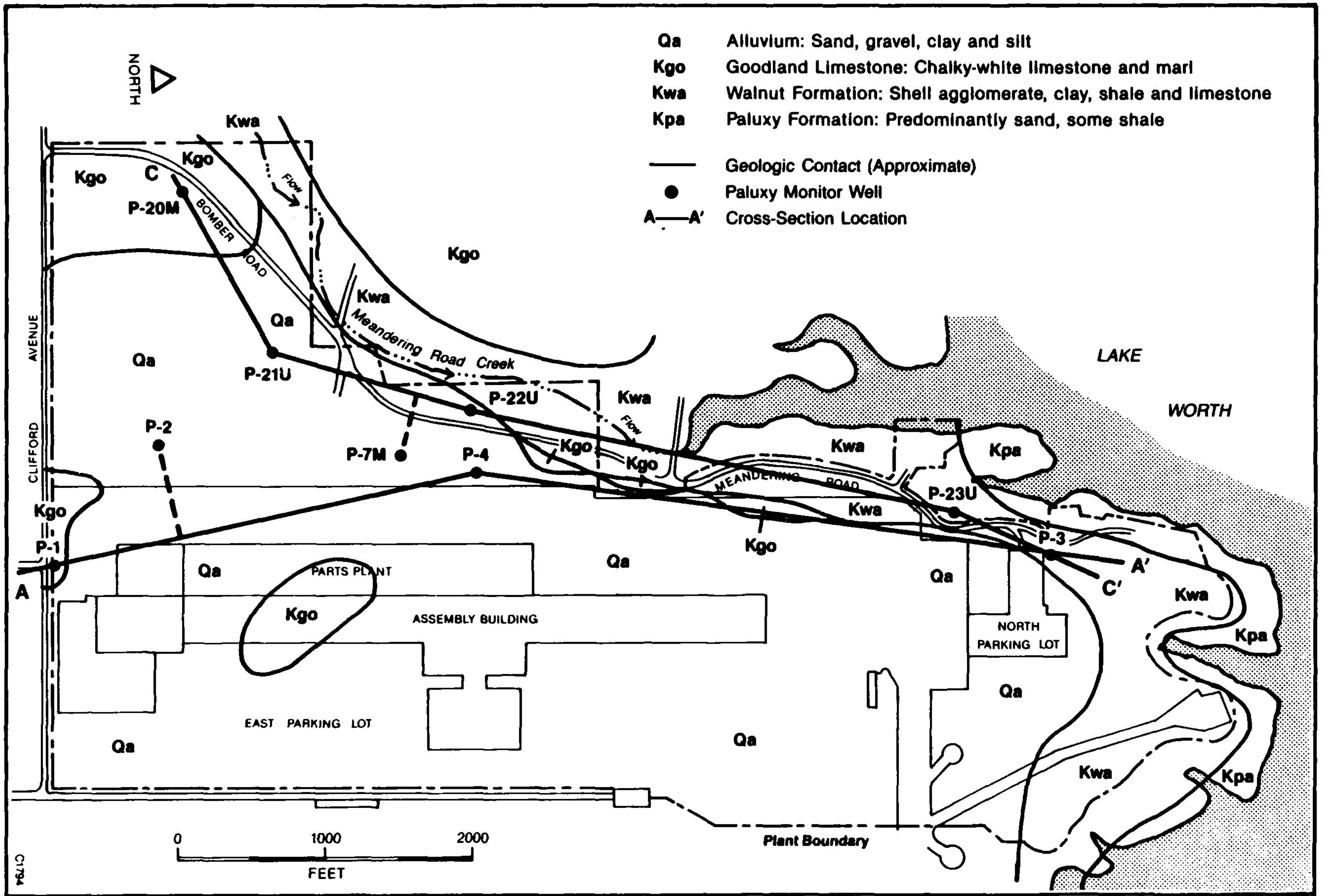


Figure 2-6. General Geologic Map of AF Plant 4, Texas

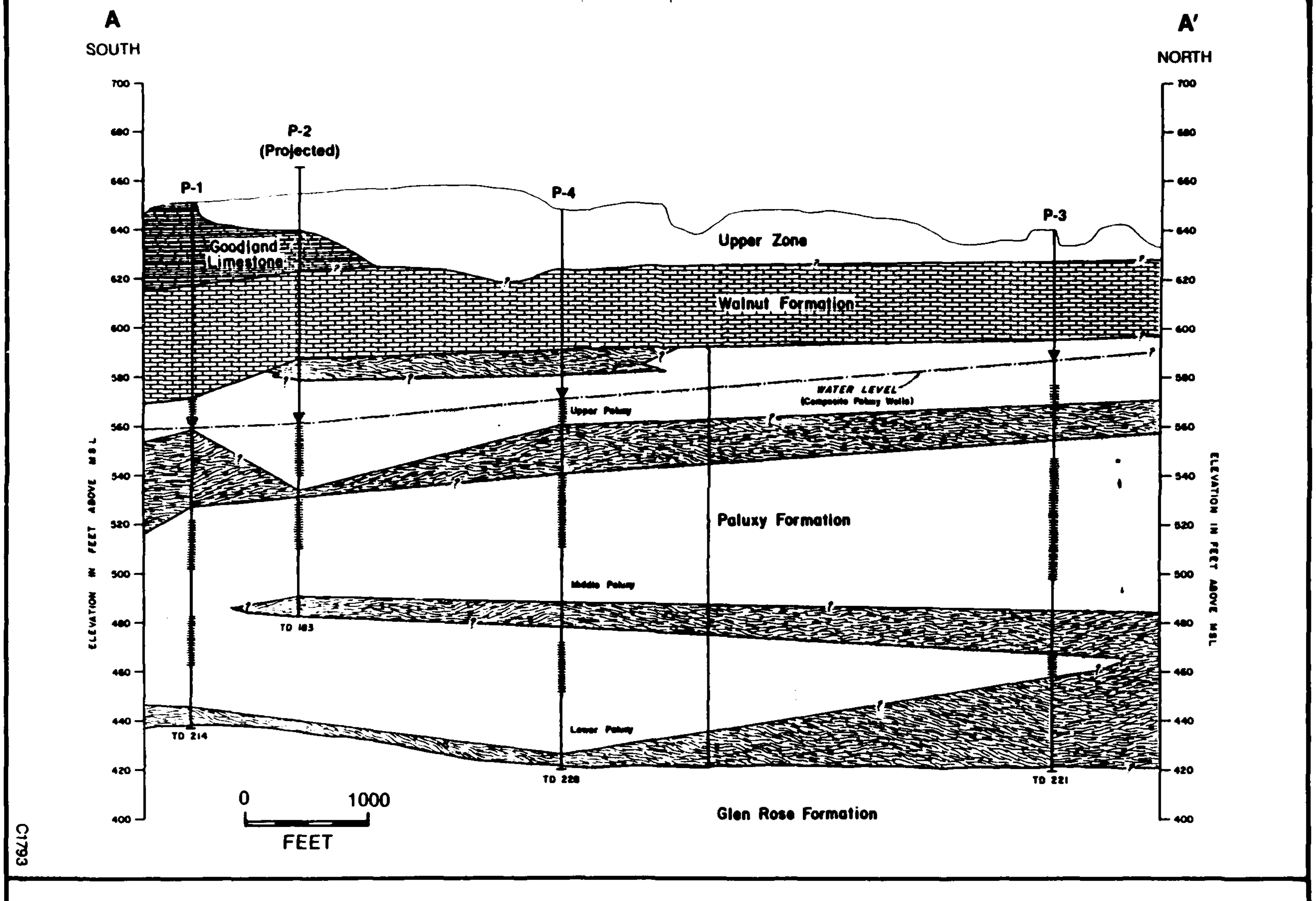
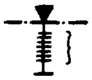


Figure 2-7. Generalized North-South Cross-Section through AF Plant 4, Texas (From Hargis & Associates, 1985).

EXPLANATION

P-1	WELL IDENTIFIER
	COMPOSITE OR MIDDLE PALUXY FORMATION WATER LEVEL SCREENED OR PERFORATED INTERVAL
TD 214	TOTAL DEPTH OF BOREHOLE, FEET
▭	UPPER ZONE Alluvium and fill
▨	WALNUT FORMATION / GOODLAND LIMESTONE Fossiliferous limestone interbedded with shale and clay
▨	PALUXY FORMATION Fine-grained sand Predominately clay and shale
▭	GLEN ROSE FORMATION Limestone with some sand and clay

GEOLOGY FROM LITHOLOGIC LOGS OF MIDDLE PALUXY WELLS (UPPER PALUXY WELLS PROJECTED) ELEVATION OF LAND SURFACE IS APPROXIMATE WATER LEVEL ELEVATIONS FROM MARCH, 1985 DATA

Figure 2-7. Continued

(1985), is shown in Figure 2-6. Borings completed for the current study substantiated the data shown. These are discussed further in Section 4.

Hydrogeology

On the basis of their water-bearing properties, the geologic units at AF Plant 4 may be divided into the following five hydrogeologic units, listed from most shallow to deepest: 1) an upper perched-water zone occurring in the alluvial terrace deposits left by the Trinity River; 2) an aquitard of predominantly dry limestone of the Goodland and Walnut Formations; 3) an aquifer in the Paluxy sand; 4) an aquitard of relatively impermeable limestone in the Glen Rose Formation; and 5) a major aquifer in the sandstone of the Twin Mountains Formation. Each of these units, shown in Figure 2-5, is examined in more detail below.

Upper Zone - Groundwater occurs within fluvial sediments deposited by the Trinity River, but these deposits are usually limited in areal extent. Recharge to the water-bearing deposits is local, from rainfall and infiltration from stream channels and drainage ditches. The direction of groundwater flow is geneally controlled by the bedrock topography of the Walnut Formation.

In parts of Tarrant County, generally close to the Trinity River, water in the alluvium is developed for irrigation and residential use. The community of River Oaks, immediately east of Carswell AFB, had supply wells that developed water from the alluvial deposits at a location near the USAF Hospital. The wells were abandoned when Carswell AFB purchased the property. Groundwater present in the upper zone occurs as a perched water table and, in general, it is not hydraulically connected to the underlying aquifers (CH2M Hill, 1984). For the most part, it is not economical to develop groundwater from the alluvium because of the water's limited distribution and susceptibility to surface pollution.

Goodland/Walnut Aquitard - The perched water present in the alluvium is separated from the aquifers below by the low permeability limestones and shales of the Goodland Limestone and Walnut Formation. The aquitard is composed of moist clay and shale layers interbedded with dry limestone beds. Though primarily dry, drillers in the area report that small amounts of water enter the borehole while drilling through the Walnut Formation, suggesting that groundwater may move through the Walnut along bedding planes (Hargis and Associates, 1985). The thickness of the Goodland/Walnut aquitard is approximately 25 feet or greater beneath most of AF Plant 4. However, the top of the aquitard is an erosional surface and weathering may have reduced the thickness of the limestone in isolated areas. A soil boring at AF Plant 4, beneath Building 189 along Grants Lane, revealed that the Goodland Limestone there had been completely eroded and only three feet of the Walnut Formation remained (Hargis and Associates, 1985). It is also reported that the upper zone and the Paluxy Formation are in contact at the eastern boundary of AF Plant 4, where both the Goodland and Walnut Formations have eroded away (Hargis and Associates, 1985). In areas of similarly extensive erosion, water in the upper zone could come in contact with water in the Paluxy aquifer.

Paluxy Aquifer - The Paluxy aquifer, whose areal extent is shown in Figure 2-8, is the most shallow aquifer occurring beneath AF Plant 4. In the plant area, water in the Paluxy would naturally occur under confined conditions beneath the Goodland/Walnut aquitard (except where the aquitard has eroded away, as discussed above). However, extensive pumping in the Fort Worth area has lowered the Paluxy potentiometric surface below the top of the formation, resulting in unconfined conditions beneath the base. The Paluxy Formation is divided into upper and lower sand members and the aquifer is likewise divided into upper and lower aquifers. Whereas the upper sand is fine-grained and shaley, the lower sand is more coarse and permeable; therefore, most wells are completed in the lower section.

Recharge to the Paluxy aquifer occurs where the formation outcrops west of AF Plant 4. The Paluxy also outcrops north of the plant in the bed of

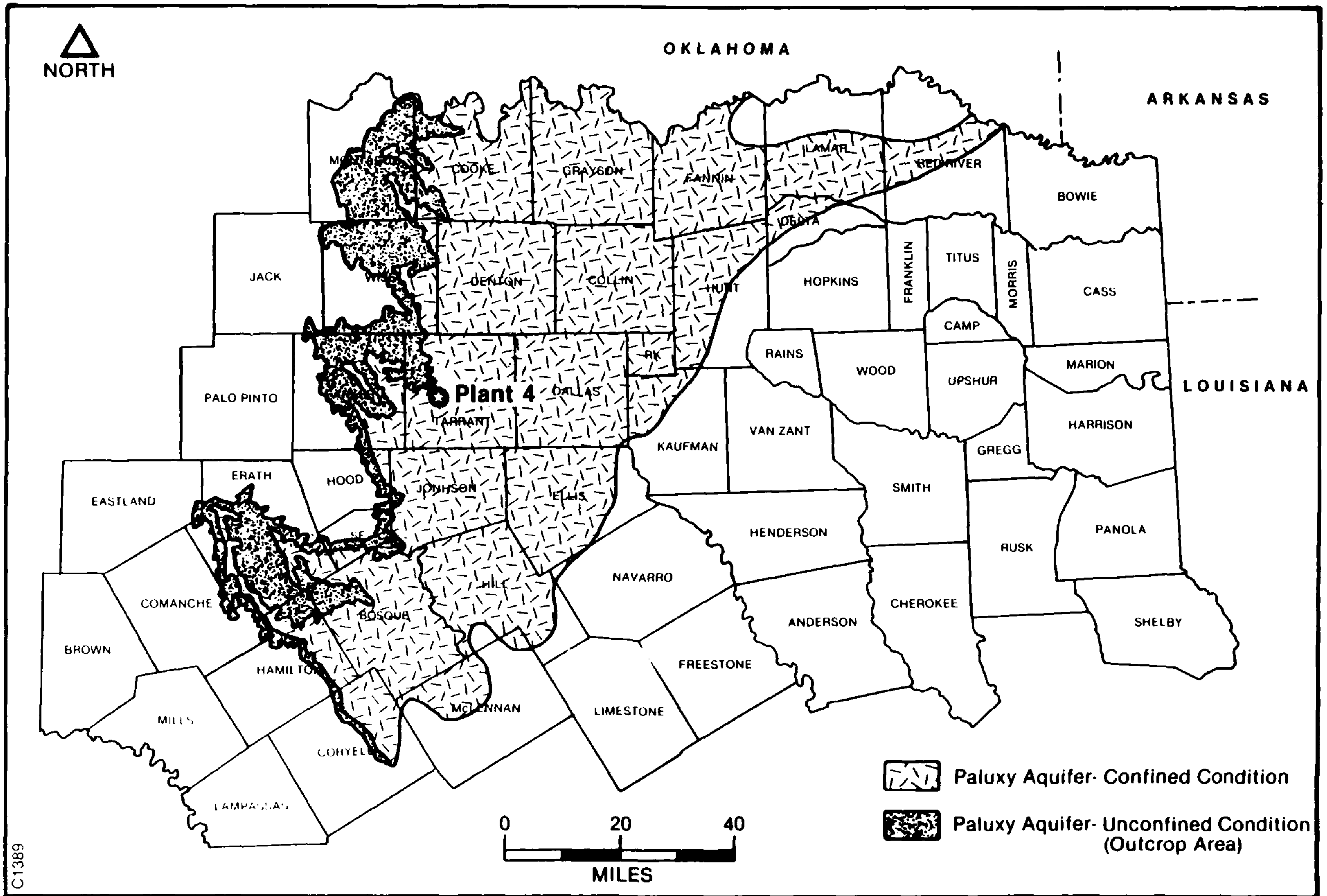


Figure 2-8. Areal Extent of the Paluxy Aquifer, North Texas

Lake Worth. The lake represents a significant recharge point for the aquifer and creates a potentiometric high in its vicinity. Regional groundwater flow within the Paluxy is southeastward, in the direction of the regional dip. At Plant 4, groundwater flow is influenced by recharge from Lake Worth, which creates a potentiometric high, and by groundwater withdrawals by the community of White Settlement. This drawdown results locally in a more southerly flow direction within the Paluxy aquifer.

The Paluxy aquifer is an important source of potable groundwater in the Fort Worth area. Communities surrounding AF Plant 4, especially White Settlement, develop municipal water supplies from the Paluxy and, to a greater extent from the Twin Mountains aquifer below. Because of its extensive use as a potable and municipal water supply, water levels in the Paluxy aquifer have declined significantly over the years. Water levels in the immediate AF Plant 4 vicinity have not decreased as much as in the Fort Worth area in general because of the proximity of the Lake Worth recharge area and because the base does not develop water from the Paluxy.

Transmissivities in the Paluxy aquifer range from 1,263 to 13,808 gallons per day per foot (gpd/ft), an average of 3,700 gpd/ft (CH2M Hill, 1984). The Paluxy Formation thickness ranges from 140 to 190 feet, averaging 160 feet in Tarrant County. The actual water-bearing thickness in the AF Plant 4 area probably approximates the formation thickness, but the aquifer is separated into two distinct water-bearing zones, denoted as the upper and middle/lower Paluxy. In some cases, the middle and lower Paluxy are also separated by low-permeability layers. In the vicinity of AF Plant 4, hydraulic conductivities range from 13 to 140 gpd/ft^2 (based on an approximate sand thickness for the aquifer of 100 ft.). Well yields within the Paluxy aquifer range from 10 to 480 gallons per minute (gpm), averaging approximately 100 gpm.

Water quality in the Paluxy aquifer is generally good and is satisfactory for potable use. Table 2-3 shows the range of chemical constituents in Paluxy groundwater reported by the Texas Department of Water Resources.

TABLE 2-3. RANGE OF CONSTITUENTS IN GROUNDWATER FROM SELECTED WELLS IN THE PALUXY FORMATION, TARRANT COUNTY

Constituent or Property	Concentration
Bicarbonate (HCO_3)	177-689
Boron (B)	0.1-0.6
Calcium (Ca)	0-120
Chloride (Cl)	5-117
Fluoride (F)	0-4.5
Iron (Fe)	0-9.9
Magnesium (Mg)	0-43
Nitrate, (NO_3) [as Nitrogen]	0-10.0
Silica (SiO_2)	1-30
Sodium (Na)	11-740
Sulfate (SO_4)	6-1,080
Dissolved Solids	264-2,176
Total Hardness ($CaCO_3$)	2-401
pH	7.1-9.2
Sodium-Absorption Ratio (SAR)	0.2-68.8
Residual Sodium Carbonate (RSC)	0-10.0
Specific Conductance (umhos at 25°C)	427-3,193

NOTE: Analyses given are in milligrams per liter except specific conductance, pH, SAR, and RSC.
SOURCE: Texas Department of Water Resources, 1982, quoted in CH2M Hill, 1984.

Glen Rose Aquitard - Below the Paluxy Aquifer are the fine-grained limestone, shale, marl, and sandstone beds of the Glen Rose Formation. The thickness of the formation ranges from 250 to 450 feet. Although the sands in the Glen Rose Formation yield small amounts of water to wells in Fort Worth and western Tarrant County, the relatively impermeable limestone is an aquitard restricting water movement between the Paluxy aquifer above and the Twin Mountains aquifer below.

Twin Mountains Aquifer - The Twin Mountains Formation is the oldest formation used for water supply in the AF Plant 4 area. The formation consists of a basal conglomerate of chert and quartz, grading upward into coarse- to fine-grained sand interbedded with shale. The formation occurs approximately 600 feet below AF Plant 4. The thickness of the formation ranges from 250 to 430 feet.

Recharge to the Twin Mountains aquifer occurs west of AF Plant 4, where the formation crops out. Water movement is eastward in the downdip direction. Like water in the Paluxy aquifer, Twin Mountains water occurs in water table conditions in the recharge area and becomes confined as it moves downdip.

The Twin Mountains aquifer is the principal aquifer in Tarrant County. The formation yields large water supplies for municipal and industrial purposes. Transmissivities in the Twin Mountains aquifer range from 1,950 to 29,700 gpd/ft and average 8,450 gpd/ft in Tarrant County. Hydraulic conductivities range from 8 to 165 gpd/ft^2 and average 68 gpd/ft^2 in Tarrant County (CH2M Hill, 1984).

Groundwater withdrawals from the Twin Mountains aquifer, primarily for municipal water supply, have reduced the water levels. Between 1955 and 1976, the potentiometric surface of the aquifer dropped approximately 250 feet.

Water suitable for potable use occurs in the Twin Mountains aquifer throughout the Fort Worth area; however, water in the upper sands in the aquifer east of Fort Worth may be too mineralized for human consumption.

2.4 Site Descriptions

Phase I studies for the AF Plant 4 Installation Restoration Program were completed by CH2M Hill in August 1984. The purpose of the Phase I study was to identify by means of a records search past waste management activities that may have caused groundwater contamination and the migration of contaminants.

Twenty sites were identified in the Phase I investigation. These 20 and one additional site (listed in Table 2-4) were investigated in the Phase II Stage 1 study. Locations of the waste sites are shown in Figure 2-9. Figure 2-10 is an index map, showing the areas covered by the larger scale, site-specific maps presented in the following subsections. The general features of each site are discussed below. Figures associated with each site also show the locations of the monitor wells and soil borings discussed in Sections 3 and 4 below. Most of the information provided was obtained from the Installation Restoration Program Phase I records search report (CH2M Hill, 1984).

2.4.1 Site 1, Landfill 1

Landfill 1 was used to dispose of much of the facilities' wastes from 1942 until about 1966. This site, located west of Warehouse 3 (Facility 14) between the fence and Meandering Road (Figure 2-11), encompasses approximately six acres. Currently, the site is completely covered by an employee parking area.

Several types of hazardous and nonhazardous wastes were reportedly disposed of in Landfill 1. Drums of liquid wastes were buried in the

TABLE 2-4. PHASE II STAGE 1 SITES AT AF PLANT 4

Site 1, Landfill 1
Site 3, Landfill 3
Site 12, Chrome Pit 3
Site 17, Former Fuel Storage Site
Site 2, Landfill 2
Site 4, Landfill 4
Zone 1 (Site 13, Die Pits; Site 11, Chrome Pit 2; Site 8, FDTA 5)
Site 15, Fuel Saturation Area (FSA) 2
Site 20, Wastewater Collection Basins
Site 16, Fire Saturation Area 3
Site 9, Fire Department Training Area (FDTA) 6
Site 6, Fire Department Training Area 3
Site 7, Fire Department Training Area 4
Site 18, Solvent Lines
Site 10, Chrome Pit 1
Site 5, Fire Department Training Area 2
Site 14, Fire Saturation Area 1
Site 19, Nuclear Aerospace Research Facility (NARF) Area
Jet Engine Test Stand, Building 21

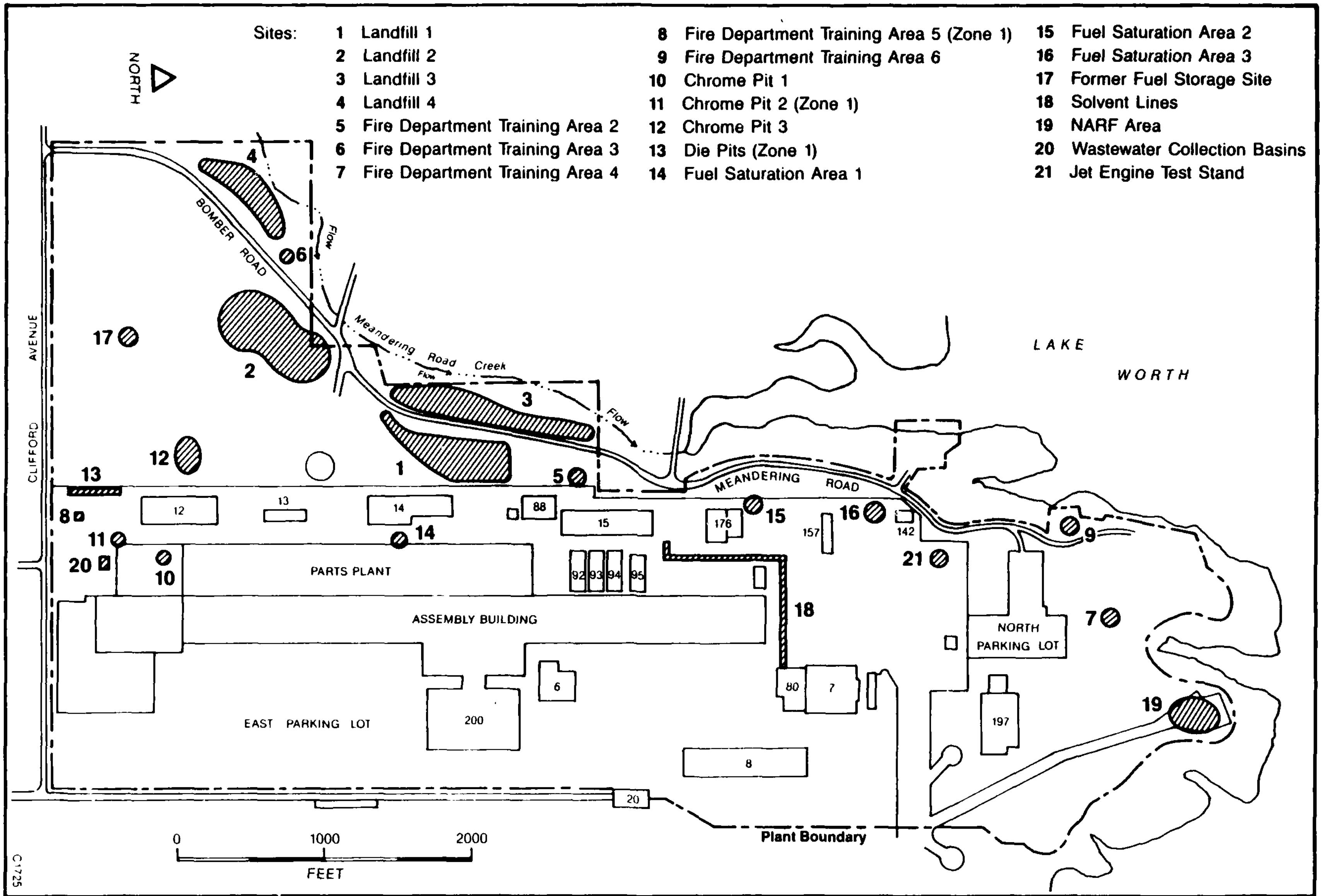
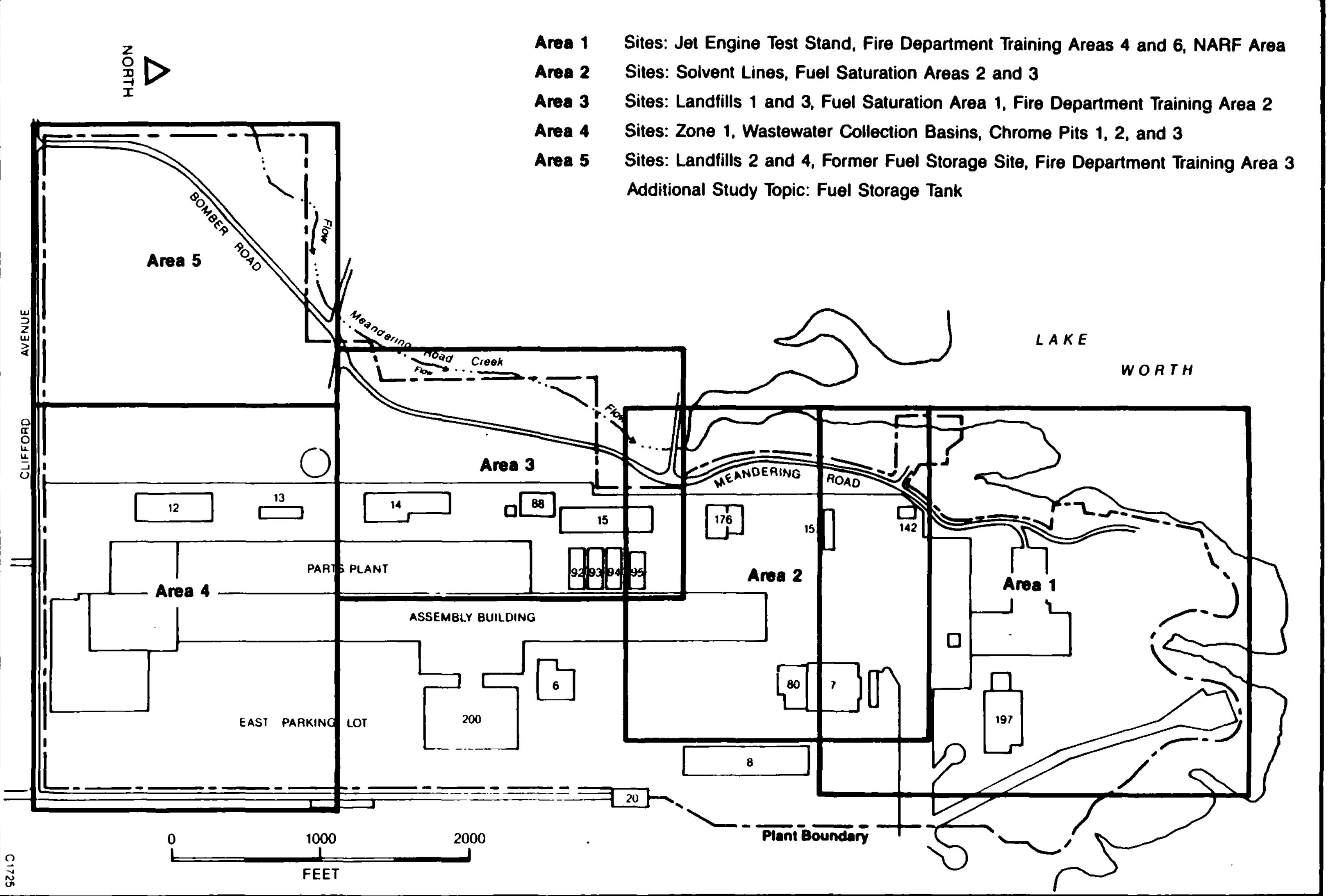


Figure 2-9. IRP Phase II Stage 1 Waste/Contamination Sites, AF Plant 4, Texas



Area 1	Sites: Jet Engine Test Stand, Fire Department Training Areas 4 and 6, NARF Area
Area 2	Sites: Solvent Lines, Fuel Saturation Areas 2 and 3
Area 3	Sites: Landfills 1 and 3, Fuel Saturation Area 1, Fire Department Training Area 2
Area 4	Sites: Zone 1, Wastewater Collection Basins, Chrome Pits 1, 2, and 3
Area 5	Sites: Landfills 2 and 4, Former Fuel Storage Site, Fire Department Training Area 3
	Additional Study Topic: Fuel Storage Tank

Figure 2-10. Index Map for Individual Area Maps, AF Plant 4, Texas

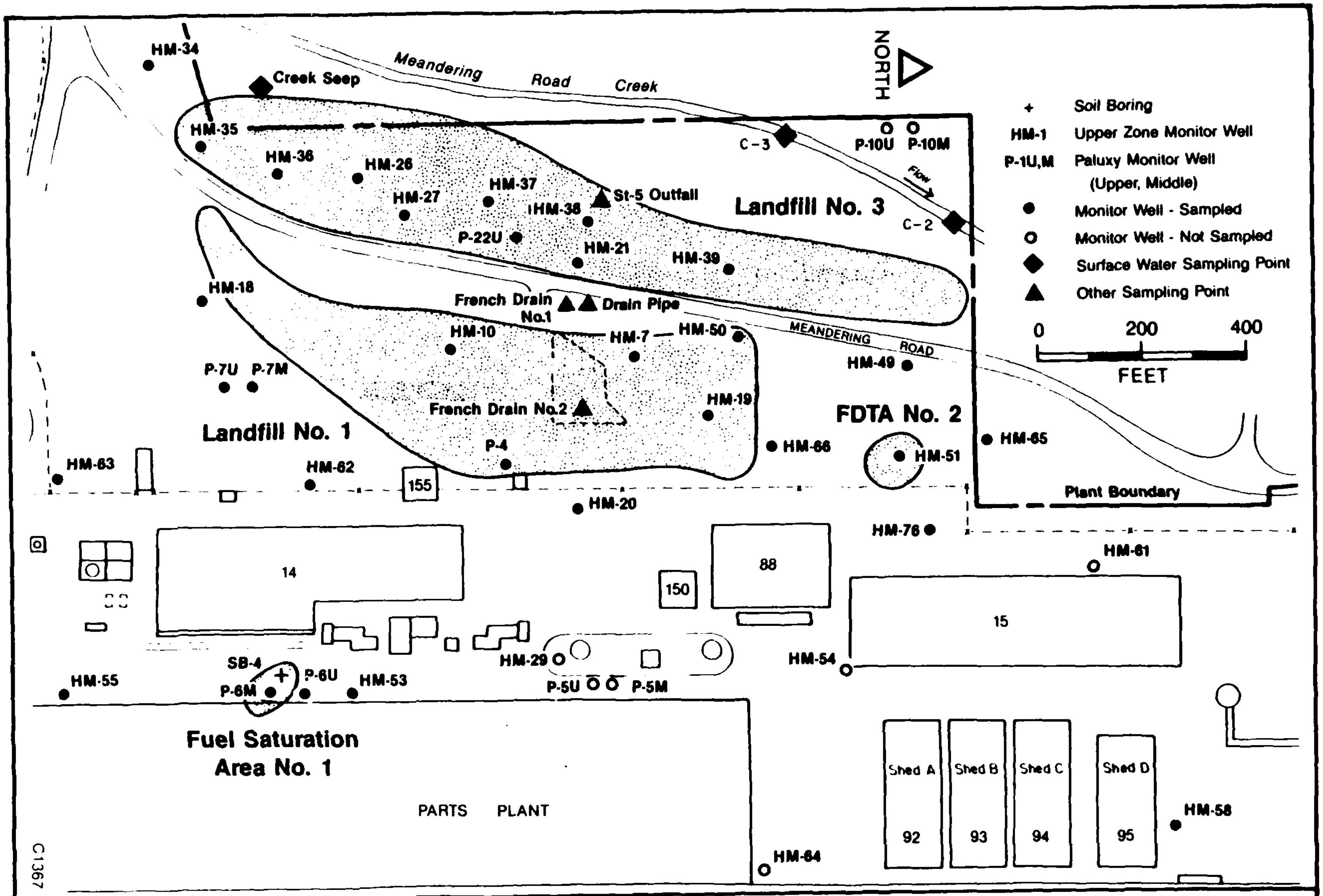


Figure 2-11. Location Map for Sites 1 and 3, Landfills 1 and 3; Site 17, Fuel Saturation Area 1; and Site 5, Fire Department Training Area 2, AF Plant 4, Texas

landfill, and tanks and bousers loaded with chemical wastes (solvents, thinners, paints, etc.) were emptied into the landfill or into shallow pits at various locations throughout the landfill area. Miscellaneous contaminated oils and fuels were also disposed of in pits and were routinely burned. Sludge from these pits was periodically dredged out and deposited in the landfill area. At least five separate or overlapping pits are discernible on historical aerial photographs of this site. Other hazardous wastes suspected to be present at this site include metals (e.g., mercury, magnesium, etc.), chromate sludges, and cyanide. Although some hazardous wastes are probably scattered throughout much of the landfill, most of the fill material probably consists of trash, rubble, plasters (aircraft moldings), lumber, and fill dirt.

Extensive remedial action has been carried out here since the site was closed during the 1960s. Before the parking lot was graded for paving, two 6-inch perforated pipes were laid on bedrock to channel leachate drainage to a stormwater outfall to Meandering Road Creek. In 1982 and 1983, following identification of hazardous substances in the storm drain, the original drain lines were connected to an additional 20 feet of 4-inch perforated drain line (French drain), which was placed on bedrock upgradient from the existing storm sewer to intercept flows and to allow collection and disposal. The existing 36-inch storm sewer and catch basins were lined with PVC material to eliminate infiltration of percolate.

In 1983, additional remedial action was carried out. Since the main source of residual contamination was suspected to be the former waste oil pits, a portion of the site was excavated to bedrock and removed from the AF Plant 4 facility to an approved hazardous waste facility. To make this excavation, a portion of the parking lot was removed and approximately 11,000 cubic yards of earth were removed. Six 24-inch drain lines were placed in the bottom of this pit and connected to a collector box for surface collection of percolate. The pit was backfilled and has been reconverted to a parking area.

Percolate from the three collection points is periodically pumped, analyzed for pollutants, and disposed of off-site as hazardous waste when necessary.

2.4.2 Site 3, Landfill 3

Landfill 3 is located west of Landfill No 1. between Meandering Road and Meandering Road Creek (Figure 2-11). This landfill covers approximately 3 acres of land that was formerly a low area bordering the creek. Interviewees reported that from about 1942 to 1945 this site was used for disposing of miscellaneous wastes, including hazardous liquid wastes consisting of mixed oils and solvents. At least one pit (possibly more) present in this area during the 1940s was used for holding and burning some of the liquid wastes. Other wastes appear to have been disposed of on the ground and later buried. From about 1945 until 1966, there is no evidence of significant activity. From 1966 until 1967, fill dirt and rubble were used to finish filling and grading the site. Water quality analyses from upper zone monitoring wells (HM-26 and HM-27) have indicated the presence of elevated levels of volatile organic compounds in the groundwater. CH2M Hill (1984) considered these data to be indirect evidence for contaminant migration within the upper zone at Site 3.

2.4.3 Site 12, Chrome Pit 3

Chrome Pit 3 is located west of Warehouse 1 in the radar range area (Figure 2-12). The approximate dimensions of this pit are 66 feet by 165 feet. The depth is 10 to 15 feet. From about 1957 until 1973, barium chromate sludge, dilute metal solutions, and drums of unidentified liquids were disposed of in this pit.

Soil borings and shallow groundwater sampling conducted in 1982 confirmed contamination at this site. Approximately 8,900 cubic yards of contaminated soils were excavated during December 1983 and January 1984, and

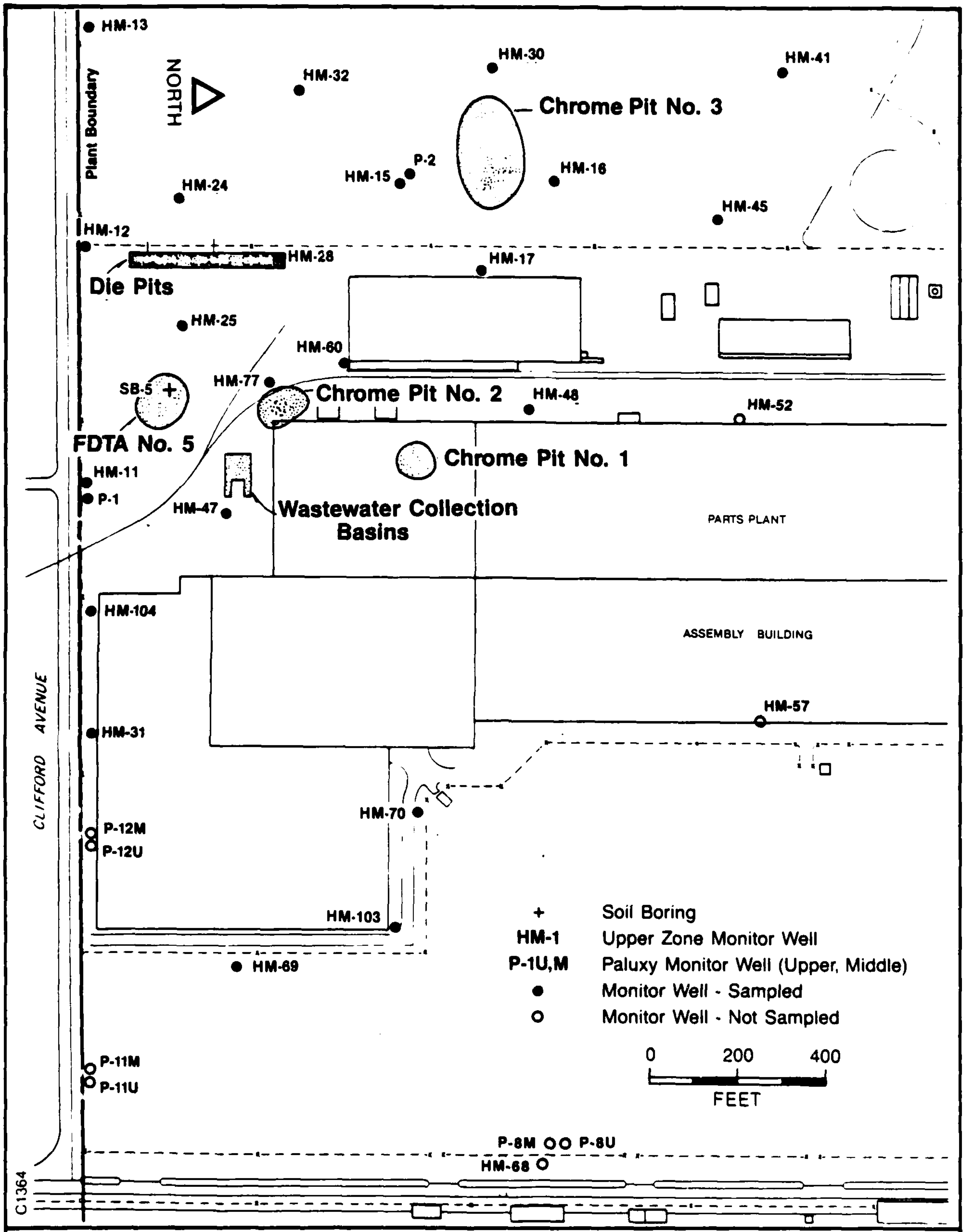


Figure 2-12. Location Map for Sites 10 and 12, Chrome Pits 1 and 3; Zone 1 (Site 13, Die Pits; Site 11, Chrome Pit 2; and Site 8, Fire Department Training Area 5); and Site 20, Wastewater Collection Basins, AF Plant 4, Texas

disposed of off site at an approved hazardous waste landfill. Soil testing conducted during the excavation indicated that most significantly contaminated soils had been removed from the site.

2.4.4 Site 17, Former Fuel Storage Site

The site of the former fuel storage tank is located at the southwest corner of AF Plant 4, near the center of the radar range area (Figure 2-13). A 100,000-gallon JP-4 aboveground fuel storage tank was located here from the early 1940s until 1962. Sampling at this site in 1982 confirmed that soils and underlying groundwater are contaminated by fuels and other organic compounds.

2.4.5 Site 2, Landfill 2

Landfill 2 is located in the northern portion of the present radar range, west of Warehouse 2 (Figure 2-13). This site, south of the employee parking area, occupies approximately 7.5 acres bordering Meandering Road. It originally consisted of some low areas and a livestock watering hole. Most of this site was reportedly filled with construction rubble, plasters, and fill dirt during the early 1940s; however, 1962 and earlier aerial photographs show some inspecified activity at the stock watering hole. This area, reportedly used for disposing of lumber and tires, was assumed to be periodically burned. No reports exist of hazardous substances being deposited at this site. The Phase I report provided no additional data on the nature of the activity at the site.

2.4.6 Site 4, Landfill 4

Landfill 4 is located near the southwest boundary of the AF Plant 4 facility (Figure 2-13). This landfill, formerly part of the low area bordering the adjacent creek, occupies approximately two acres of land west of Meandering Road. Landfill 4 was reportedly used for disposing of clean

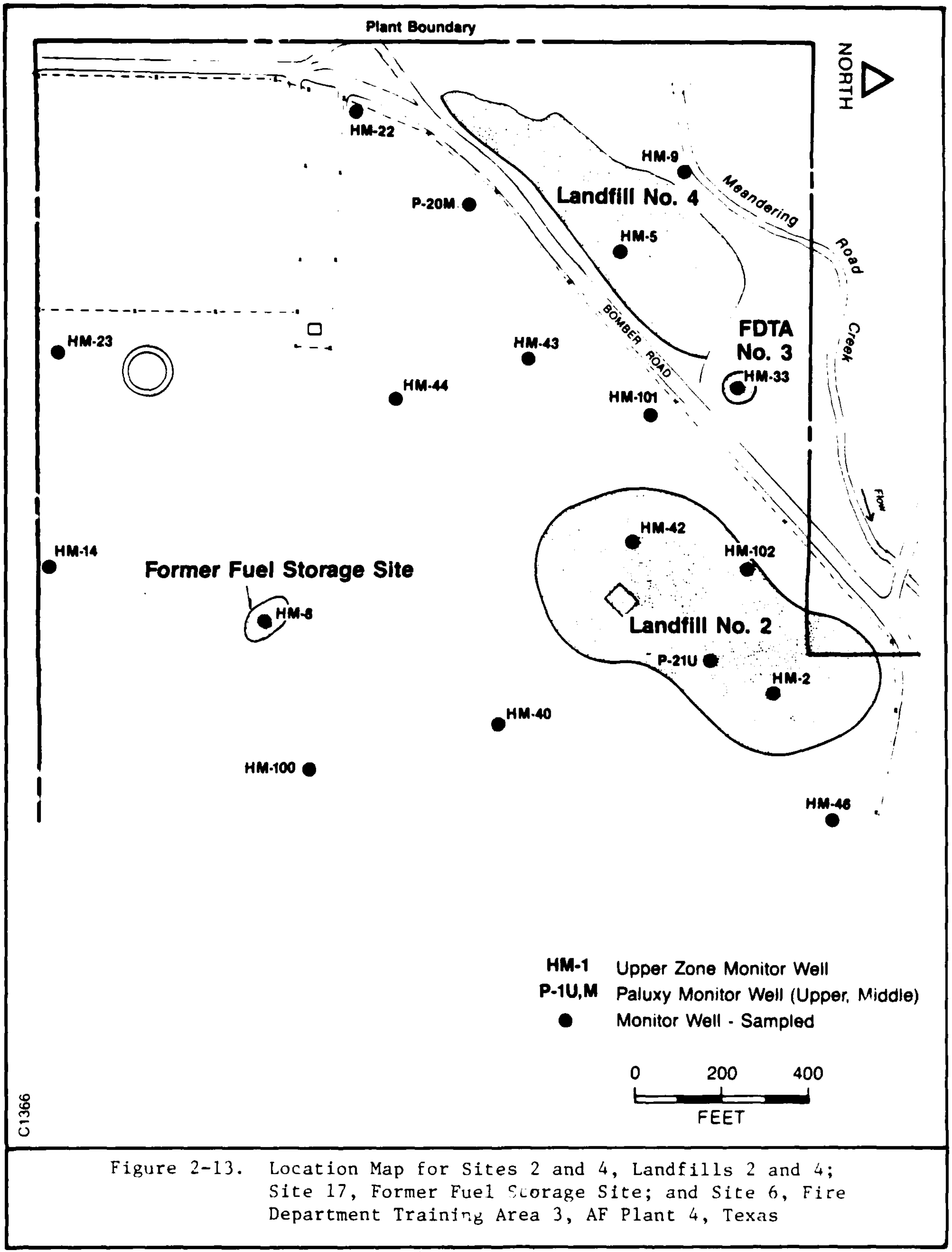


Figure 2-13. Location Map for Sites 2 and 4, Landfills 2 and 4; Site 17, Former Fuel Storage Site; and Site 6, Fire Department Training Area 3, AF Plant 4, Texas

construction rubble from 1956 until the early 1980s. Aerial photographs and a 1973 memo suggest that other types of wastes may have been disposed of from 1966 until at least 1973. Because of this evidence, small quantities of high-hazard wastes (solvents, oils, fuels, thinners, etc.) are thought to be present in the landfill. VOCs and other organic compounds have been found in two upper zone monitoring wells (HM-5 and HM-9) installed here in 1982. CH2M Hill (1984) considered these data to be indirect evidence of upper zone migration at this site. Recent data from the wells, however, give no indication of the presence of these compounds.

2.4.7 Zone 1 (Site 13, Die Pits; Site 11, Chrome Pit 2; Site 8, Fire Department Training Area 5)

Three sites have been combined into one zone, shown on Figure 2-12. The site 13 die pits are located on the west side of the present die yard near the south fence of AF Plant 4. Three pits approximately 20 feet by 90 feet were constructed here in 1956. The pits were used for disposing of chromate sludges, metal solutions, and other chemical wastes until 1962, when the site was graded and the entire die yard was paved. One Phase I interviewee reported that some of the contaminated soils at this site were spread around the die yard during grading and levelling activities. The site of the original pits was excavated in 1983-84, and approximately 1,100 cubic yards of contaminated soils were disposed of at an approved off-site hazardous waste landfill. No quantitative analyses of soils from other parts of the die yard were made at that time.

Site 11, Chrome Pit 2, located in the present die yard area, was used during the mid-1940s. Miscellaneous liquid and solid chemical wastes, in addition to chromate solutions, were probably disposed of at this site. According to the Phase I report, the actual location could not be accurately confirmed.

Site 8, the Fire Department Training Area 5, was reportedly used for fire extinguisher training during the mid-1960s. This site, consisting of a shallow pit about 10 feet by 20 feet, in which waste fuels, oils, or chemicals were deposited for training exercises, is located in the die yard area south of Warehouse 1. It has been graded and paved.

2.4.8 Site 15, Fuel Saturation Area 2

Fuel Saturation Area 2 is located just northwest of the Paint Shop, Facility 176 (Figure 2-14). This site reportedly became saturated by fuels from leaking buried fuel lines between the 1970s and the early 1980s.

2.4.9 Site 20, Wastewater Collection Basins

The Wastewater Collection Basins site is located just south of the Process Building, Facility 181 (Figure 2-12). Two concrete-lined waste basins, each with a capacity of 85,000 gallons, are used to collect and settle suspended solids from chemical wastewaters before discharge to the City of Forth Worth sanitary sewer system. Supernatant from these basins is analyzed for pH and chromium before discharge to the sewer. Settled sludge is periodically removed from these basins, dewatered, and disposed of off site. The basins have been used from about 1966 until the present. Evidence has shown that several spills from vapor degreaser tanks in the Process Building have occurred since installation of these tanks. Some of the spilled chemicals (primarily trichloroethylene) have flowed to the basins via floor drains. They are suspected to be a possible source of organic chemical and metal groundwater contamination (from cracks or leaking drains).

2.4.10 Site 16, Fuel Saturation Area 3

Fuel Saturation Area 3 is located just southwest of Facility 142 (Figure 2-14). This site reportedly became saturated by fuels from leaking

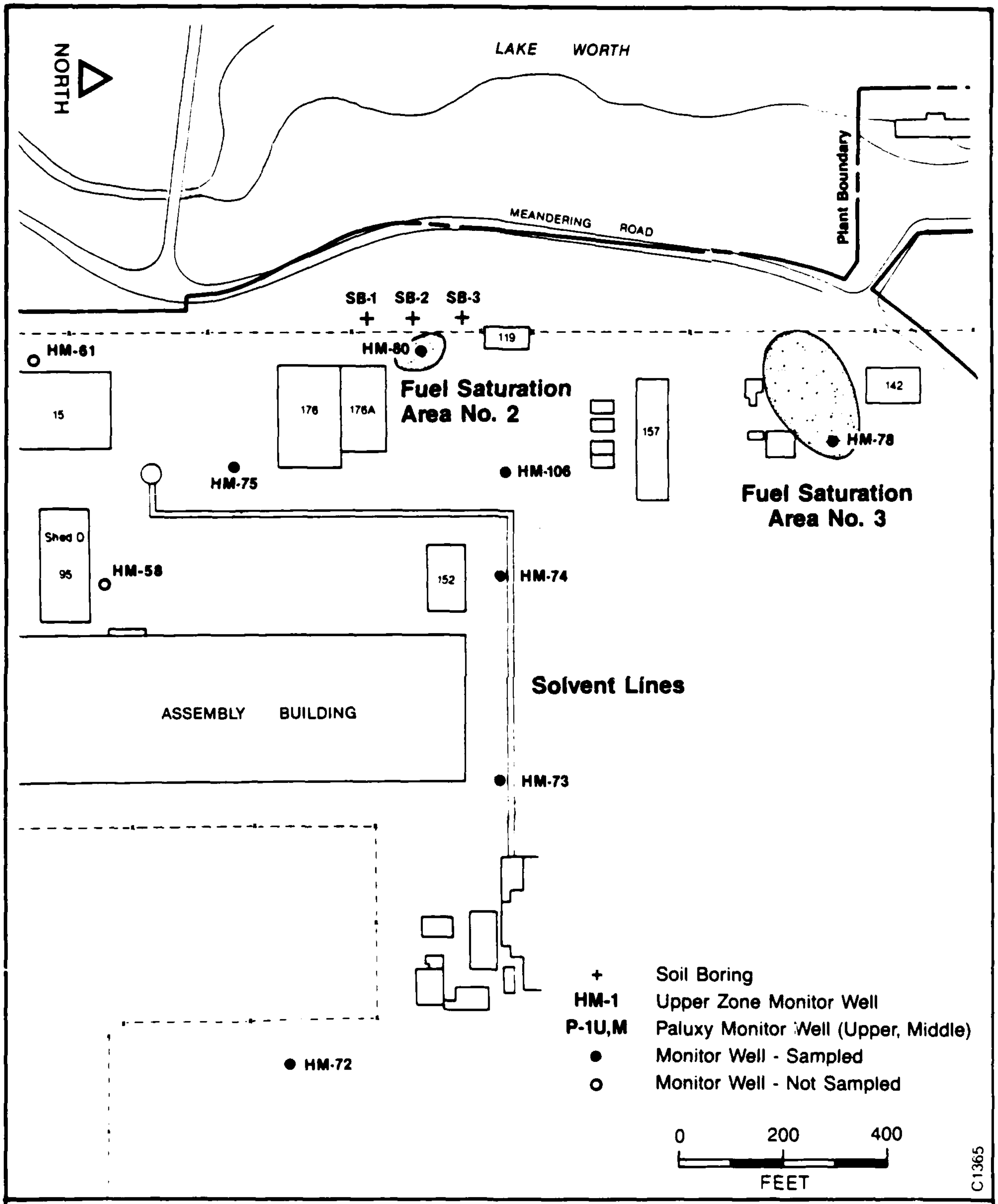


Figure 2-14. Location Map for Site 18, Solvent Lines and Sites 15 and 16, Fuel Saturation Areas 2 and 3, AF Plant 4, Texas

buried fuel lines between the mid-1970s and the early 1980s. This site is the subject of current remedial action planning by Intellus.

2.4.11 Site 9, Fire Department Training Area 6

Fire Department Training Area (FDTA) 6 was the designated FDTA from the late 1950s until 1980, when it was closed. This site consisted of a 50-foot diameter gravel-lined ring surrounded by a low, earthen berm. FDTA 6 is located north and adjacent to the DYNAFORM facility, Facility 175 (Figure 2-15). Before 1970, training exercises were conducted here twice a year. After 1970, exercises were conducted at monthly intervals. Approximately 250 gallons of waste fuels and oils were reportedly used for each exercise. In addition, the Phase I report indicated that larger quantities of contaminated fuels and oils were probably deposited in the FDTA between exercises.

In 1983, FDTA 6 was excavated and removed as part of the hazardous waste remedial action being carried out at AF Plant 4. The excavated material was analyzed and disposed of at approved off-site hazardous waste landfills. No monitoring wells have been installed to determine the status of groundwater contamination.

2.4.12 Site 6, Fire Department Training Area 3

FDTA 3, used during the mid-1960s for routine fire department training exercises, is located north of Landfill 4 between Meandering Road and the adjacent creek (Figure 2-13). Training exercises here also used about 250 gallons of waste fuels and oils per exercise. Since the site is not readily visible on historical aerial photographs, its location and present condition have not been accurately determined.

2.4.13 Site 7, Fire Department Training Area 4

FDTA 4 was also used for fire department training exercises during the late 1960s. This site is thought to be located north of the north

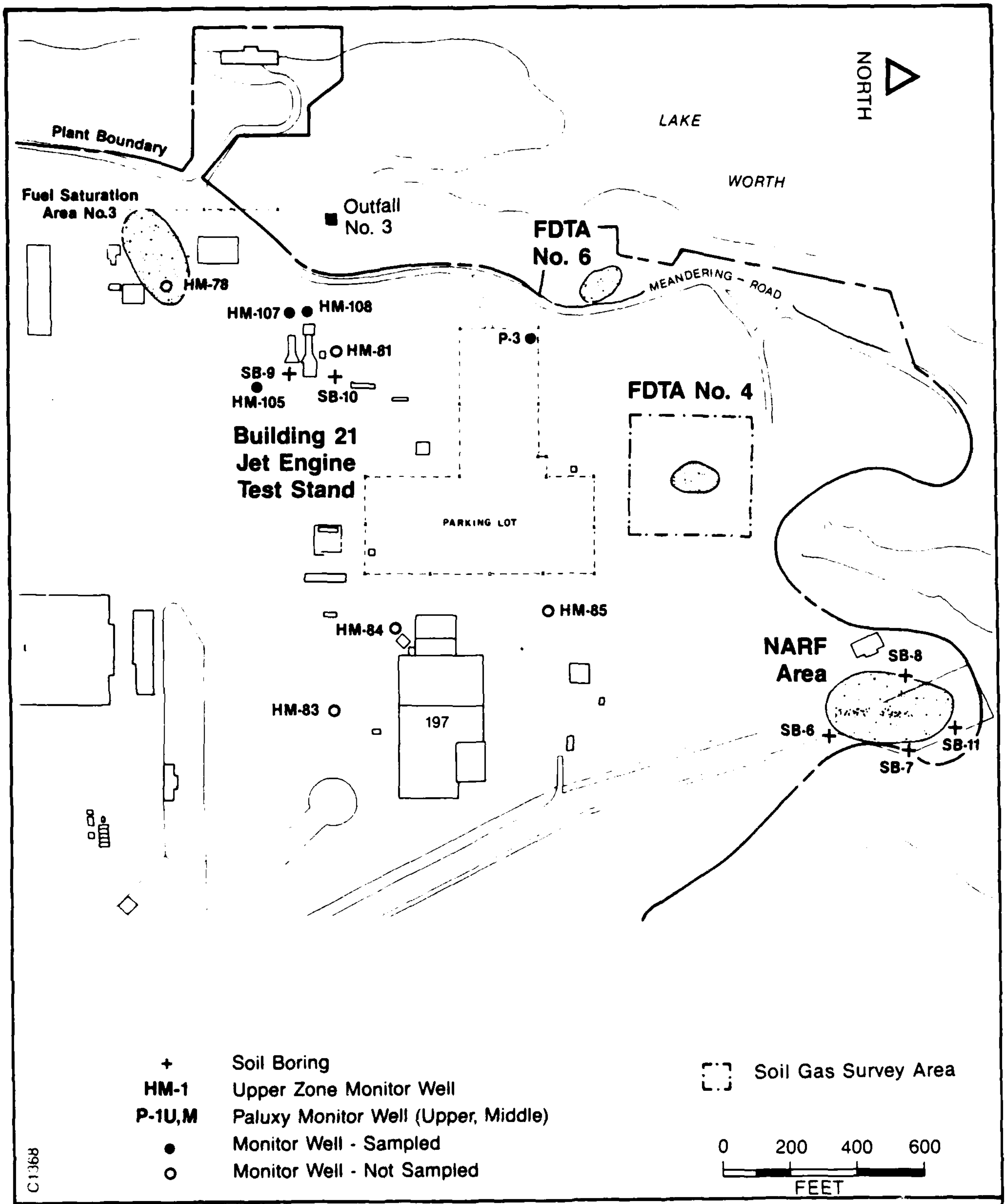


Figure 2-15. Location Map for Building 21, Jet Engine Test Stand; Sites 7 and 9, Fire Department Training Areas 4 and 6; and Site 19, NARF Area, AF Plant 4, Texas

employee parking area, at a location known as "Tater Hill" (Figure 2-15). Training exercises used the same amount of waste fuels and oils. Since the site is not readily visible on historical aerial photographs of AF Plant 4, its location and present condition have not been accurately determined.

2.4.14 Site 18, Solvent Lines

The Solvent Lines site is located along the route of the former buried solvent lines from the northeast corner of Facility 15 to the test lab, Facility 80 (Figure 2-13). These lines reportedly leaked during the 1940s before they were drained, capped, and abandoned in place in 1944. According to the Phase I report, the actual locations of the leaks could not be determined. The contents of these solvent lines reportedly contained xylene, methyl ethyl ketone, and kerosene.

2.4.15 Site 10, Chrome Pit 1

Chrome Pit 1, located under the present process building, Facility 181, was used during the early 1940s (Figure 2-12). Miscellaneous liquid and solid chemical wastes, in addition to chrome wastes, were probably disposed of at this site. The actual location could not be accurately confirmed from Phase I interviews or aerial photographs.

2.4.16 Site 5, Fire Department Training Area 2

Fire Department Training Area (FDTA) 2 was used between 1955 and 1956. This site consisted of a 50-foot diameter earthen ring located just north of Landfill 1 (Figure 2-11). Exercises were held infrequently (twice a year); however, disposal of waste oils and fuels and uncontrolled burns may have been more frequent. This site is currently located under the pavement in the west employee parking area.

2.4.17 Site 14, Fuel Saturation Area 1

Fuel Saturation Area 1 is located west of, and adjacent to, the Parts Plant, Facility 5 (Figure 2-11). This area is just north of the fuel tank truck unloading and pumping station. From the 1970s up until the early 1980s, the ground at this site reportedly became saturated by fuels from leaking buried fuel lines. This site is the subject of current remedial action planning by Intellus.

2.4.18 Site 19, Nuclear Aerospace Research Facility (NARF) Area

The Nuclear Aerospace Research Facility (NARF) formerly located at the north end of AF Plant 4 (Figure 2-15), housed several experimental atomic reactors between 1953 and 1974. The facility was decommissioned and disposed of by contractor in 1974.

2.4.19 Jet Engine Test Stand, Building 21

This site, a jet engine test building, (Figure 2-15) was not previously identified in Phase I. It is located north of a fuels test area, previously identified as Site 16 and a known area of fuel contamination. The sump downslope of Building 21, constructed in 1975, collects water used for cooling, noise suppression, and clean up in Building 21. This water is pumped into the industrial waste line. The area immediately south of Building 21 contains two underground tanks once used for fuel storage. These tanks, along with all others, are being investigated as potential sources of contamination by the operating contractor, General Dynamics. Outfall 3, downgradient of Building 21, is regularly sampled as part of IRP and NPDES monitoring activities.

3.0 FIELD PROGRAM

Radian performed the following activities at AF Plant 4 as part of the IRP Phase II Stage 1 investigation: 1) Geophysical surveys in the vicinity of two landfill areas and a fire department training area; 2) Installation of nine shallow (upper zone) groundwater monitor wells; 3) Installation of four monitor wells into the Paluxy aquifer; 4) Drilling of nine soil borings; 5) Hand-augered borings at one site; 6) Soil gas survey; and 7) Collection and analysis of groundwater, surface water, and soil samples. The period of performance of the field activities was from November 1985 through August 1986.

3.1 Field Techniques

The following sections contain descriptions of the field techniques used in this investigation. The techniques discussed include geophysical surveys, soil survey, hollow-stem auger and rotary drilling, monitor well installation, hand augering, and soil and water sampling. The Technical Operations Plan (TOP) presented in Appendix K describes field procedures in detail.

3.1.1 Terrain Conductivity (Geophysical) Surveys

Terrain conductivity surveys using electromagnetic profiling (EMP) were performed to assess the vertical and lateral extent of wastes and to gain a better understanding of subsurface conditions. The EMP technique measures conductance of subsurface materials. Anomalous conductance values represent the presence of materials with different conductivity than the surrounding materials. In addition to natural variations in conductivity, anomalies may be due to factors such as the presence of metal objects, fill material, or chemical contamination in the subsurface.

Survey results were used to evaluate the extent of contamination and the need for and location of soil borings. EMP surveys were conducted at Landfill 2, Landfill 3, and Fire Department Training Area (FDTA) 2. A Geonics

EM-34 terrain conductivity meter was used to conduct the electromagnetic profiling. Delta Geophysical, a Radian subcontractor, performed the geophysical surveys.

Before conducting the surveys, a control grid was established using appropriate reference points (buildings, roads, etc.). Within each survey area, baselines were established and gridpoints were staked at 30-foot intervals along the baseline. Conductivity data were collected at stations at 30-foot spacings perpendicular to the baselines. This provided a 30 by 30-foot grid for each area.

The depth measured by the EM-34 depends on the coil separation and orientation of the instrument, on the applied frequency, and, to some extent, on the conductivity profile of the subsurface. To evaluate boundary conditions and types of subsurface material present beneath each site, conductivity data were gathered from an effective depth of 45 feet. To identify plumes of contamination migrating from each site area, conductivity data were collected from two effective depths: 45 and 90 feet.

3.1.2 Soil Gas Survey

The presence of volatile organic chemicals (VOCs) in shallow soil gas indicates contamination from the observed compounds either in the vadose zone near the probe or in groundwater below the probe. The technology is most effective in mapping low molecular weight halogenated solvent chemicals and petroleum hydrocarbons possessing high vapor pressures and low aqueous solubilities. These compounds readily partition out of the groundwater and into the soil gas as a result of their high gas/liquid partitioning coefficients. Once in the soil gas, VOCs diffuse vertically in response to a chemical concentration upgradient where the above-ground atmosphere acts as a sink and the groundwater acts as a source for the compounds.

A field van equipped with two Varian 3300 gas chromatographs and two Spectra-Physics SP4270 computing integrators was used in the survey. Soil gas samples were collected by driving a hollow steel probe from 2 to 12 feet into the ground and evacuating 5 to 10 liters of gas with a vacuum pump. During the soil gas evacuation, samples were collected by inserting a syringe needle through the silicone evacuation line and down into the steel probe. Ten milliliters of gas were collected for immediate analysis in the analytical field van. Soil gas was subsampled (duplicate injections) in volumes ranging from 1 uL to 2 mL, depending on the VOC concentration at any particular location. Detection limits for the halogenated hydrocarbons ranged from 0.00002 to 0.00007 ug/L in soil gas using the electron capture detector, while the limits for petroleum hydrocarbons ranged from 0.01 to 6.0 ug/L using the flame-ionization detector. Detection limits are a function of the injection volume as well as of the detector sensitivity for individual compounds. The minimum detectable quantity of halogenated hydrocarbons (e.g., TCA) is about 2.5×10^{-11} grams, while the minimal detectable quantity of petroleum hydrocarbons (e.g., benzene) is approximately 5×10^{-9} grams.

Quality assurance procedures were followed to ensure that cross-contamination of soil gas samples was not occuring. Before sampling syringes were purged with nitrogen (i.e., carrier gas) and checked for contamination by injection into the gas chromatograph. System blanks were run periodically to confirm that the probes, adaptors, and 10 mL syringes were not contaminated. Soil gas probes were used only once during the course of a working day and then thoroughly cleaned before use on the following day. Analytical instruments were continuously checked for calibration using standards prepared in water from commercially available pure chemicals. Soil gas pumping was monitored by a vacuum gauge to ensure that an adequate gas flow from the vadose zone was maintained.

Soil gas was collected from a total of 28 sampling points at approximately 100-foot intervals at FDTA 4. An area approximately 600 by 600-feet was surveyed. The target depth for soil gas sampling was 5 to 6 feet below the ground surface at the majority of probe locations. At 8 of the sampling locations, probes were driven to the 8-12 foot depth interval to determine if VOCs were being biodegraded in the shallow soil gas. Since petroleum hydrocarbons (e.g., aviation fuel components) are particularly susceptible to oxidative biodegradation in the shallow soil, where aerobic conditions prevail, sampling for petroleum hydrocarbons is usually conducted at greater depths than for halocarbons.

Soil gas samples were analyzed for methane, total petroleum hydrocarbons, carbon tetrachloride (CCl_4), 1,1,1-trichloroethane (TCA), trichloroethylene (TCE) and perchloroethylene (PCE). Total petroleum hydrocarbons were defined as C_4 to C_{10} aliphatic and alicyclic compounds, as well as benzene, toluene and xylene isomers. These petroleum compounds are the major constituents of aviation fuels. Methane is produced as a by-product of subsurface biodegradation, and the other four compounds (i.e., CCl_4, TCA, TCE and PCE) are the most common industrial solvents.

3.1.3 Drilling Techniques

Drilling at AF Plant 4 was performed to directly determine subsurface conditions by collecting and describing soil samples and to install groundwater monitor wells. Before the start of drilling, General Dynamics personnel were informed of monitor well and borehole locations for utility clearances.

Drilling at AF Plant 4 was accomplished using a hollow-stem auger rig for the upper zone monitor wells and soil borings. A rotary drilling rig (both mud and air) was used for the monitor wells installed into the Paluxy aquifer. Selection of these methods was based on the anticipated depth of completion, the need for water-level observations, and the expected geologic conditions. The following paragraphs describe the procedures used for drilling activities.

Hollow-Stem Augering

A hollow-stem auger drilling rig, the CME-75, was used to perform shallow soil borings and to install the upper zone monitor wells. The hollow-stem method allowed an accurate examination of soil conditions, identification of the position of the water table, and recovery of soil samples. The holes were drilled dry; no drilling fluids or additives were used. After each borehole was completed, the drilling rig and equipment were thoroughly cleaned to prevent cross-contamination.

Samples of soil were collected with either a Shelby-tube or a split-spoon sampler. The samplers were driven in advance of the auger flights. Samples were generally taken at five foot intervals or where lithologic changes were noted. The samples were recovered at the surface, described in terms of lithology and moisture, and retained. At certain sites, a pre-determined number of soil samples were selected for chemical analysis. At least one sample was from the water-table interface; selection of other samples was based on visible contamination of the soil, color or texture, or real-time organic vapor analyzer readings. The samples selected for chemical analysis were cooled to 4°C and shipped to Radian's laboratory. The parameters analyzed are listed in Table 1-2.

Cuttings suspected of contamination (on the basis of OVA readings and visual evidence of contamination) were placed in steel 55-gallon drums. Samples of the cuttings were collected and submitted for chemical analysis. Disposal of the cuttings was based on the results of the chemical analyses. Section 3.4 discusses the chemical analysis of drill cuttings and fluids produced in the field program.

Rotary Drilling

Rotary drilling techniques were used for the installation of monitor wells into the Paluxy Formation. The rotary drilling was performed with a

Gardner-Denver 1500 CD truck-mounted rig. Using the air rotary method, a 6.75-inch diameter bit was used to advance a pilot borehole through the upper zone alluvial material and/or the Goodland Formation to a depth of approximately five feet into the underlying Walnut Formation. The borehole was then reamed with a 20-inch bit using mud rotary. All drilling operations in the upper zone material were continuously monitored with an OVA. A 16-inch diameter steel casing was installed from the surface to the full depth of the borehole and the annular space was grouted. After achieving a positive seal and allowing the grout to cure for 24 hours, the borehole was advanced using a 15-inch bit and mud rotary method through the Walnut Formation and approximately five feet into the upper sand member of the Paluxy Formation. A 10.75-inch diameter steel casing was installed from the surface to the full depth and the annular space was pressure-grouted to the surface. After achieving a positive seal and allowing the grout to cure for 24 hours, the borehole was advanced using an 8-inch bit and air rotary (if possible) or mud rotary to the final depth at the shale/clay unit dividing the upper and middle sand members of the Paluxy Formation. One Paluxy well (P-20M) was completed in the middle sand member because the upper sand member was dry.

The drilling fluid used during mud rotary operations consisted of potable water and bentonite. As the borehole was advanced, the cuttings discharged at the surface were examined for lithology, moisture, and other features useful in describing stratigraphic conditions. All cuttings were retained in a portable, above-ground, mud pit and transfered to steel 55-gallon drums pending the results of chemical analyses. Drilling conditions, such as relative rate and ease of penetration, were noted by the driller. Water encountered during drilling was noted with respect to depth of occurrence. When drilling was completed, a sample of the drilling fluids was placed into a clean, one quart glass mason jar with a Teflon-lined lid and chilled for shipment to Radian's laboratory. The drilling mud was analyzed for purgeable halocarbons, as well as for EP Toxicity and Ignitability.

3.1.4 Monitor Well Installation and Development

Groundwater monitor wells were installed either immediately after completion of the drilling operations or after the borehole was noted to produce sufficient water to warrant a well. Monitor well construction specifications are summarized in Table 3-1. Construction methods were consistent with the specifications provided in the Statement of Work. These methods were outlined in the Technical Operations Plan, which was provided to the USAFOEHL on 14 November 1985 for outside distribution for review and comment. All well materials were cleaned before installation in the borehole. Where necessary, appropriate changes were made on a site-by-site basis and approved by the USAFOEHL Technical Program Manager. Decisions relating to the setting of screen and casing, the length of screen, and the amount of sand pack were made on the basis of observed water seepage and static water level. If appropriate, the borehole was allowed to remain open overnight. There were no difficulties associated with caving or borehole integrity.

Upper Zone Monitor Wells

All upper zone monitor wells were completed (screened) in the alluvium or man-made fill overlying the plant site. Wells were installed in the following manner: screen and casing sections were steam-cleaned and assembled on the ground, then lowered carefully into the borehole. As the string of screen and casing was lowered, additional sections of casing were added until the bottom of the screen reached the bottom of the borehole. The top of the casing was capped during construction to prevent downhole completion materials (sand and grout) from entering the casing. Clean sand (Texas Blastsand No. 1A) was poured slowly down the annular space until the top of the sand pack was one to two feet above the top of the screen, as measured by the supervising geologist. Bentonite pellets were then poured from the surface on top of the sand pack and hydrated to form a two foot thick, impermeable seal. Following emplacement of the bentonite seal, neat cement grout

TABLE 3-1. MONITOR WELL CONSTRUCTION SPECIFICATIONS, IRP PHASE II STAGE I, AF PLANT 4, TEXAS

1. Casing:
   - Upper Zone - Two inch diameter, threaded and flush joint, Schedule 40 PVC.
   - Paluxy - 16 inch steel casing, into top of Walnut Formation and grouted; 10 3/4 inch steel casing through Walnut Formation and grouted; 5 inch, Schedule 80 PVC to total depth.

2. Screen:
   - Upper Zone - Two inch diameter, threaded and flush-joint factory-slotted, Schedule 40 PVC, 0.020 inch slot. Normal screen length 10 feet.
   - Paluxy- 5 -inch diameter, threaded flush-joint factory-slotted Schedule 80 PVC, 0.010 inch slot.

3. Sand/gravel pack: Washed, bagged and rounded sand/gravel with grain size compatible with screen slot and formation (Texas Blastsand No. 1A). A sand pack was emplaced from bottom of the borehole to 2 feet above the top of the well screen. Sand was emplaced at a controlled rate to avoid bridging.

4. Bentonite seal: Two feet of granulated or pelletized bentonite was placed above the sand section.

5. Grout: Neat cement (Type I Portland cement) grout tremied from the top of the bentonite seal to land surface. A grout mixture of 6:1 Portland cement and bentonite was used. The grout was allowed to set for at least 24 hours before any well development activities.

6. Surface completion: The PVC casing was cut off to provide a two to three foot stickup and a solid cap was placed on the casing. A 5 inch square protective steel well protector, 4 feet in length, was placed over the exposed PVC casing, and seated in the cement. A locking cap is incorporated in the well cover.

7. Alternate flush completion: The PVC casing was cut off after installation about 3 inches below ground level. An end plug or casing cap was provided for each well. A steel flush utility type box was placed over the exposed casing and seated in the cement. A locking well cap lid or box was used. The utility box cover was painted for corrosion control and visibility.

8. Guard pipes or posts: Three 3-inch diameter steel posts, 6 feet in length, with a minimum of 2 feet below ground, installed radially 4 feet from the wellhead (Not emplaced for flush surface completion).

was prepared (6-gallons of potable water per 100-lb sack of Type I Portland cement) and tremied from the top of the bentonite seal to the land surface. While the cement was still wet, surface well covers were installed. The covers consisted of either a protective locking metal meter box or a 4-inch diameter steel casing with lockable lid. To protect the well from vehicular damage, three steel guard posts were positioned radially 2-3 feet from each above-ground well completion.

After allowing the cement grout to cure in the well for a minimum of 24 hours, the wells were developed using a hand-operated pump or by bailing using a ball-valve bailer. Some of the wells were slow to recover and were bailed dry several times and allowed to recover before development was considered complete. Other wells produced sufficient water to be developed completely without a recovery period. Water was removed from the well until the water was virtually sediment-free. Appendix E contains the records of well development operations.

Southwestern Laboratories of Dallas, Texas, a Radian subcontractor, performed the upper zone monitor well drilling, monitor well installation, and development.

Paluxy Formation Wells

The Paluxy Formation wells were installed through a steel surface casing that was grouted in place through the Walnut Formation, as discussed above. The completion activities and materials for the Paluxy wells are as follows. Screen and casing, consisting of 5-inch diameter Schedule 80 PVC, was installed into the 8-inch borehole. Clean sand (Texas Blastsand No. 1A) was slowly poured down the annular space to a level of two feet above the top of the screen. Bentonite pellets were then placed on top of the sand pack to a thickness of 2-feet to form a seal. Neat cement was then tremied down the annular space until the grout was within the 10.75-inch steel casing to a thickness of at least 5 feet. The remainder of the annular space was filled with clean sand to 1 foot from the surface, after which cement was then emplaced. The well was developed by bailing until a virtually sediment-free discharge was produced. A 1/2 horsepower stainless steel submersible pump was installed after development. A protective metal box, surface electrical connections, steel guard posts, and a concrete well pad were placed after the pump was installed.

Underground Resource Management, Inc. of Austin, Texas, a Radian subcontractor, performed the drilling, monitor well installation, and development of the Paluxy wells.

3.1.5 Surveying

After all new monitor wells were installed, wellhead elevations were determined to the nearest 0.05 foot and horizontal locations of the monitor wells were determined to an accuracy of 1 foot. Monitor well locations were then drafted onto a map of AF Plant 4. A local surveying firm, Sempco, Inc., performed this task. Table 3-2 presents results of the survey of monitor wells, including depths and screened intervals.

3.1.6 Environmental Sampling

Environmental samples collected as part of this investigation included soil, surface water, and groundwater. The following subsections describe the techniques used in acquiring samples.

3.1.6.1 Soil Sampling

Soil samples were collected by hand augering at one site and by Shelby tubes or split-spoon samplers at boreholes advanced by hollow-stem augering.

TABLE 3-2. GENERAL SPECIFICATIONS FOR MONITOR WELLS INSTALLED DURING IRP PHASE II STAGE 1, AF PLANT 4, TEXAS

Monitor Well	Measuring Point Elevation (feet MSL)	(East) Range	(North) Range	Screened Interval[1]	Screen Elevations (feet MSL)	Total Depth[1]
HM-100	670.10	33+55.16	5+88.55	33.5-48.5	636.9-621.9	49
HM-101	664.99	41+47.58	13+34.64	19-34	646.3-631.3	34
HM-102	654.65	37+63.73	16+03.47	14-44	641.0-611.0	44
HM-103	648.28	10+91.76	07+26.61	29-39	619.6-609.6	39
HM-104	649.71	18+34.45	00+04.28	23.5-38.5	626.5-611.5	39
HM-105	641.92	20+58.27	59+54.99	5.5-20.5	636.8-621.8	21
HM-106	649.76	22+60.57	49+66.64	15.1-30.1	635.0-620.0	34
HM-107	642.33	22+58.27	60+22.15	7.5-22.5	631.2-616.2	23
HM-108	639.76	22+56.65	60+96.95	5-15	631.9-621.9	15
P-20M	673.23	46+35.42	9+48.13	125-155	547.9-517.9	155
P-21U	660.99	36+02.36	14+85.83	85-105	575.7-555.7	110
P-22U	631.98	31+23.23	28+52.24	47.8-62.8	583.9-568.9	62.8
P-23U	626.92	24+09.67	61+78.15	35.6-55.3	591.0-571.3	55.3

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[1] Feet below ground level.

Hand augering was performed at FDTA 6. Samples were retrieved from depths ranging from six to 18 inches at six locations within the perimeter of the FDTA. The sampling technique involved precleaning the auger, augering down until the auger was filled with soil and inspecting the contents for visual or aromatic indications of hydrocarbons. At the surface, each sample was placed in a clean one quart glass mason jar with a Teflon-lined lid and cooled to 4°C for shipment to Radian's laboratory for analysis. Soils were analyzed for the parameters listed in Table 1-2. Soil samples were also taken with Shelby tubes and split-spoon samplers during drilling in the upper zone, as described in Section 3.1.3.

3.1.6.2 Surface Water Sampling

During Phase II Stage 1 efforts at AF Plant 4, surface water samples were collected from five creek locations, five outfalls, and two French drains. Surface water grab samples were collected directly in the clean container to minimize handling of the sample.

Field measurements of specific conductance, pH, and temperature were taken on an aliquot of the sample recovered. Specific conductance and pH were taken using a Myron L EP-10/pH meter. Temperature was taken using a mercury thermometer. Before the field measurements the pH meter was calibrated using pH 4, 7, and 10 standard solutions and the conductivity meter was calibrated using a 1413 umhos/cm KCl conductivity standard solution. All instruments used during field measurements were cleaned with deionized water before use.

At each location, observations were made regarding the flow conditions and other pertinent featurs. Table 1-2 shows the analytical schedule for surface water samples. The samples were stored and preserved according to the requirements outlined in Table 3-3.

3.1.6.3 Groundwater Sampling

Groundwater samples were collected from 113 monitor wells. Sampling was conducted once for each well except for one Paluxy Formation well (P-23),

TABLE 3-3. COLLECTION AND PRESERVATION OF WATER SAMPLES, IRP PHASE II STAGE 1, AF PLANT 4, TEXAS

Parameter	Container*	Preservation
Purgeable Halocarbons	Glass, 40 mL VOA vial	Cool to 4°C
Purgeable Aromatics and Xylene	Glass, 40 mL VOA vial	HCl to $pH<2$; Cool to 4°C
Base/Neutral and Acid Extractable Organics and Pesticides	Amber glass, 1 liter	Cool to 4°C
Metals	Plastic, 500 mL	HNO_3 to $pH<2$; cool to 4°C
Hydrocarbon Fuels	Glass, 1 quart	H_2SO_4 to $pH<2$; cool to 4°C
Oil and Grease	Glass, 1 quart	H_2SO_4 to $pH<2$; cool to 4°C

*All containers with Teflon™-lined lids.

which was sampled twice. Groundwater sampling activities began in January 1986, and were concluded in August 1986. Table 1-2 shows the analytical schedule for groundwater samples. The samples were stored and preserved according to the requirements outlined in Table 3-3. Field sampling methodologies and equipment are detailed in the following sections and in the Technical Operations Plan in Appendix K.

Water Level Measurements

Water level measurements at each monitor well were taken with an Actat Olympic well probe immediately before sample collection. The probe and associated electrical line were washed with laboratory grade detergent, rinsed with tap water, then rinsed with deionized water between measurements to preclude the possibility of cross-contamination. Measurements were taken to the nearest 0.01 foot with respect to the top of the PVC casing. Water level measurements taken before each sampling operation are shown in Section 4.

Purging Operations

Each monitor well was purged either immediately before sample collection or within one day of sample collection (for low yield wells) to ensure that representative formation water was collected. Purging operations were conducted using a Teflon bailer, a hand pump or an installed electric submersible pump. Purging operations were considered complete when three wetted well volumes had been evacuated from a monitor well. All downhole equipment used for purging operations was cleaned with laboratory grade detergent and tap water, rinsed with tap water, then rinsed with deionized water to prevent cross-contamination. In cases where overt evidence of chemical contamination was noted in a well (color, odor, oil, etc.) the bailer was washed with technical grade methyl alcohol, thoroughly rinsed with deionized water, and allowed to dry completely.

Field Measurements

Specific conductance, pH, and temperature measurements were taken from an aliquot of the sample recovered. Specific conductance and pH were taken with a Myron L EP-10/pH meter. Temperature was taken with a mercury thermometer. Before the field measurements, the pH meter was calibrated using pH 4, 7, and 10 standard solutions and the conductivity meter was calibrated using a 1413 umhos/cm KCl conductivity standard solution. In some instances, field data were not collected due to instrument malfunction, possibility of instrument fouling, or oversight. These are noted in the data tables in Section 4.3.

Sample Capture

Samples were collected after each well was purged of standing water to ensure that groundwater characteristics were representative. Samples were collected for the analyses shown in Table 1-2. After collection, samples were placed in containers and preserved according to the requirements listed in Table 3-3. All samples were chilled to 4°C after collection. Samples were placed in ice chests and shipped by overnight express or hand carried to the analytical laboratory. Field quality assurance measures (e.g., chain of custody forms) were employed to ensure that, once samples were collected, sample integrity was maintained during shipping and handling and before analysis. QA/QC procedures are discussed in the Technical Operations Plan (Appendix K).

3.1.7 Numbering System for Wells and Sampling Locations

The wells and borings drilled at Air Force Plant 4 during the IRP Phase II Stage 1 investigation are identified by an alpha-numeric label. Upper zone monitor wells are labeled with the letters HM or F, followed by a dash and a number. The HM series represents monitor wells installed by Hargis & Montgomery, Hargis & Associates and Radian. Hargis & Montgomery and Hargis & Associates installed monitor wells 1 through 85. Radian installed HM wells 100 through 108. The F series of wells represents those monitor wells installed by Intellus.

Monitor wells drilled into the Paluxy Formation are denoted by the prefix P, followed by a number. In most cases, the number is followed by a U or an M, representing completion in the upper Paluxy or middle Paluxy. Where the P is followed by a number only, the well was completed throughout multiple Paluxy Formation aquifers.

Soil borings are labeled with the letters SB, followed by a number. Surface water sampling points on Meandering Road Creek are designated by the letter C, followed by a number. Outfall samples are labeled OF, followed by the outfall number.

3.1.8 Field Safety

Before field work began, a detailed field Safety Plan was prepared which anticipated likely field hazards and prescribed appropriate personnel protective equipment for the field team. EPA Level C protection (impervious clothing, gloves, boots, and full-face or half-face cartridge respirators) was employed during drilling and/or well installation at Landfills 1 and 3. During drilling operations soil samples and drill cuttings were monitored for signs of contamination with a photoionization detector and Draeger tubes. If no contamination was detected, then EPA level D protection (same as level C, except that respirators were carried, but not worn) was deemed appropriate. Level D protection was used at all other drilling locations. The complete text of the Safety Plan used for this project is contained in the Appendix K.

3.2 Site Activities

Field activities conducted at each site in the AF Plant 4 IRP Phase II Stage 1 investigation are described in the following subsections. Site activities are presented and discussed in the order in which they appear in the delivery order. Wells and sampling activities are discussed with their associated sites in the Statement of Work. Figure 3-1 is an index map showing

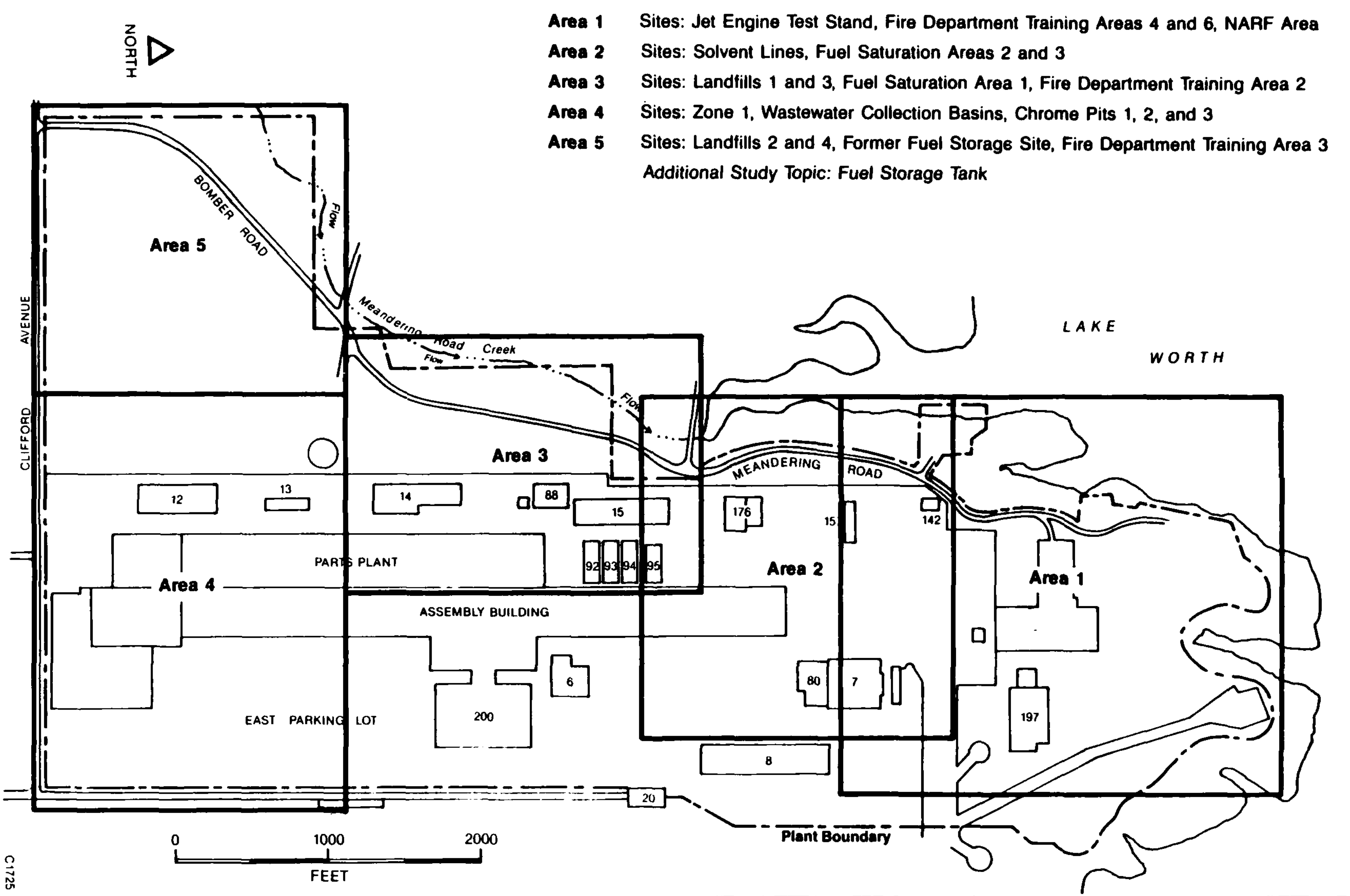

Figure 3-1. Index Map for Individual Area Maps, AF Plant 4, Texas

the areas covered by the site-specific maps presented in the following sections. Site activities are summarized in Table 3-4.

3.2.1 Site 1, Landfill 1

Investigation activities at Landfill 1 included collection of surface water samples from five creek locations, the creek seep, and two French drains; and collection of groundwater samples from six upper zone monitor wells and two Paluxy monitor wells. The St-5 outfall was identified in the delivery order as a sampling location; however, the outfall was dry during the field program, precluding sample collection. Figure 3-2 shows the location of Landfill 1.

Surface Water Sampling: The purpose of surface water sampling was to determine if contaminants were present in Meandering Road Creek west of AF Plant 4. Sampling at 5 locations along the creek and at one creek seep location was performed by Radian personnel January 29 and 30, 1986. These locations were spaced along the full length of the creek; however, only 2 sampling locations, C-2 and C-3, are located directly opposite (west) of Landfill 1 and Landfill 3. The French drains and the drainpipe were sampled on 12 February 1986. Details of the sampling procedures are outlined in Section 3.1.5.2. The surface water samples were analyzed for VOC, BNA, and heavy metals. Results of the surface water analyses are presented in Section 4.3.1.

Groundwater Sampling: One sample from each of 6 upper zone wells and 3 Paluxy wells was collected by Radian personnel during 29 January through 1 March 1986. The purpose of groundwater sampling and analysis was to confirm earlier investigations and to gain additional data concerning the nature and extent of contamination. Details of the sampling procedures are outlined in Section 3.1.5.3. Groundwater samples were analyzed for VOC, BNA, and heavy metals. Results of the groundwater analyses are presented in Section 4.3.1.

TABLE 3-4. SUMMARY OF IRP PHASE II, STAGE 1 INVESTIGATION ACTIVITIES, AF PLANT 4, TEXAS

Site	Investigation Activities	Purpose	Map Location
Landfill 1	1. Sample surface water at 5 locations on Meandering Road Creek and the creek seep.	1. Evaluate possible impact of landfill leachate on creek.	Figure 3-2.
	2. Sampling French drains 1 and 2 and the drain pipe.	2. Characterize leachate discharge.	
	3. Sample groundwater from 6 existing upper zone and 2 Paluxy wells.	3. Evaluate possible effect of landfill on groundwater.	
Landfill 3	1. Conduct a terrain conductivity survey.	1. Determine presence and possible configuration of the landfill. Use data to determine if additional drilling required.	Figure 3-2.
	2. Install Paluxy monitor well screened in upper sand member.	2. Evaluate Paluxy groundwater directly downgradient of landfill.	
	3. Sample groundwater from 9 existing upper zone wells and 1 new Paluxy well.	3. Evaluate possible effect of landfill on groundwater.	
Chrome Pit 3	1. Sample groundwater from 8 existing upper zone wells and 1 Paluxy well.	1. Determine post-closure groundwater quality.	Figure 3-4.

(continued)

TABLE 3-4. (Continued)

Site	Investigation Activities	Purpose	Map Location
Former Fuel Storage Site	1. Install 1 upper zone well. 2. Sample groundwater from 2 existing and wells 1 new upper zone well.	1. Provide data on groundwater flow and quality in Radar Range area. 2. Evaluate possible effect of former fuel storage site on groundwater.	Figure 3-5.
Landfill 2	1. Conduct a terrain conductivity survey. 2. Install Paluxy monitor well in upper sand member. 3. Sample groundwater from 7 upper zone wells and 1 new Paluxy well.	1. Determine landfill limits and horizontal extent of contamination, if any. 2. Evaluate Paluxy groundwater directly downgradient of landfill. 3. Evaluate possible effects of landfill on groundwater.	Figure 3-5.
Landfill 4	1. Install 1 upper zone well and 1 Paluxy well screened in middle sand unit (upper unit was dry). 2. Sample groundwater from 3 upper zone wells and 1 Paluxy well.	1,2. Determine possible effects of landfill on groundwater.	Figure 3-5.

(continued)

TABLE 3-4. (Continued)

Site	Investigation Activities	Purpose	Map Location
Zone 1	1. Drill borehole at FDTA 5. 2. Sample groundwater from 7 existing upper zone wells and 1 Paluxy well.	1. Determine soil conditions and presence of water underlying FDTA 5. 2. Evaluate possible effects of disposal pits and fire training area on groundwater.	Figure 3-4.
Fuel Saturation Area 2	1. Drill 3 boreholes along the length of the buried fuel line. 2. Sample groundwater and measure fuel lens at 1 upper zone well.	1. Determine soil conditions and presence of fuel in the subsurface. 2. Evaluate possible effect of fuel line on groundwater.	Figure 3-6.
Wastewater Collection Basins	1. Install 1 upper zone monitor well (located south of site because of access restrictions). 2. Sample groundwater from 5 upper zone wells. 3. Determine location and depth of buried sanitary and industrial waste lines. Evaluate need for additional sampling and analysis of soil.	1,2. Evaluate possible effects of basins on groundwater. 3. Evaluate effect of lines, if any, on movement of contamination in subsurface.	Figure 3-4.

(continued)

TABLE 3-4. (Continued)

Site	Investigation Activities	Purpose	Map Location
Fuel Saturation Area 3	1. Sample groundwater at 1 upper zone well.	1. Evaluate possible effect of buried fuel line on groundwater.	Figure 3-7.
Fire Department Training Area 6	1. Hand-auger and collect shallow soil samples for analysis. 2. Sample groundwater from 1 Paluxy well.	1. Determine possible effects of fire training exercises on shallow soil. 2. Evaluate groundwater quality of Paluxy upgradient of AF Plant 4.	Figures 3-7, 8.
Fire Department Training Area 3	1. Install 1 upper zone monitor well west of FDTA 3 (monitor well already exists at site). 2. Sample groundwater from 2 upper zone wells.	1. Determine groundwater flow conditions west of FDTA 3. 2. Evaluate possible effects of FDTA 3 on groundwater.	Figure 3-5.
Fire Department Training Area 4	1. Conduct a soil-gas survey.	1. Determine location of FDTA 4 and possible effects on shallow soil.	Figure 3-7.
Solvent Lines	1. Install 1 upper zone monitor well. 2. Sample groundwater from 4 upper zone monitor wells.	1. Improve monitoring coverage of groundwater conditions. 2. Evaluate possible effect of solvent lines on groundwater.	Figure 3-6.

(continued)

TABLE 3-4. (Continued)

Site	Investigation Activities	Purpose	Map Location
Chrome Pit 1	1. Install upper zone monitor well east of site (outside of building).	1. Evaluate groundwater conditions east of Chrome Pit 1.	Figure 3-4.
	2. Sample groundwater from 2 upper zone wells.	2. Evaluate possible effect of Chrome Pit 1 on groundwater.	
Fire Department Training Area 2	1. Conduct a terrain conductivity survey.	1. Determine the extent of a hydrocarbon plume, if any.	Figure 3-2.
	2. Sample groundwater from 7 upper zone wells.	2. Evaluate possible effect of FDTA 2 on groundwater.	
Fuel Saturation Area 1	1. Drill 1 borehole near FSA 1.	1. Determine soil conditions and presence of fuel in subsurface.	Figure 3-2.
	2. Sample groundwater from 2 upper zone wells, 1 upper zone borehole, and 2 Paluxy wells.	2. Evaluate effects of FSA 1 on groundwater.	
NARF	1. Drill 4 boreholes in the upper zone.	1. Determine shallow soil conditions and presence of RAM in soil.	Figure 3-7.
	2. Sample groundwater from 3 upper zone wells.	2. Evaluate possible effect of NARF on groundwater.	
	3. Conduct review of NARF and White Settlement records for radionuclide analyses.	3. Determine past operations and exact location of NARF.	

(continued)

TABLE 3-4. (Continued)

Site	Investigation Activities	Purpose	Map Location
Jet Engine Test Stand	1. Install 3 upper zone wells and drill 2 boreholes.	1. Collect and analyze soil samples and evaluate groundwater flow and chemistry.	Figure 3-7.
	2. Sample groundwater from 3 upper zone monitor wells.	2. Evaluate possible effect of Jet Engine Test Stand on groundwater.	
	3. Sample surface water at Outfalls 1 and 5.	3. Evaluate effect of discharge to surface water near facility.	
Ambient Monitoring	1. Sample groundwater from 11 upper zone wells and 8 Paluxy wells.	1. Evaluate groundwater quality in areas away from waste disposal spill sites.	Figure 3-9.
East Parking Lot	1. Sample groundwater from 3 upper zone monitor wells and 2 Paluxy wells.	1. Evaluate groundwater quality at east portion of AF Plant 4.	Figure 3-10.
Fuel Storage Tank	1. Sample groundwater from upper zone well HM-23.	1. Evaluate possible effect of the Fuel Storage Tank on groundwater.	Figure 3-5.
Lake Worth Monitor Well	1. Install 1 Paluxy well near Lake Worth.	1. Evaluate groundwater quality of Paluxy aquifer near recharge source, Lake Worth.	Figure 3-9.

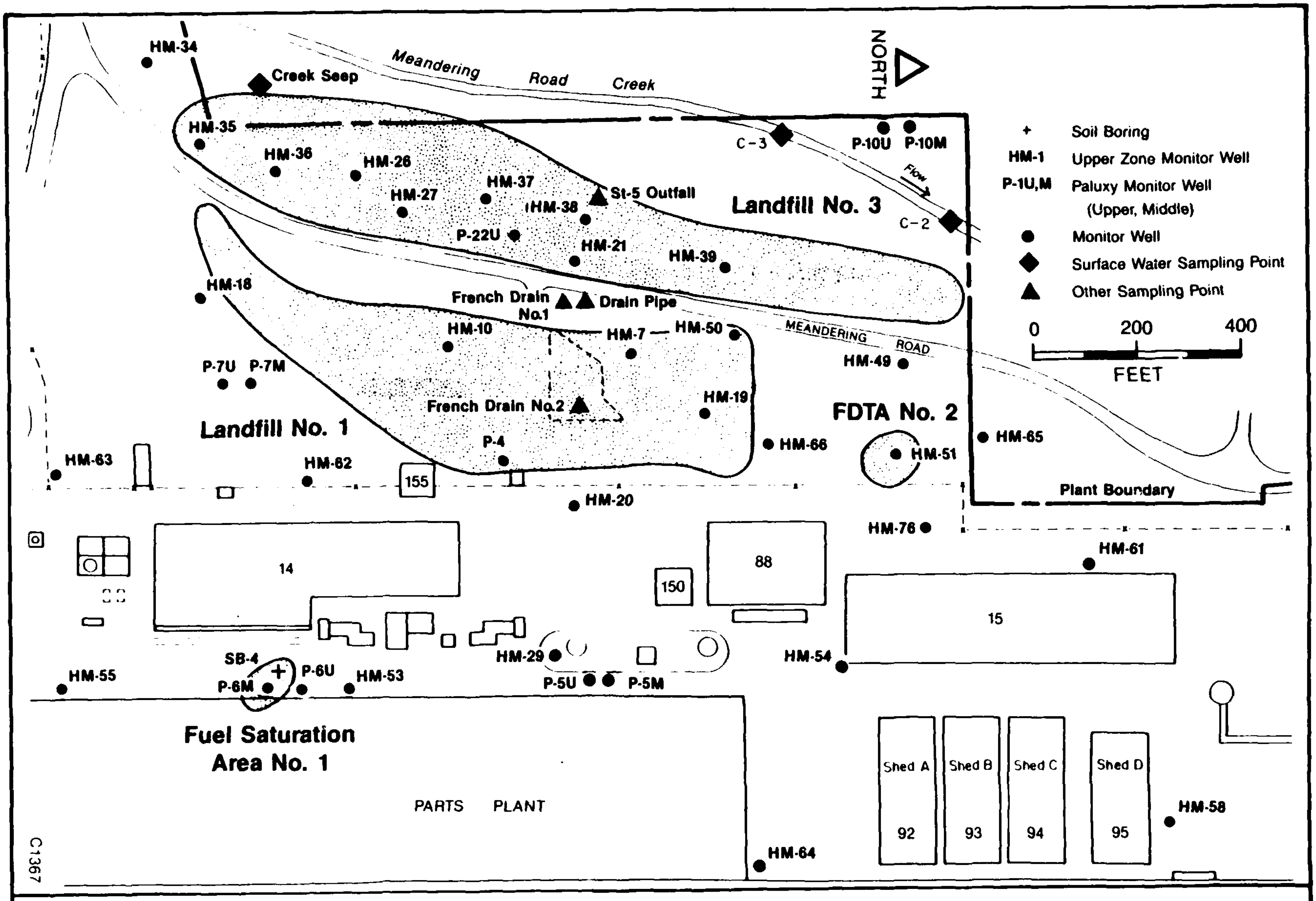

Figure 3-2. Phase II Activities at Sites 1 and 3, Landfills 1 and 3; Site 17, Fuel Saturation Area 1; and Site 5, Fire Department Training Area 2, AF Plant 4, Texas

3.2.2 Site 3, Landfill 3

Investigation activities at Landfill 3 included: performance of geophysical (EMP) surveying, installation of one monitor well (P-22U) completed in the upper member of the Paluxy Formation, and collection of groundwater samples from nine existing upper zone monitor wells and the newly installed Paluxy well. Figure 3-2 shows the location of Landfill 3.

Terrain Conductivity Survey: The purpose of the terrain conductivity survey conducted in November 1985 was to determine the presence and configuration of waste disposal areas. This was accomplished using electromagnetic profiling to measure electrical conductivities of the subsurface material. To perform the survey at Landfill 3, a grid was established, as described in Section 3.1.1. Figure 3-3 illustrates the area of the survey at Landfill 3, as well as the other survey locations at AF Plant 4. The area of the terrain conductivity survey grid is approximately 2100 by 250 feet. Electromagnetic profile readings were taken every 30 feet.

Monitor Well Installation: One monitor well (P-22U) was installed in the Landfill 3 area as part of this investigation. The well was completed in the upper member of the Paluxy Formation. Drilling and well installation activities took place from 18 to 21 March 1986. Soil samples and samples of the drilling fluids were collected as described in Section 3.1.3. The Paluxy well location was selected in conjunction with existing Paluxy monitor wells to further define groundwater flow direction on the eastern boundary of AF Plant 4 and to note possible contamination migrating onto the AF Plant 4 boundary.

Groundwater Sampling: One sample from each of 9 upper zone wells (HM-21, 26, 27, 34, 35, 36, 37, 38, and 39) was collected by Radian personnel during 31 January through 27 February 1986. The Paluxy well (P-22U) was sampled on 10 April 1986. The purpose of groundwater sampling and analysis was to confirm earlier investigations and to gain additional data on the nature and extent of contamination. Details of the sampling procedures are

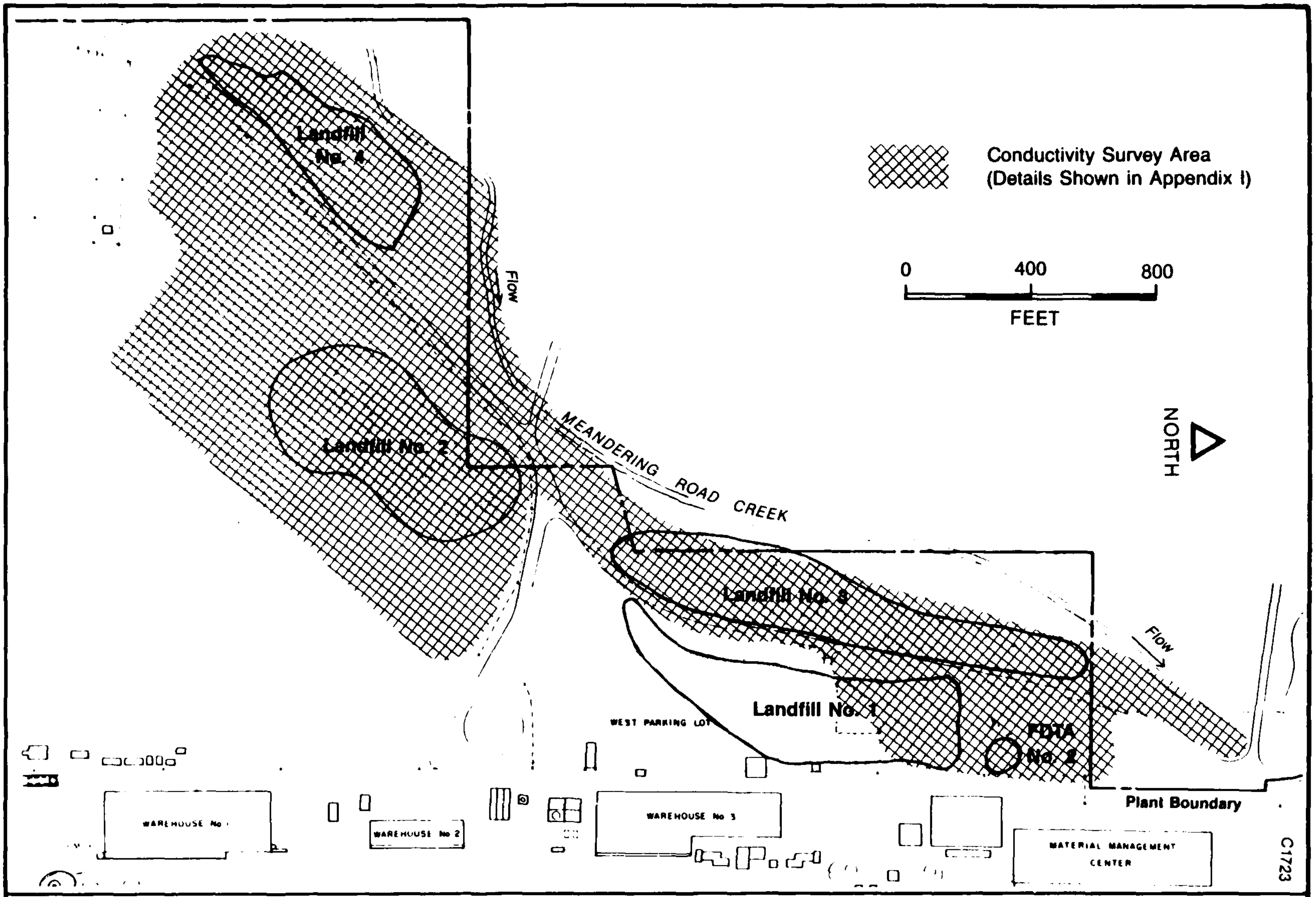

Figure 3-3. Locations of Terrain Conductivity Surveys, AF Plant 4, Texas

outlined in Section 3.1.5.3. The groundwater samples were analyzed for VOC, BNA, and heavy metals. Results of the groundwater analyses are presented in Section 4.3.2.

3.2.3 Site 12, Chrome Pit 3

Investigation activities at Chrome Pit 3 included: collection of groundwater samples from eight existing upper zone monitor wells and one Paluxy monitor well. Figure 3-4 shows the location of Chrome Pit 3.

Groundwater Sampling: The purpose of groundwater sampling and analysis was to evaluate post-closure groundwater conditions at the site. One groundwater sample was collected and analyzed from each of wells HM- 13, 15, 16, 17, 30, 32, 41, 45, and P-2. Field sampling was performed by Radian personnel from 11 to 25 February 1986. Details of the sampling procedures are outlined in Section 3.1.5.3. The groundwater samples were analyzed for VOC, BNA, and heavy metals. Results of the groundwater analyses are presented in Section 4.3.3.

3.2.4 Site 17, Former Fuel Storage Site

Investigation activities at the Former Fuel Storage Site included: installation of one upper zone monitor well (HM-100), collection of upper zone groundwater samples from two existing monitor wells and the newly installed monitor well, and investigation of the existence of a fuel lens, if any, in these monitor wells. Figure 3-5 shows the location of the Former Fuel Storage Site.

Monitor Well Installation: One monitor well (HM-100) was installed southeast of the former fuel storage site and completed in the upper zone alluvium. Soil samples were collected using split-spoons as described in Section 3.1.3. The purpose of installing monitor well HM-100 was to improve the definition of groundwater flow in the upper zone and to note any contamination that may exist in the vicinity of Site 17. The flow direction of water in the

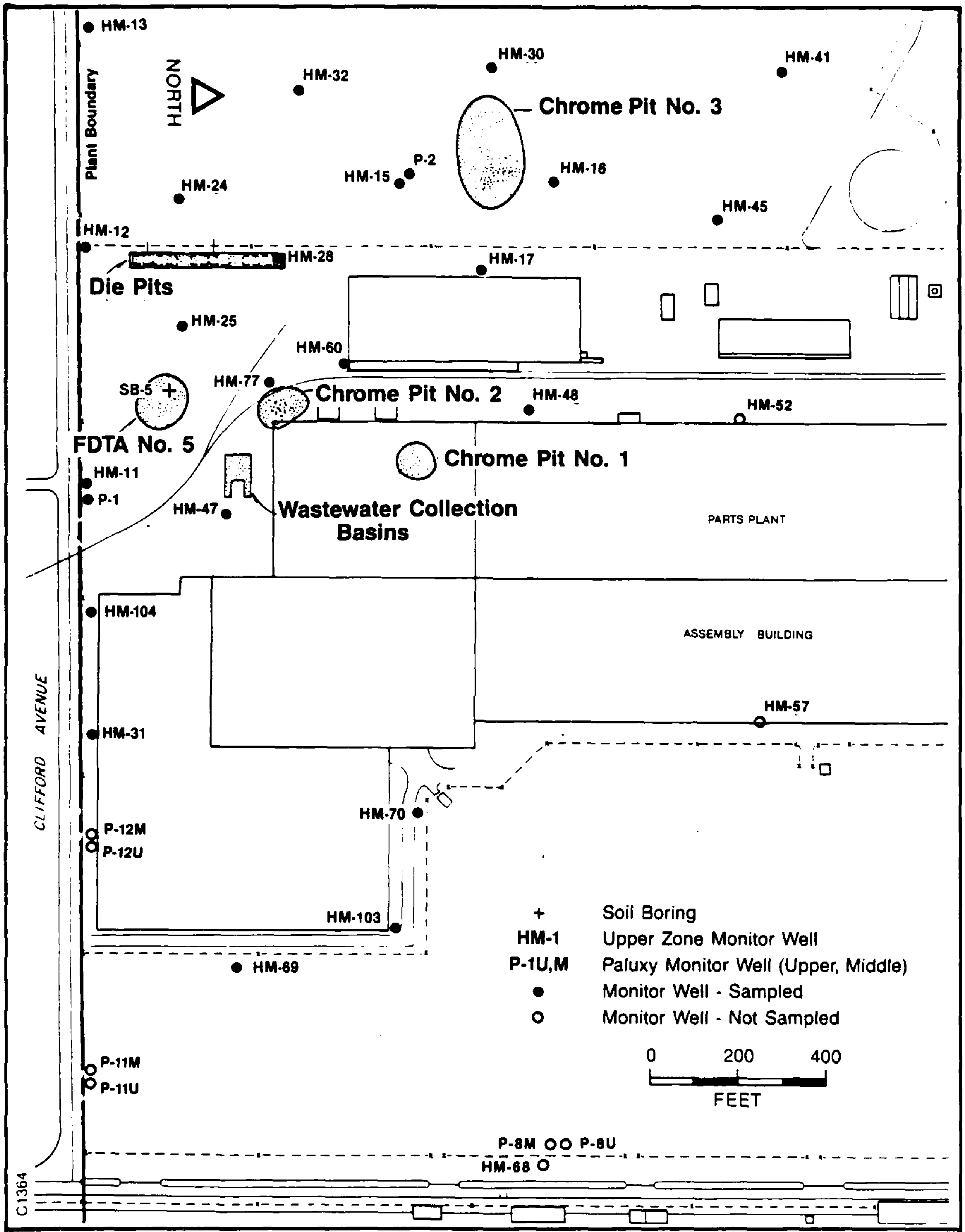

Figure 3-4. Phase II Activities at Sites 10 and 12, Chrome Pits 1 and 3; Zone 1 (Site 13, Die Pits; Site 11, Chrome Pit 2; and Site 8, Fire Department Training Area 5); and Site 20, Wastewater Collection Basins, AF Plant 4, Texas

upper zone is difficult to identify because of the variability of the strata in the upper zone and the resultant scattered occurrence of groundwater. The upper zone material at this site consists of either alluvium or the Goodland Formation. The Goodland Formation, a calcareous shale underlying most of AF Plant 4, acts as a barrier to flow.

Groundwater Sampling: One sample from each of two existing upper zone wells (HM-8 and HM-14) was collected during 13 to 19 February 1986, and from one new well (HM-100) on 11 April 1986. The purpose of groundwater sampling and analysis was to confirm earlier investigations and to gain additional data on the nature and extent of contamination. Details of the sampling procedures are outlined in Section 3.1.5.3. The groundwater samples were analyzed for hydrocarbon fuels. Results of the analyses are presented in Section 4.3.4.

3.2.5 Site 2, Landfill 2

Investigation activities at Landfill 2 included: performance of geophysical surveying, installation of a monitor well (P-21U) completed in the upper member of the Paluxy Formation, and collection of groundwater samples from seven existing monitor wells and the newly installed Paluxy monitor well. Figure 3-5 shows the location of Landfill 2.

Terrain Conductivity Survey: The purpose of the terrain conductivity survey was to determine the presence and configuration of waste disposal areas. This was accomplished by using electromagnetic profiling to measure electrical conductivities of the subsurface material. To perform the survey at Landfill 2 a grid was established, as described in Section 3.1.1. Figure 3-3 illustrates the area of the survey at Landfill 2, as well as the other EMP survey locations at AF Plant 4. The area of the EMP survey grid is approximately 1800 by 800 feet. Electromagnetic profile readings were taken every 30 feet. The survey was performed in November, 1985.

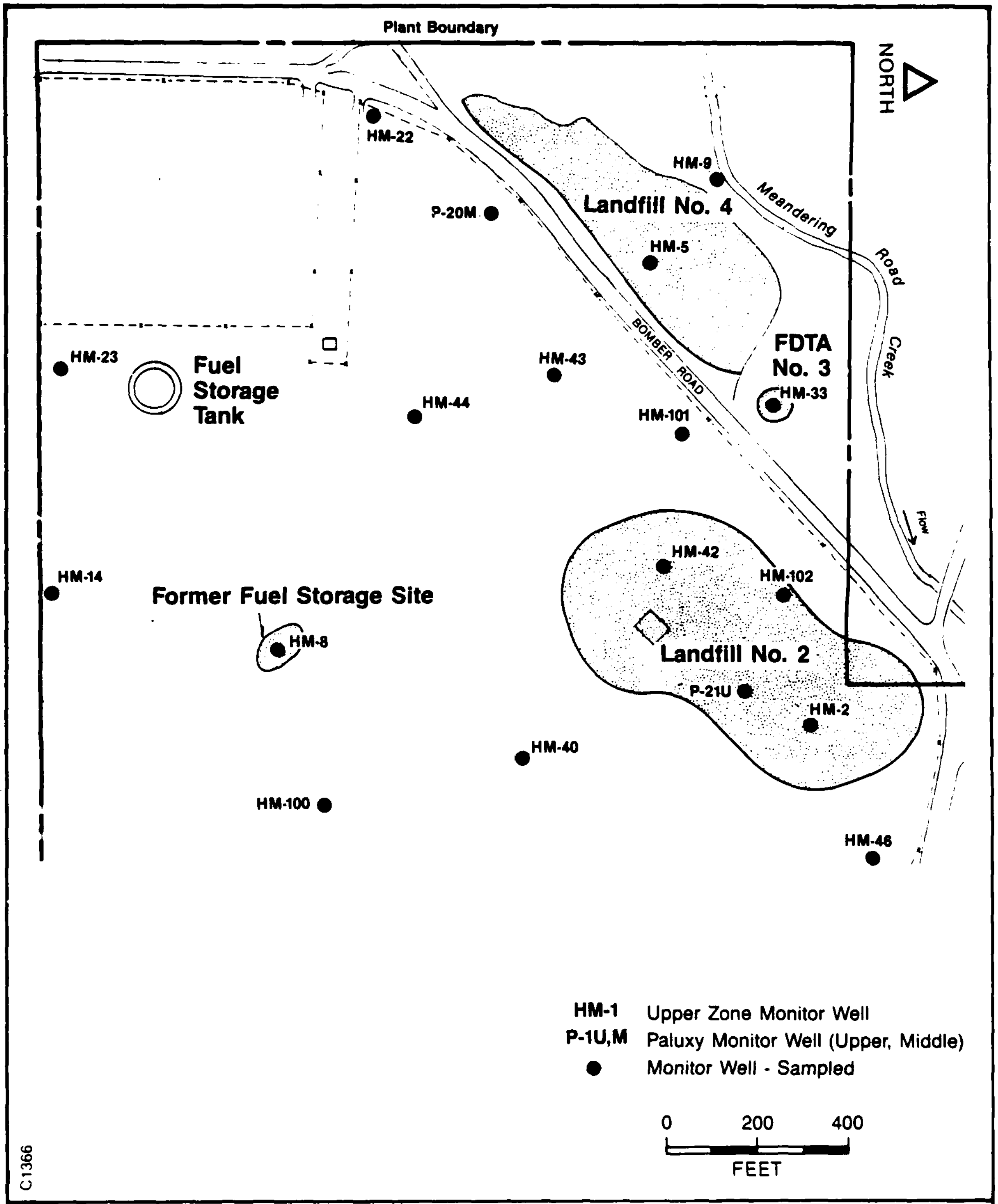

Figure 3-5. Phase II Activities at Sites 2 and 4, Landfills 2 and 4; Site 17, Former Fuel Storage Site; and Site 6, Fire Department Training Area 3, AF Plant 4, Texas

Monitor Well Installation: One new monitor well (P-21U) was installed in the Landfill 2 area. The well was completed in the upper member of the Paluxy Formation. Soil samples were taken as described in Section 3.1.3, along with samples of drilling fluids. The location of P-21U was selected to complement the existing Paluxy well network and determine the quality of groundwater downgradient of Landfill 2 and of other waste disposal areas.

Groundwater Sampling: One sample from each of the upper zone wells (HM-2, 22, 40, 42, 43, 44, and 46) was collected during the period 20-25 February 1986. The Paluxy well (P-21U) was sampled on 10 April 1986. The purpose of groundwater sampling and analysis was to confirm earlier investigations and to gain additional data on the nature and extent of contamination in the upper zone and the Paluxy aquifer. Details of the sampling procedures are given in Section 3.1.5.3. The groundwater samples were analyzed for VOC, BNA, and heavy metals. Results of the analyses are presented in Section 4.3.5.

3.2.6. Site 4, Landfill 4

Investigation activities at Landfill 4 included: installation of two monitor wells (HM-101 and P-20M) and collection of groundwater samples from the two existing monitor wells and the two newly installed monitor wells (Figure 3-5).

Monitor Well Installation: Monitor well HM-101 was completed in the upper zone, and P-20M was completed in the middle member of the Paluxy Formation. Monitor well P-20M was intended to be installed in the upper member of the Paluxy Formation, but the upper member was dry so the well was installed to coincide with uppermost occurrence of water, this being the middle member of the Paluxy. Both monitor wells were installed south of Landfill 4 on the AF Plant 4 Radar Range. Soil samples collected from split spoons, as described in Section 3.1.3, and samples of drilling fluids were also taken. HM-101 is located along the fence line of the Radar Range, an area with few monitor wells. This location was chosen to more accurately define groundwater flow and the occurrence of contamination in the upper zone. The P-20M location was selected to note migration of contamination, if any, from east of the AF Plant 4 boundary, and also because it was upgradient of the Paluxy well installed in the Landfill 2 area.

Groundwater Sampling: One sample from each of the existing upper zone wells (HM-5, HM-9) was collected during 12 to 27 February 1986. Monitor well HM-101 was sampled on 18 April 1986 and P-20M was sampled on 9 April 1986. The purpose of groundwater sampling and analysis was to confirm earlier investigations and to gain additional data on the nature and extent of contamination in the upper zone and the Paluxy aquifer. Details of the sampling procedures are given in Section 3.1.5.3. The groundwater samples were analyzed for VOC, BNA, and heavy metals. Results of the analyses are presented in Section 4.3.6.

3.2.7 Zone 1: Site 13, Die Pits; Site 11, Chrome Pit 2; Site 8, FDTA 5

Since Zone 1 contains three sites in close proximity to each other, the field activities were designed to account for their proximity. Field activities at Zone 1 included: drilling of a borehole (SB-5) in the vicinity of the Site 8 Fire Department Training Area (FDTA) 5 and collection of groundwater samples from seven existing upper zone monitor wells and from one existing Paluxy monitor well. Figure 3-4 shows the location of the borehole wells, and sites.

Borehole: Soil boring SB-5 was drilled in the area of FDTA 5 (Figure 3-4). Based on color, odor, and OVA readings, soil samples were collected from split spoons, as described in Section 3.1.3, and submitted for analysis of hazardous constituents. Originally, the purpose of the borehole was to allow for the installation of an upper zone monitor well; however, no water was noted in the borehole even after it had remained open for two days. Therefore, the borehole was grouted from the total depth to the land surface.

Groundwater Sampling: One sample from each of the upper zone wells (HM-11, 12, 24, 25, 28, 60, and 77) and Paluxy well P-1 was collected during 6 to 19 February 1986. The purpose of groundwater sampling and analysis was to confirm earlier investigations and to gain additional data on the nature and extent of contamination in the upper zone and the Paluxy aquifer. Details of the sampling procedures are given in Section 3.1.5.3. The groundwater samples were analyzed for VOC, BNA, and heavy metals. In addition, groundwater from HM-77 was analyzed for hydrocarbon fuels and oil and grease. Results of the analyses are presented in Section 4.3.7.

3.2.8 Site 15, Fuel Saturation Area 2

Investigation activities in Fuel Saturation Area (FSA) 2 included: drilling of three boreholes along the length of a buried fuel line, collection of a groundwater sample from an existing upper zone monitor well, and observation of the monitor well for the existence of a fuel lens. The location of FSA 2 is shown in Figure 3-6.

Boreholes: Three boreholes (SB-1, 2 and 3) were drilled just west of the fence along a buried fuel line in the upper zone. Locations for drilling were selected after verbal communication with Resource Engineering, Inc., the subcontractor to Intellus for Phase IV field work. Drilling was accomplished between 24 and 26 January 1986. These boreholes were drilled to determine if hydrocarbons existed in the soil and groundwater near the fuel line. Soil samples were collected from split spoons as described in Section 3.1.3. The boreholes were left open overnight to see if groundwater was present and if hydrocarbons existed on the surface of the water table. After the observations were completed, each borehole was grouted to the surface.

Groundwater Sampling: Groundwater samples were collected from HM-80 on 5 February 1986. Samples were collected and analyzed to determine if contamination was present in the groundwater at the buried fuel line. Details of the sampling procedures are given in Section 3.1.5.3. The samples were

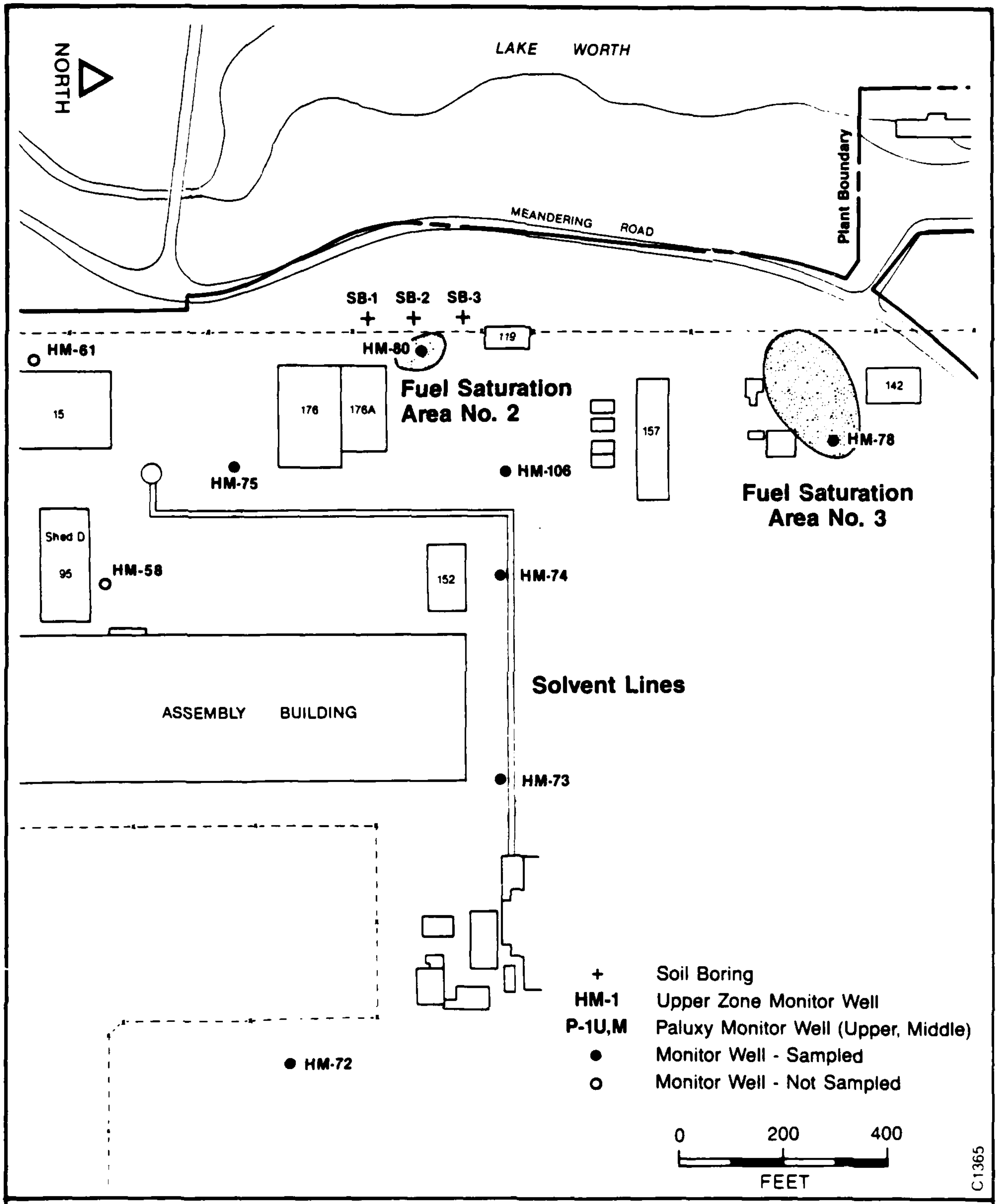

Figure 3-6. Phase II Activities at Site 18, Solvent Lines and Sites 15 and 16, Fuel Saturation Areas 2 and 3, AF Plant 4, Texas

analyzed for VOC and hydrocarbon fuel. Results of the analyses are presented in Section 4.3.8.

3.2.9 Site 20, Wastewater Collection Basins

Investigation activities at the Wastewater Collection Basins (Figure 3-4) included: installation of an upper zone monitor well (HM-104), collection of groundwater samples from four existing monitor wells and the newly installed well, determination of the location and depth of the buried sanitary and industrial waste lines, as well as of the need for soil sampling along the waste lines (based on soil and groundwater analysis).

Monitor Well Installation: Monitor well HM-104 was installed between 22 and 23 January 1986. Soil samples were collected from split spoons, as described in Section 3.1.3. The monitor well was located southeast of the basins at the southwest corner of Building 188. This location was selected to gain information on the direction of groundwater flow and on contamination in the area.

Groundwater Sampling: One sample from each of the upper zone monitor wells HM-31, 47, 69, and 70 was taken during 6 and 21 February 1986. Monitor well HM-104 was sampled on 10 April 1986. The purpose of groundwater sampling and analysis was to confirm earlier investigations and to gain additional data on the nature and extent of contamination in the upper zone. The groundwater samples were analyzed for VOC, oil and grease, hydrocarbon fuel, and heavy metals. Results of the analyses are presented in Section 4.3.9.

3.2.10 Site 16, Fuel Saturation Area 3

Investigation activities in Fuel Saturation Area 3 (FSA 3) (Figure 3-7) included the collection of a groundwater sample from one existing well and observation of the existence of a fuel lens, if any, in the monitor well.

Groundwater Sampling: Sampling of upper zone monitor well, HM-78, was performed on 5 February 1986 to confirm earlier investigations and to gain additional data on the nature and extent of contamination in the upper zone. The groundwater sample was analyzed for VOC and hydrocarbon fuel. Results of the analysis are presented in Section 4.3.10.

3.2.11 Site 9, Fire Department Training Area 6

Investigation activities in Fire Department Training Area 6 (FDTA 6) (Figure 3-7) consisted of hand augering, the collection of six soil samples, and the collection of one groundwater sample from an existing Paluxy monitor well.

Hand Augering: The purpose of collecting soil samples by hand augering was to determine whether shallow soil contamination exists at this suspected fire training site. Field work occurred on 12 May 1986. Each hand auger site was within the suspected boundary of FDTA 6, as shown in Figure 3-8. The perimeter of FDTA 6 was shown to Radian personnel by the AF Plant 4 fire department and marked with flags. Four of the auger sites were placed along the perimeter on the northern half of FDTA 6 and the remaining two were placed along the center line of the area. Since the southern half of FDTA 6 had very little topsoil, it was not sampled. Soil samples were taken as described in Section 3.1.5.1. One soil sample was submitted for analysis for VOC, BNA, oil and grease, and hydrocarbon fuel. Results of the analyses are presented in Section 4.3.11.

Groundwater Sampling: Radian personnel collected a groundwater sample from P-3 on 4 February 1986. The purpose of this effort was to gain additional data on the groundwater quality conditions in the Paluxy aquifer at this site. Details of the sampling procedures are given in Section 3.1.5.3. The groundwater sample was analyzed for VOC, BNA, oil and grease, and hydrocarbon fuel. Results of the chemical analysis are presented in Section 4.3.11.

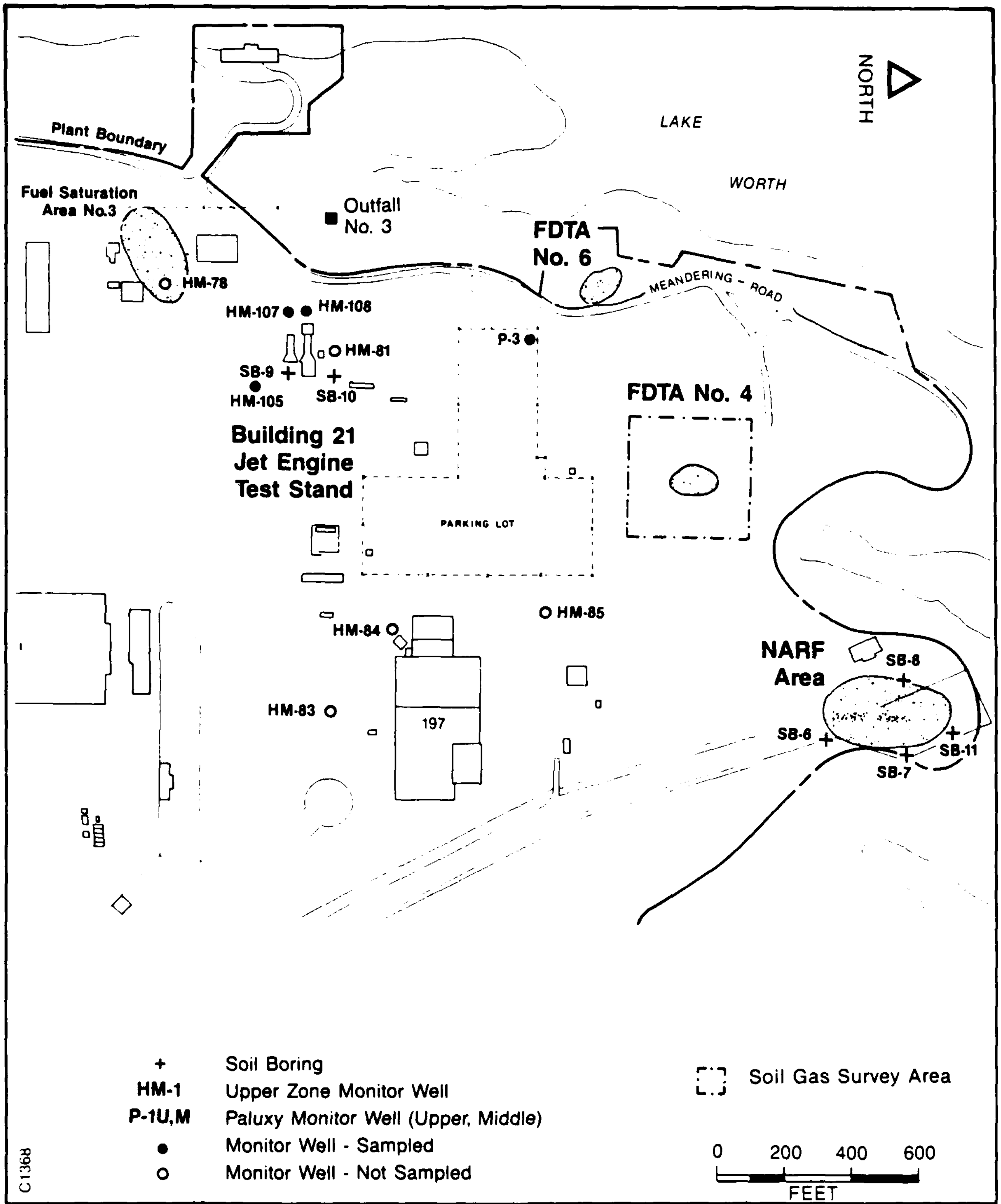

Figure 3-7. Phase II Activities at Building 21, Jet Engine Test Stand; Sites 7 and 9, Fire Department Training Areas 4 and 6; and Site 19, NARF Area, AF Plant 4, Texas

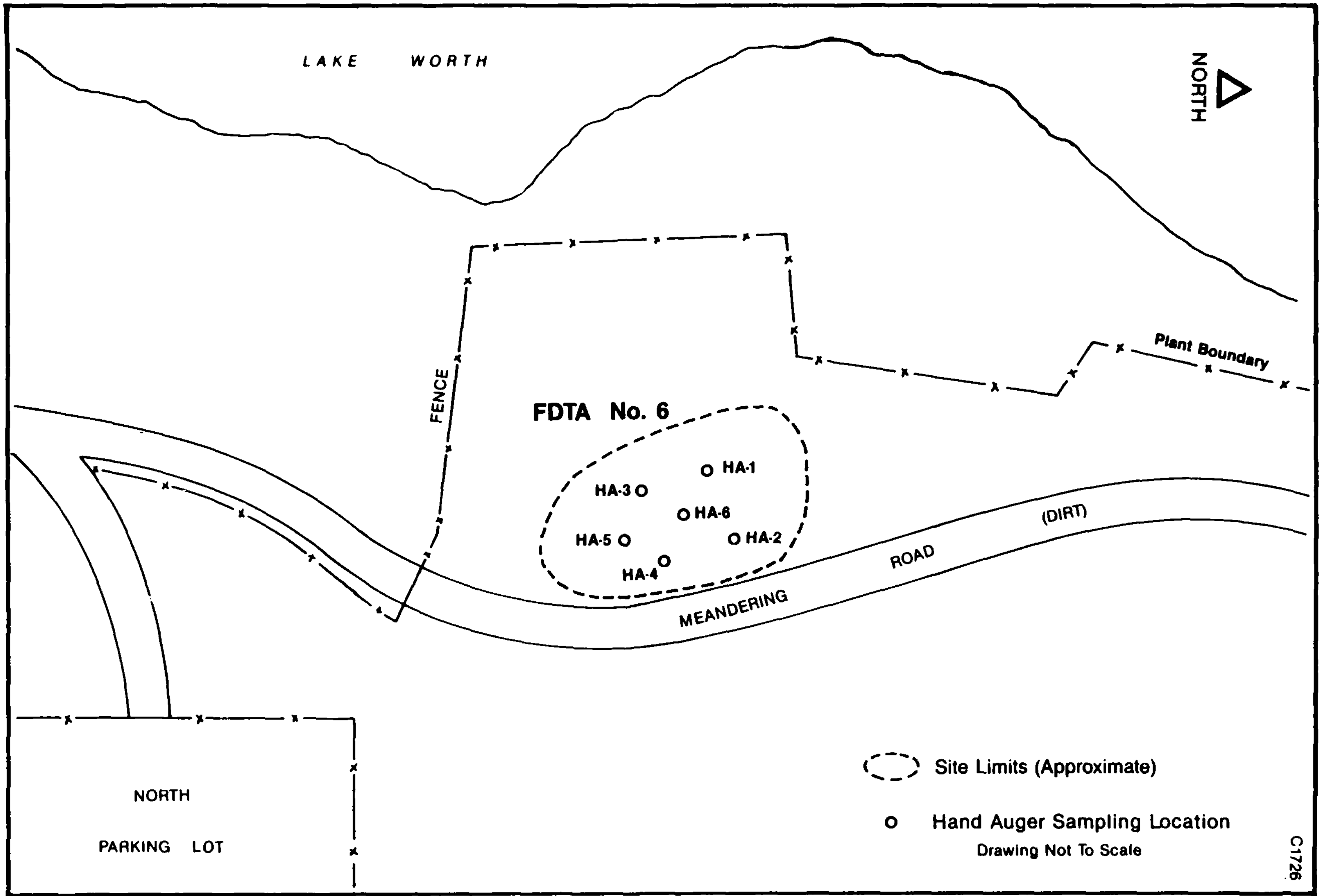

Figure 3-8. Hand Auger Sampling Locations, Site 9, Fire Department Training Area 6, AF Plant 4, Texas

3.2.12 Site 6, Fire Department Training Area 3

Investigation activities at Fire Department Area 3 (FDTA 3) (Figure 3-5) included the installation of a groundwater monitor well HM-102 and collection of groundwater samples from monitor wells HM-33 and HM-102.

Monitor Well Installation: One new monitor well (HM-102) completed in the upper zone was installed west of FDTA 3 in the vicinity of Landfill 2. Soil samples were collected from split spoons as described in Section 3.1.3. The location for this monitor well was selected to improve coverage of groundwater flow monitoring points.

Groundwater Sampling: Groundwater samples were collected from HM-33 on 28 February 1986 and from HM-104 on 10 April 1986. The purpose of collecting and analyzing the groundwater was to determine the nature and extent of contamination at the fire training site. Details of the sampling procedures are given in Section 3.1.5.3. Groundwater samples were analyzed for VOC, oil and grease, and hydrocarbon fuel. Results of the analyses are presented in Section 4.3.12.

3.2.13 Site 7, Fire Department Training Area 4

Investigation activities at Fire Department Training Area 4 (FDTA 4) (Figure 3-7) included an attempt to determine the location of the old fire training area by conducting a soil-gas survey.

Soil-Gas Survey: Soil-gas samples were collected and analyzed, as described in Section 3.1.2, from a total of 28 points at FDTA 4. The target depth for soil-gas sampling was 5 to 6 feet below the ground surface at most of the probe locations. At eight of the sampling locations, probes were driven to the 8 to 12 foot depth interval to determine if volatile organic compounds (VOCs) were being biodegraded in the shallow soil gas. Since petroleum hydrocarbons are particularly susceptible to oxidation biodegradation in shallow soil where aerobic conditions prevail, sampling for petroleum hydrocarbons is usually conducted at greater depths than is sampling for halocarbons.

Soil-gas samples were analyzed for methane, total petroleum hydrocarbons, carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene, and perchloroethylene. Total petroleum hydrocarbons were defined as C_4 to C_{10} aliphatic and alicyclic compounds and benzene, toluene and xylene isomers. These petroleum compounds are the major constituents of aviation fuels. Methane is produced as a by-product of subsurface biodegradation, and the other four compounds are the most common industrial solvents.

After 28 soil-gas samples were taken and no hydrocarbons were noted, Radian personnel contacted the AF Plant 4 fire department and requested a more precise location for the fire training area described in the Phase I report. Three fire department personnel, each with from 20 to 30 years experience at AF Plant 4, came to the site and stated that no FDTA had ever existed at this location; therefore, activities at this site were terminated.

3.2.14 Site 18, Solvent Lines

Investigation activities along the Solvent Lines included the installation of a monitor well (HM-106) and collection of groundwater samples from four existing upper zone monitor wells and from HM-106. Figure 3-6 shows the location of this site.

Monitor Well Installation: Monitor well HM-106 was installed along the Solvent Lines and completed in the upper zone (Figure 3-6). Drilling and well installation took place on 26 January 1986. The purpose of the additional upper zone monitor well was to complement the existing well network at the Solvent Lines by providing additional information on the direction of groundwater flow and groundwater quality in the upper zone. Soil samples were collected from split spoons, as described in Section 3.1.3. The new monitor well was installed at the northwest bend along the solvent line, approximately 400 feet east of Building 119.

Groundwater Sampling: One groundwater sample was collected from each of the four existing wells (HM-72, 73, 74, and 74) from 5 to 26 February 1986. Monitor well HM-106 was dry and could not be sampled. Details of the sampling procedures are given in Section 3.1.5.3. The groundwater samples were analyzed for oil and grease, xylene, and methyl ethyl ketone. Results of the chemical analyses are presented in Section 4.3.14.

3.2.15 Site 10, Chrome Pit 1

Investigation activities at Chrome Pit 1 included the installation of a monitor well (HM-103) and collection of groundwater samples from an existing monitor well (HM-48) and HM-103.

Monitor Well Installation: *One new monitor well (HM-103) was installed* east of Chrome Pit 1 and completed in the upper zone (Figure 3-4). Well installation activities took place on 21 January 1986. Soil samples were taken as described in Section 3.1.3. The monitor well is located east of the chrome pit on the northeast corner of Building 188. This location was selected to gather data on groundwater flow in the upper zone in this area and to determine if contamination exists there. The monitor well was not installed directly next to Chrome Pit 1 because the site is located beneath the floor of Building 181.

Groundwater Sampling: Groundwater sampling was performed by Radian personnel at HM-48 on 14 February 1986 and at HM-103 on 10 April 1986. Details of the sampling procedures are given in Section 3.1.5.3. The groundwater samples were analyzed for VOC and chromium. Results of the analyses are presented in Section 4.3.15.

3.2.16 Site 5, Fire Department Training Area 2

Investigation activities at Fire Department Training Area (FDTA) 2 (Figure 3-3) included performance of a terrain conductivity survey and collection of groundwater samples from seven existing upper zone monitor wells.

Terrain Conductivity Survey: The purpose of the terrain conductivity (EMP) survey performed in November, 1985 was to determine the presence and configuration of the fire training area and to gain information on the northern limits of Landfill 1, located just south of FDTA 2. The survey used electromagnetic profiling to measure electrical conductivities of the subsurface material. To perform the survey, a grid was established, as described in Section 3.1.1. Figure 3-3 illustrates the area of the EMP survey at FDTA 2, and the other survey locations at AF Plant 4. The area of the EMP survey grid is approximately 800 feet by 250 feet. Electromagnetic profile readings were taken every 30 feet.

Groundwater Sampling: Radian personnel collected one groundwater sample from each of monitor wells HM-19, 49, 51, 65, 66, and 76 during 11 February to 1 March 1986. The purpose of the groundwater sampling and analysis program was to gain additional information on the nature and extent of contamination at FDTA 2. Details of the sampling procedures are given in Section 3.1.5.3. The groundwater samples were analyzed for VOC, oil and grease, and hydrocarbon fuel. Results of the analyses are presented in Section 4.3.16.

3.2.17 Site 14, Fuel Saturation Area 1

Investigation activities at Fuel Saturation Area (FSA) 1 (Figure 3-2) included drilling one borehole (SB-4); collecting groundwater samples from the borehole, from two existing upper zone monitor wells, and from two existing Paluxy monitor wells; and observing the monitor wells for a fuel lens, if any, on the surface of the water table.

Borehole: One borehole (SB-4) was drilled into the upper zone just west of FSA 1 on the east side of Building 14 (Figure 3-2). Soil samples were collected from split spoons, as described in Section 3.1.3. The borehole was drilled to the water table and the liquid was sampled. The sample contained only fuel; therefore the complete thickness of the fuel lens on the water table could not be determined. After sampling, the borehole was grouted to the surface and the sample was analyzed for hydrocarbon fuels. Results of the analysis are presented in Section 4.3.17.

Groundwater Sampling: One groundwater sample was collected from each of monitor wells HM-53, HM-55, P-6M, and P-6U during 4 to 10 February 1986. Samples were collected and analyzed to determine the presence of contamination in the upper zone and to gain additional information on the groundwater quality in the Paluxy aquifer. Details of the sampling procedures are given in Section 3.1.5.3. The groundwater samples were analyzed for hydrocarbon fuel. Results are presented in Section 4.3.17.

3.2.18 Nuclear Aerospace Research Facility (NARF) Area

Investigation activities at the Nuclear Aerospace Research Facility (NARF) (Figure 3-7) included drilling four boreholes (SB-6, 7, 8 and 9), collecting soil samples, collecting groundwater samples from three existing monitor wells, researching past analytical data from wells at Plant 4 and White Settlement for radionuclide results during the NARF operations period, and ascertaining the exact locations of past operations. The purpose of these activities was to ascertain the presence or absence of radioactive material (RAM) on the surface and subsurface of the former reactor locations, as well as at the old aircraft decontamination area.

A representative of White Settlement stated that no information on radionuclides is available for White Settlement. AF Plant 4 personnel stated that the information on the wells at AF Plant 4 during NARF operations was archived and that separate action would be required to retrieve it.

Boreholes: A total of four boreholes (SB-6, 7, 8 and 11) were drilled within the NARF area in the upper zone (Figure 3-7). Initially, only three boreholes were to be drilled in the NARF area, one as a monitor well. However, no water was noted in any of the three boreholes; therefore, a fourth borehole was attempted. The fourth boring was also dry and no more attempts were made. Soil samples were collected from split spoons, as described in Section 3.1.3, except that samples were collected at two foot intervals. Soil samples were submitted for analysis of alpha, beta, and gamma radionuclides. Each borehole was grouted to the surface after sampling was completed. Results of the analyses are presented in Section 4.3.18.

Groundwater Sampling: Radian personnel performed groundwater sampling at HM-83, 84, and 85 on 21 August 1986. Details of the sampling procedures are given in Section 3.1.5.3. Groundwater samples were analyzed for VOC, BNA, heavy metals, oil and grease, RAM, and hydrocarbon fuels. Results of the analyses are presented in Section 4.3.20.

3.2.19 Jet Engine Test Stand, Bldg. 21

Investigation activities at the Jet Engine Test Stand (Figure 3-7) included installation of three monitor wells (HM-105, 107, and 108), drilling of two boreholes (SB-9 and 10), collection of groundwater samples from the three newly installed monitor wells, and collection of surface water samples from Outfall 5 and Outfall 001.

Monitor Well Installation: Three monitor wells (HM-105, 107 and 108) were installed around the Jet Engine Test Stand, two west and one south of the facility. The monitor wells were all completed in the upper zone. Drilling and well completion were performed on 11 August 1986. Soil samples were collected from split spoons as described in Section 3.1.3. The monitor well locations were chosen because of the lack of monitor wells in the immediate vicinity of Building 21. Their purpose was to gain information on groundwater flow in the upper zone and data on the groundwater chemistry downgradient of the facility. Originally, the monitor wells were to be installed at the north, south, and west sides of the facility; however, the boring on the north side of the facility was dry. This is probably because the Goodland Formation, generally a dry or low-yield formation, is on the north side of the facility.

Boreholes: Two boreholes (SB-9 and -10) were drilled at the Jet Engine Test Stand, one north and one south of the facility. Soil samples were collected from split spoons, as described in Section 3.1.3. Drilling and sampling was conducted 22 July 1986. The boring on the north side of the facility was dry while the boring on the south side encountered groundwater and liquid hydrocarbon. The hydrocarbons may be related to abandoned underground fuel storage tanks located approximately 6 feet north of the borehole. Each borehole was grouted to the surface after sampling was complete.

Groundwater Sampling: Radian personnel performed groundwater sampling from 19 to 20 August 1986. Details of the sampling procedures are given in Section 3.1.5.3. Groundwater samples were analyzed for oil and grease and hydrocarbon fuel. Results of the analyses are presented in Section 4.3.19.

Surface Water Sampling: Radian personnel performed field sampling on 20 August 1986. Outfalls 1 and 5 were sampled every hour over an eight hour period. A total of nine samples was collected, consisting of the eight samples and a composite of the eight. Details of the sampling procedures are outlined in Section 3.1.5.2. Surface water samples were analyzed for oil and grease and hydrocarbon fuel. Results of the surface water analyses are presented in Section 4.3.19.

3.3 Additional Study Topics

In addition to the investigations related to the waste disposal sites presented above, four additional study topics were identified for field investigations. Each is discussed below:

3.3.1 Ambient Monitoring

Investigation activities for Ambient Monitoring involved the collection of groundwater samples from eleven existing upper zone monitor wells and eight existing Paluxy monitor wells (Figure 3-9). The purpose of this activity was to gain continuing information on groundwater quality in the upper zone and Paluxy aquifer in areas not directly associated with waste disposal sites.

Radian personnel performed groundwater sampling from 31 January through 26 February 1986. One sample was collected from each of HM-29, 52, 54, 56, 57, 58, 59, 61, 64, 79, and 81; and from P-5U, 5M, 9U, 9M, 10U, 10M, 11U, and 11M. Details of the sampling procedures are given in Section 3.1.5.3. The groundwater samples were analyzed for VOC, BNA, oil and grease, hydrocarbon fuel, and heavy metals. Chromium was also specified for analysis in the delivery order, but this parameter was already included in the list of heavy metals. Results of the analyses are presented in Section 4.3.20.

3.3.2 East Parking Lot

Investigation activities for the East Parking Lot involved the collection of groundwater samples from three existing upper zone monitor wells and two Paluxy monitor wells (Figure 3-10). The purpose of this activity was to gain continuing information on the quality of groundwater in the upper zone and Paluxy aquifer in areas not directly associated with waste disposal sites.

Radian personnel performed groundwater sampling from 3 to 28 February 1986. One sample was collected from each of HM-68, 71, and 82; and P-8U and 8M. Details of the sampling procedures are given in Section 3.1.5.3. Groundwater samples were analyzed for VOC, BNA, oil and grease, hydrocarbon fuel, and heavy metals (chromium was also specified for analysis in the delivery order, but this parameter was already included in the parameter list of heavy metals). Results of the analyses are presented in Section 4.3.21.

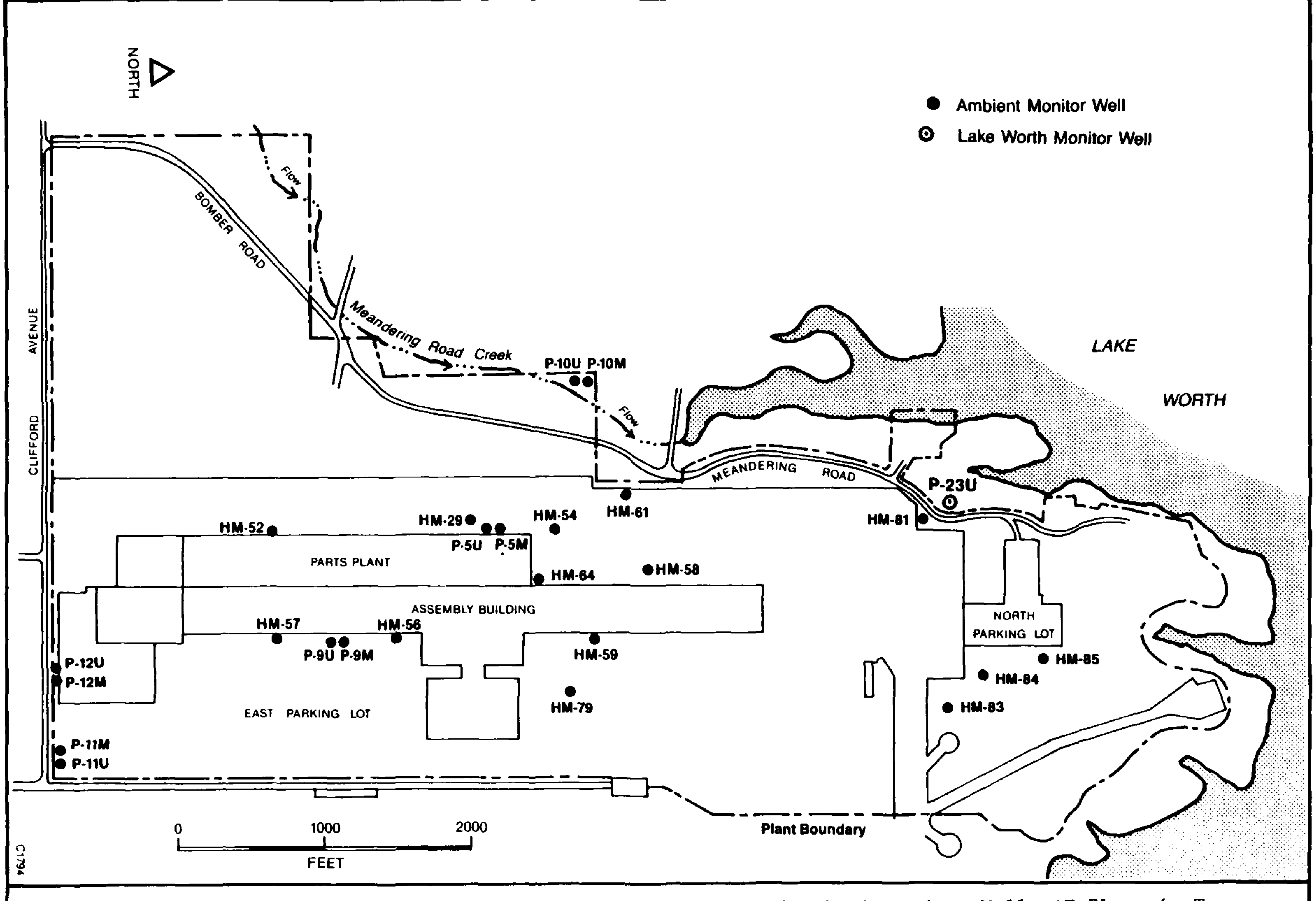

Figure 3-9. Phase II Activities - Ambient Monitoring and Lake Worth Monitor Well, AF Plant 4, Texas

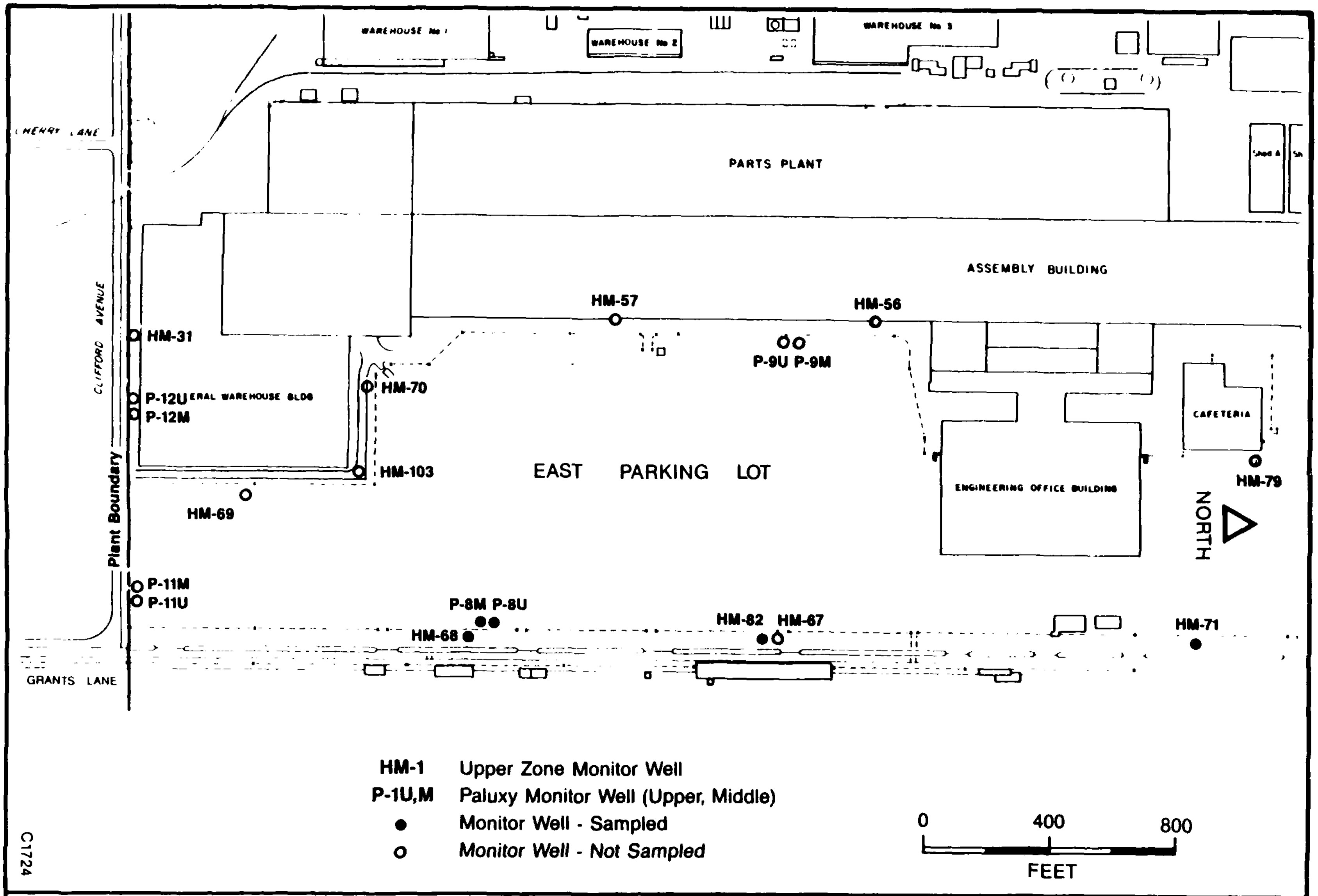

Figure 3-10. Phase II Activities - East Parking Lot Monitor Wells, AF Plant 4, Texas

3.3.3 Fuel Storage Tank

Investigation activities for the Fuel Storage Tank consisted of collecting a groundwater sample from upper zone monitor well HM-23 (Figure 3-5). The purpose of this activity was to determine groundwater quality in the upper zone at the Fuel Storage Tank.

Radian personnel performed groundwater sampling at HM-23 on 18 February 1986. Details of the sampling procedures are given in Section 3.1.5.3. The groundwater samples were analyzed for oil and grease and hydrocarbon fuel. Results of the analyses are presented in Section 4.3.22.

3.3.4 Lake Worth Monitor Well

Investigation activities at this area included installing Paluxy monitor well (P-23U) and collecting two groundwater samples, one month apart.

Monitor Well Installation: A Paluxy monitor well (P-23U) was installed west of Meandering Creek Road, and west of Building 21 in the upper member of the Paluxy Formation (Figure 3-9). Soil samples and samples from the drilling fluids were taken as described in Section 3.1.3. This location was selected to determine the groundwater quality in the Paluxy aquifer directly downgradient of a major recharge source, Lake Worth.

Groundwater Sampling: Radian personnel performed groundwater sampling at P-23U on 18 April and 21 August 1986. Details of the sampling procedures are given in Section 3.1.5.3. Groundwater samples were analyzed for VOC, BNA, and heavy metals. Results of the analyses are presented in Section 4.3.22.

3.4 Hazardous Constituents in Soil and Drilling Fluids

Selected samples of soils and drilling fluids from drilling and well installation operations were analyzed for a variety of parameters to determine if they should be designated hazardous materials. Selection of samples for analysis was based on the presence of discoloration, odor or positive OVA readings. Soils were analyzed for metals (EP Toxicity), chromium, and ignitability. Drilling fluids used during the installation of wells P-20M, P-21U, P-22U and P-23U were also analyzed for volatile organic compounds. Results of these analyses are given in Table 3-5. Complete analytical reports appear in Appendix A.

Table 3-6 shows the maximum concentrations of contaminants for characterization of EP Toxicity. Mercury, cadmium, and selenium were detected at concentrations above these maximum levels in soils from P-20M. Furthermore, analyses for volatile organics showed high levels of trichloroethylene in the drilling fluid used during the installation of P-22U. Therefore, on the basis of these tests for hazardous constituents, materials from P-20M and P-22U should be considered hazardous materials.

In addition, it was previously recommended (based on further analytical work reported in Section 4), that materials from HM-103, SB-2, and SB-4 also be considered hazardous material. Analyses detected high levels of chromium and TCE in soils from HM-103 and elevated hydrocarbons in soils from SB-2 and SB-4.

TABLE 3-5. SOIL SAMPLES COLLECTED FOR HAZARDOUS CONSTITUTENTS, AF PLANT 4, TEXAS

		Monitor Well or Soil Boring ID								
		SB-1-B	SB-2-D	SB-3-C	SB-4-C	SB-5	SB-9-B	HM-103-C	HM-104-A	HM-105
	Method Detection Limit	FSA2	FSA2	FSA2	FSA1	Zone 1	Bldg. 21	Chrome Pit 1	WWCB	Bldg. 21
Date Sampled		1/24/86	1/24/86	1/26/86	1/26/86	1/23/86	7/22/86	1/21/86	1/22/86	8/11/86
Analytical Parameters[a]										
RCRA Metals (mg/L)										
Ag	0.002	0.027	0.017	0.017	0.018	0.019	0.018	0.023	0.015	0.019
As	0.002-0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ba	0.009	0.046	0.15	0.30	0.25	0.23	1.5	0.20	0.12	0.64
Cd	0.002	ND	ND	0.005*	0.003*	0.005*	ND	ND	0.007*	0.005*
Cr	0.005	0.02*	0.02*	0.02*	0.01*	0.009*	0.027	0.02*	0.01*	0.02*
Hg	0.0002	ND	0.0002*	ND	ND	ND	0.08	ND	0.0004*	0.0003*
Pb	0.001-0.002	0.002*	0.009	0.006	0.010	0.003*	0.015	0.006	0.006	0.008
Se	0.002-0.004	ND@	ND	ND	ND	ND	ND(.02)	ND	ND	ND(.02)@
Ignitability		No	No	No	No	No	No	No	No	No
Volatile Organics (mg/kg)		NA	NA	NA	NA	NA	NA	NA	NA	NA
Method 8240 Concentration Factor										
Methylene Chloride	0.0028									
trans-1,2-Dichloroethylene	0.0016									
Trichloroethylene	0.0019									
Toluene	0.006									
1,1,1-Trichloroethane	0.0038									
1,2-Dichloroethane	0.0028									
Ethylbenzene	0.0072									
Tetrachloroethylene	0.0041									
Method 601 (Halogenated Hydrocarbons) Concentration Factor										
Methylene Chloride	0.25 ug/L									
Chloroform	0.05 ug/L									
trans-1,2,-Dichloroethylene	0.10 ug/L									
Trichloroethylene	0.12 ug/L									
Method 602 (Aromatic Compounds) Concentration Factor										
Toluene	0.2 ug/L									

(Continued)

TABLE 3-5. (Continued)

		Monitor Well or Soil Boring ID							
Date Sampled	Method Detection Limit	HM-106-B Sovent Lines 1/26/86	HM-107 Bldg. 21 8/11/86	HM-108 Bldg. 21 8/11/86	P-20 LF4 2/28/86	P-21 LF2 2/28/86	P-22 LF3 Water 3/20/86	P-22 LF3 Mud 3/20/86	P-23 Lake Worth Mud 3/20/86
Analytical Parameters[a]									
RCRA Metals (mg/L)									
Ag	0.002	0.005*	0.017	0.004*	0.039	0.014	NA	0.009*	0.013@
As	0.002-0.005	ND	ND	0.003*	1.6	ND(.06)	NA	ND(.06)	0.06*@
Ba	0.009	0.031	0.95	0.16	18	0.72	NA	0.099	0.15
Cd	0.002	0.004*	0.009*	ND	3.2	0.077	NA	0.003*	0.005*@
Cr	0.005	ND	0.02*	0.005*	0.031	0.02*	NA	0.02*	0.02*@
Hg	0.0002	ND	0.0013	0.0006*	3.7	0.10	NA	ND	0.004@
Pb	0.001-0.002	0.007	0.35	0.064	0.18	ND(.08)	NA	ND(.08)	ND(.08)@
Se	0.002-0.004	ND	ND	ND	2.1	ND(.08)	NA	ND(.08)	ND(.08)@
Ignitability		No	No	No	No	No	NA	No	No
Volatile Organics (mg/kg)		NA	NA	NA					
Method 8240									
Concentration Factor					1	1		1	1
Methylene Chloride	0.0028				0.005BL	0.003BL		0.069BL	ND
trans-1,2-Dichloroethylene	0.0016				ND	ND		0.0054	ND
Trichloroethylene	0.0019				ND	ND		1.2	ND
Toluene	0.006				ND	ND		0.47	ND
1,1,1-Trichloroethane	0.0038				ND	ND		0.0053	ND
1,2-Dichloroethane	0.0028				ND	ND		0.019	ND
Ethylbenzene	0.0072				ND	ND		0.006	ND
Tetrachloroethylene	0.0041				ND	ND		0.0096	ND
Method 601 (Halogenated Hydrocarbons)									
Concentration Factor									
Methylene Chloride	0.25 ug/L						0.39 ug/L		
Chloroform	0.05 ug/L						3.5 ug/L		
trans-1,2,-Dichloroethylene	0.10 ug/L						1.2 ug/L		
Trichloroethylene	0.12 ug/L						4.1 ug/L		
Method 602 (Aromatic Compounds)									
Concentration Factor							1		
Toluene	0.2 ug/L						0.69 ug/L		

NA = Not analyzed.
* = Value less than five times detection limit. Errors may range up to 100 percent.
@ = Spike recovery not within acceptable limits. Indicates interferent.
BL = Detected in reagent blank; background subtraction not performed.
a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.
ND = Not detected, values in parentheses are actual sample detection limits.

TABLE 3-6. MAXIMUM CONCENTRATION OF CONTAMINANTS FOR CHARACTERIZATION OF EP TOXICITY

Contaminant[1]	Maximum Concentration (mg/L)
Arsenic	5.0
Barium	100.0
Cadmium	1.0
Chromium	5.0
Lead	5.0
Mercury	0.2
Selenium	1.0
Silver	5.0

[1] Reference: 40 CFR 261.24.

4.0 DISCUSSION OF RESULTS AND SIGNIFICANCE OF FINDINGS

In this section, the Phase II Stage 1 hydrogeologic observations and chemical analyses are discussed on a site-by-site basis. Hydrogeologic interpretations are drawn on the basis of observed variations in groundwater flow and quality. Analytical chemistry data are discussed within the context of available regulatory standards and criteria. Two introductory sections deal with general considerations (the plant-wide geologic and hydrogeologic context) and analytical chemistry considerations (quality confirmation of organic chemical data and available federal regulatory standards and guidelines). The discussion of results and significance of findings for each site appear in separate subsections.

4.1 Hydrogeologic Considerations

The IRP Phase II Stage 1 investigation conducted at AF Plant 4 has been one of several efforts to define the nature and extent of contamination at the facility. Since previous hydrogeologic data (e.g., stratigraphy, groundwater occurrence and flow, water quality) have been gathered and interpreted, this investigation has relied heavily on the available data, both to plan the scope of work and to report and interpret the present information. Specifically, the geologic setting and the occurrence and character of the groundwater have been previously described so that the scope of the investigation reported here has been to fill in gaps in the data and orient the investigation to areas not previously studied. The following subsections describe both the use and interpretation of existing geologic data (4.1.1) and hydrogeologic data (4.1.2).

4.1.1 Geologic Data

The field program was planned and conducted to use the extensive geologic information (presented in Section 2.3) previously developed at AF Plant 4. This subsection describes the geologic data gathered in the Phase II

Stage 1 program that confirm or extend the existing geologic data at AF Plant 4.

The knowledge of geologic conditions defined by previous studies are summarized in Section 2.3. Generally, the results of the IRP Phase II Stage 1 investigation confirm previous interpretations. Since much of the field program involved the strategic placement of additional wells and boreholes to complement existing site monitor networks, no effort was needed to define basic geologic conditions at AF Plant 4. The findings and interpretations of site-specific field data gathering programs appear later in the appropriate subsections. Most of the new geologic information from the Phase II Stage 1 program came from the installation of 4 wells drilled into the Paluxy Formation along the western margin of AF Plant 4.

Figure 4.1.1-1 shows a geologic cross section of the western margin of AF Plant 4. The section is constructed mostly from the geologic logs of the four Phase II Stage 1 Paluxy wells. The location of this cross-section is shown in Figure 2-5. As with the previously developed cross section (Figure 2-6), the new section consists of alluvium at the surface and sedimentary bedrock at depth. The section confirms the undulating nature of the alluvium-bedrock contact, reflecting the erosion of bedrock and the subsequent deposition of terrace and fluvial deposits. At P-20M, drilling revealed that the upper member of the Paluxy is dry. The dry upper member at this location may reflect the greater distance from Lake Worth, a recharge source to the Paluxy aquifer. Elsewhere, the upper member of the Paluxy is only partially saturated, whereas the middle member is confined. The additional drilling conducted for the Phase II Stage 1 investigation has shown that the existing geologic interpretations are sound, and that only limited and site-specific drilling or geologic exploration is warranted for the future.

4.1.2 Hydrogeologic Data

Hydrogeologic data gathered for this investigation consisted of water-level readings at existing and new upper zone and Paluxy monitor wells.

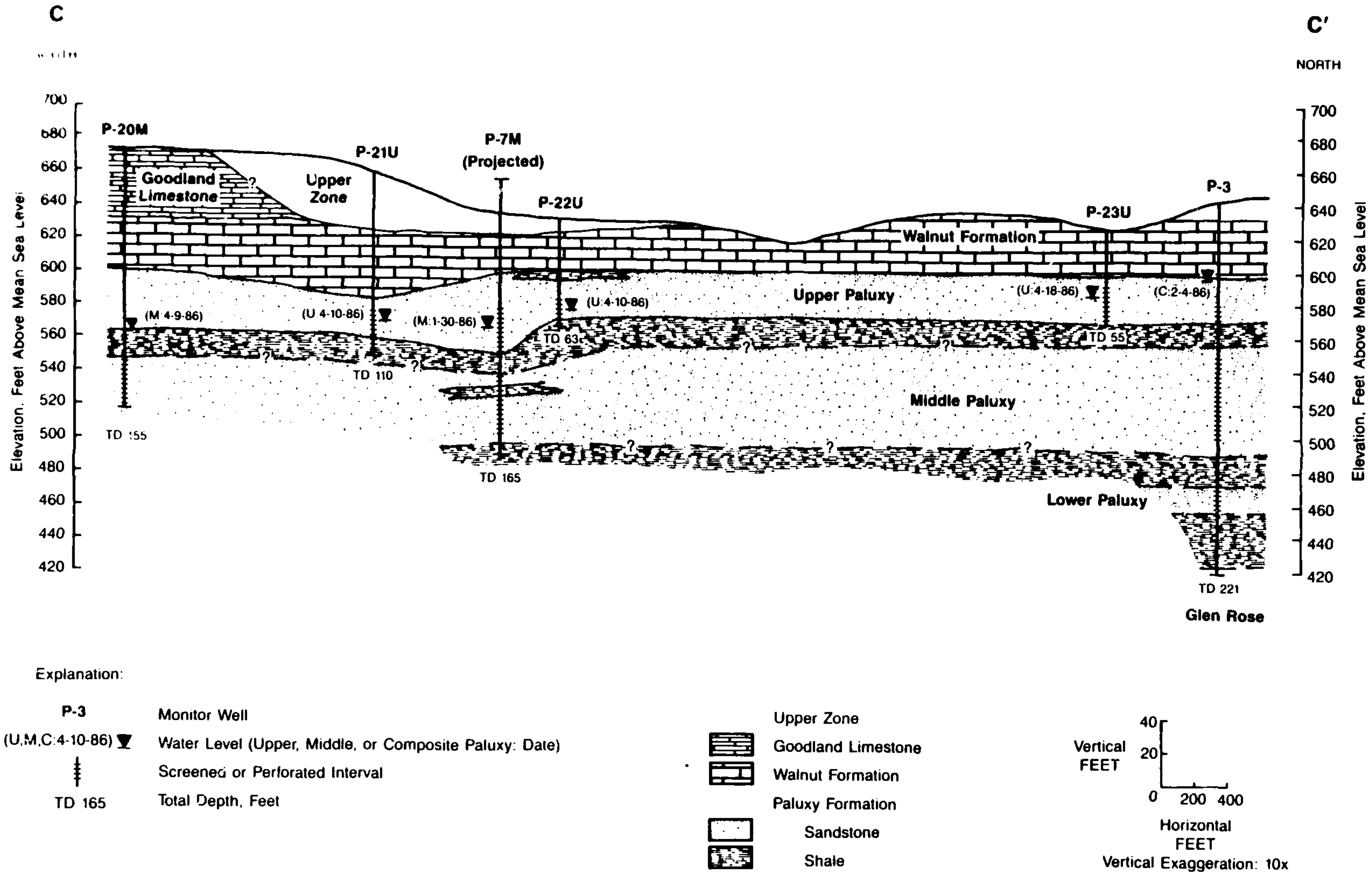

Figure 4.1.1-1. Geologic Cross Section C-C', AF Plant 4, Texas

A series of potentiometric surface maps have been prepared as a result of the water-level measurement program. The following paragraphs discuss the observations of water levels in the upper zone for AF Plant 4, the occurrence of groundwater in the Paluxy aquifer, and groundwater levels in each of the areas of AF Plant 4.

AF Plant 4 Potentiometric Surface Map (Upper Zone)

Figure 4.1.2-1 is similar to the earlier interpretations of Hargis & Associates (1985) with regard to basic inferred groundwater flow patterns. The occurrence and flow of groundwater can be seen to be related closely to the distribution and thickness of alluvial material, the bedrock topography, and surface elevations. For example, the effect of a relatively thick section of coarse-grained (i.e., permeable) alluvial material can be seen in the Radar Range area, which shows widely-spaced potentiometric contours. In other areas, such as north of Landfill 1, the effect of a steeply sloping bedrock surface with thin alluvial cover is shown by closely-spaced contour lines. In general, potentiometric surface elevations are highest (greater than 640 feet MSL) under the central part of AF Plant 4, corresponding to bedrock high areas under the Assembly and Parts Building complexes. A potentiometric high also is evident in the extreme southwestern part of the site where the Goodland Limestone and Walnut Formations crop out near Landfill 4. From those high areas, potentiometric contours decrease either toward Meandering Creek west of the site or toward Grants Lane east of the site. The lowest potentiometric contours are at elevations of 620 or 615 MSL. Inferred directions of groundwater flow are indicated on the figure.

Subtle differences between the current map and earlier versions can be found in the identity of areas without upper zone groundwater. These differences may be attributed to the combination of new data available from the Phase II Stage 1 investigation and to re-interpretation of existing geologic logs from older HM-series wells. The hatchured areas of the potentiometric surface maps should be carefully evaluated in light of the modified

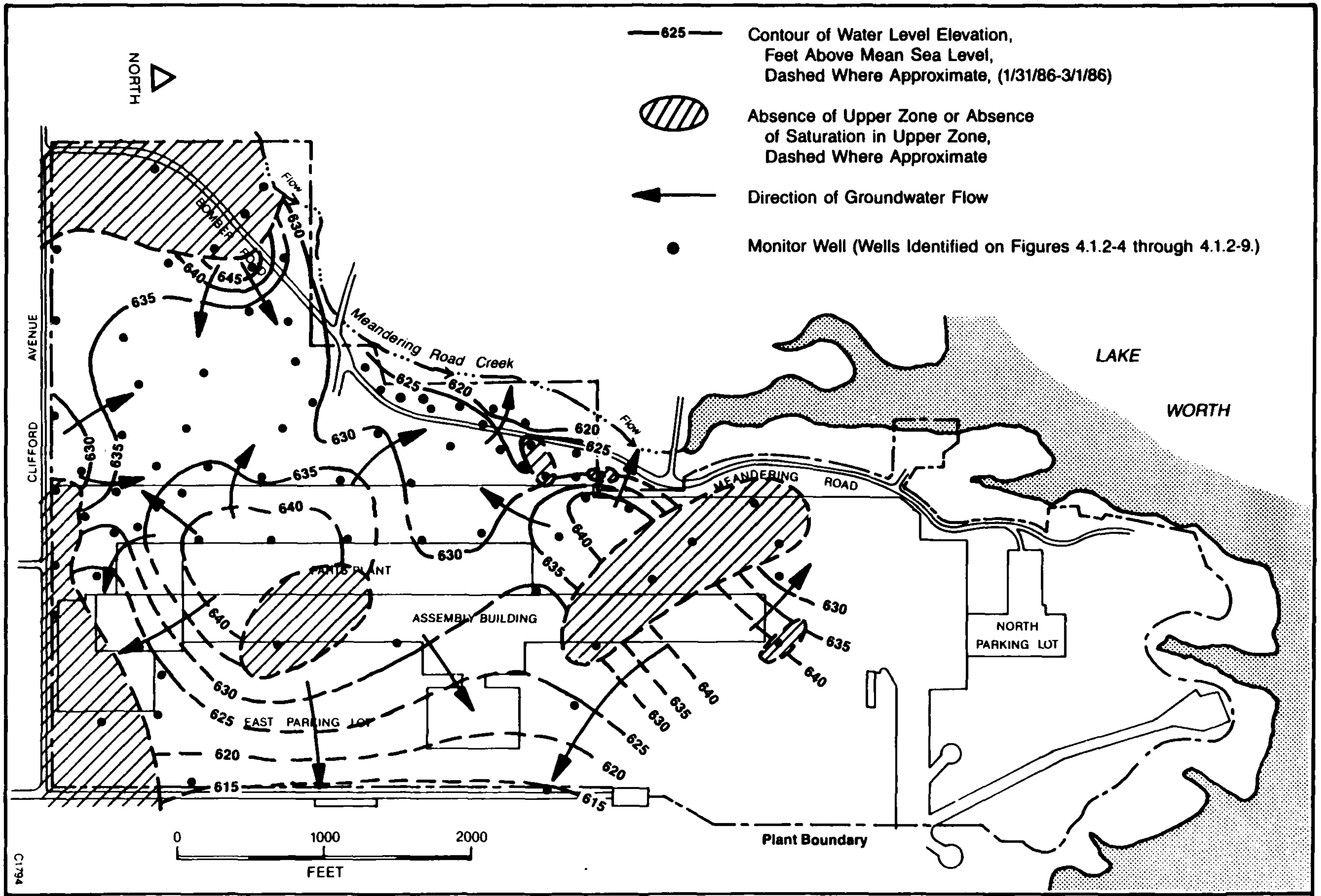

Figure 4.1.2-1. Potentiometric Surface Map of the Upper Zone, AF Plant 4, Texas

geologic map presented in Figure 2.5. Specifically, the hatchured areas signify that no upper zone groundwater is present, either because the upper zone material is present but dry or because upper zone material is not present (even though limited groundwater may occur in either the Goodland or Walnut Formations). Thus, the uppermost occurrence of groundwater at any given location may not correlate with adjacent occurrences of groundwater. This approach to the presentation of groundwater data is essentially the same as that of Hargis & Associates (1985).

AF Plant 4 Potentiometric Surface Map (Paluxy Aquifer)

Potentiometric surface maps of both the upper and middle members of the Paluxy aquifer have been prepared from the Phase II Stage 1 data. As with the upper zone maps, recent Paluxy data support earlier Hargis & Associates (1985) interpretations of the potentiometric surface and groundwater flow in the Paluxy. The additional Phase II Stage 1 wells have extended the areal coverage of these maps to the southwest portion of AF Plant 4. However, only data from wells screened in either the upper or middle Paluxy have been contoured; data from wells screened in more than one member of the Paluxy were gathered but not contoured.

Figure 4.1.2-2 illustrates the potentiometric contours and inferred direction of groundwater flow in the upper member of the Paluxy. The upper Paluxy is unconfined at AF Plant 4. Results of drilling in the southwestern corner of the AF Plant 4 property have shown that the upper Paluxy is dry. In general, the highest elevations (590 foot contour line) are to the north and, near Lake Worth, decreasing more than 30 feet to the south and east. The estimated hydraulic gradient in the upper Paluxy at the western portion of AF Plant 4 is approximately 0.03. A potentiometric surface high is evident at the East Parking lot, where the maximum elevation of greater than 570 feet, indicating a limited reversal in the regional southeast direction of groundwater flow. Thus at the East Parking Lot the hydraulic gradient is approximately 0.01 to the west and south. The extent or cause of this

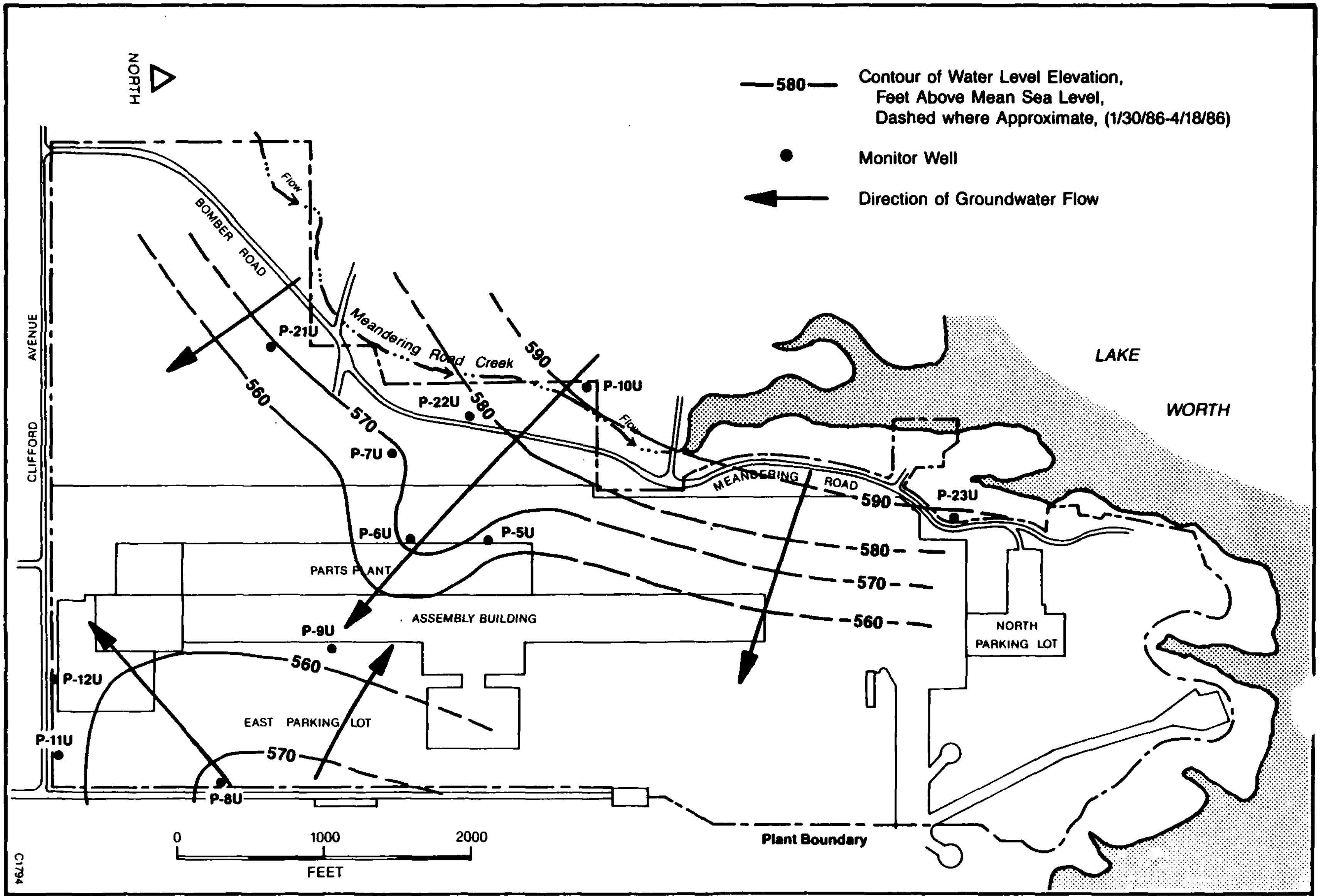

Figure 4.1.2-2. Potentiometric Surface Map of the Upper Paluxy Aquifer, AF Plant 4, Texas

potentiometric surface high is not presently understood, although earlier investigations (Hargis & Associates, 1985) suggested that the Goodland/Walnut aquitard may be locally absent, allowing direct hydraulic communication between the upper Paluxy and upper zone materials. This area was the subject of a field investigation by the U.S. Army Corps of Engineers at the time this report was written.

The water levels in P-10U and P-23U in the northern and western part of the study area are nearly equivalent in elevation to that of the spillway in Lake Worth (594 feet MSL). Thus, these water level data reflect the recharge from Lake Worth, which is directly underlain by sediments of the upper Paluxy. This conclusion was noted in previous investigations (Hargis & Associates, 1985); however, data are so sparse in the portion of AF Plant 4 bordering Lake Worth, that statements regarding recharge of the upper Paluxy from Lake Worth must be viewed as preliminary.

Figure 4.1.2-3 is a potentiometric surface map of the middle Paluxy aquifer. Although groundwater level data are limited to the southern and western portions of AF Plant 4, the pattern of the potentiometric surface contour lines is similar to that of the upper Paluxy, revealing a southeasterly direction of groundwater flow. Contour lines in the middle Paluxy are nearly uniformly spaced. Comparison of water level elevations in the upper and middle Paluxy shows a steeper hydraulic gradient in the upper Paluxy. The hydraulic gradient in the middle Paluxy is approximately 0.004 toward the southeast. Water levels in the middle Paluxy are lower than the levels in the upper Paluxy in the western portion of the site, indicating a downward vertical hydraulic gradient from the upper Paluxy to the lower Paluxy in this region.

Upper Zone Potentiometric Surface Maps

Descriptions in the following paragraphs of upper zone potentiometric surface maps prepared for AF Plant 4, are based primarily on

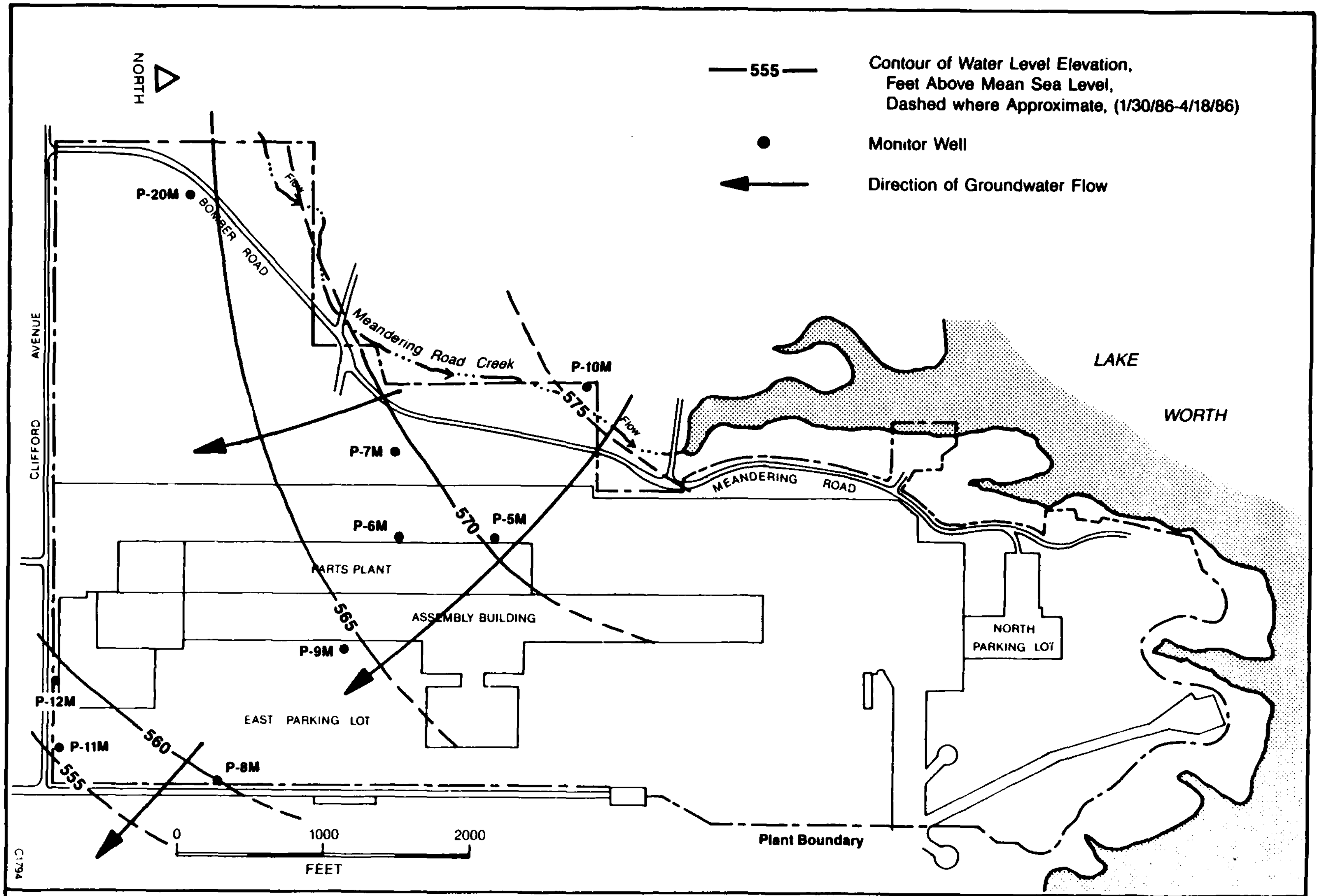

Figure 4.1.2-3. Potentiometric Surface Map of the Middle Paluxy Aquifer, AF Plant 4, Texas

the results of Phase II Stage 1 monitoring. Separate maps are presented for each area of the plant identified in Figure 3-1 and for the East Parking Lot Area.

Area 1 Upper Zone Potentiometric Surface Map

Water levels in the upper zone of Area 1, which covers the northern part of the site, were measured in August, 1986. Data are available from two widely separated areas: the Jet Engine Test Stand and Building 197 near the NARF area. Water level data have been contoured, as shown in Figure 4.1.2-4. The potentiometric contours suggest a groundwater divide resulting from a low north-south ridge separating the two areas. Groundwater flows west in the vicinity of the Jet Engine Test Stand and to the east and north at Building 197.

Little information is available to make definitive statements regarding the groundwater flow in this area, but based on limited evidence at from the Jet Engine Test Stand Building, the hydraulic gradient in the upper zone is approximately 0.016. Long-term predictions or statements regarding groundwater flow in this area would be speculative, since the upper zone is thin to absent across the area.

Area 2 Upper Zone Potentiometric Surface Map

The upper zone water level data shown in Figure 4.1.2-5 are based on measurements made in February 1986. These data reflect the complex subsurface conditions in Area 2. Review of available geologic logs shows that a large area of Fuel Saturation Area 2, extending southeast to the Solvent Lines and under the Assembly Building does not have alluvial materials of the upper zone (see hatchured area in Figure 4.1.2-5). Groundwater occurs in several wells completed in the consolidated bedrock, but these data have not been contoured with the upper zone water levels because of probable differences in flow phenomena and hydraulic gradients. At one location, HM-106, groundwater was

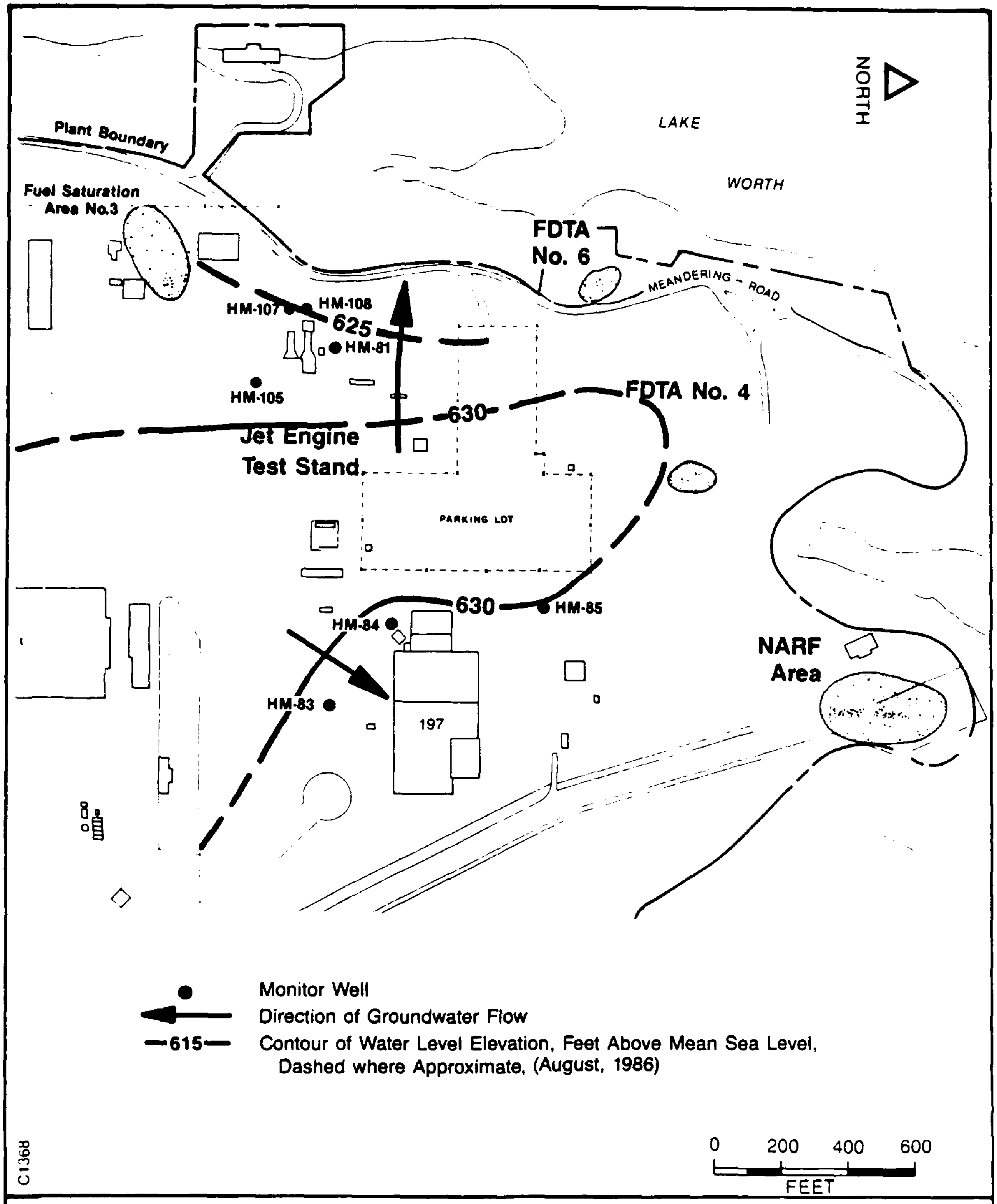

Figure 4.1.2-4. Potentiometric Surface Map of the Upper Zone in Area 1 (August, 1986), AF Plant 4, Texas

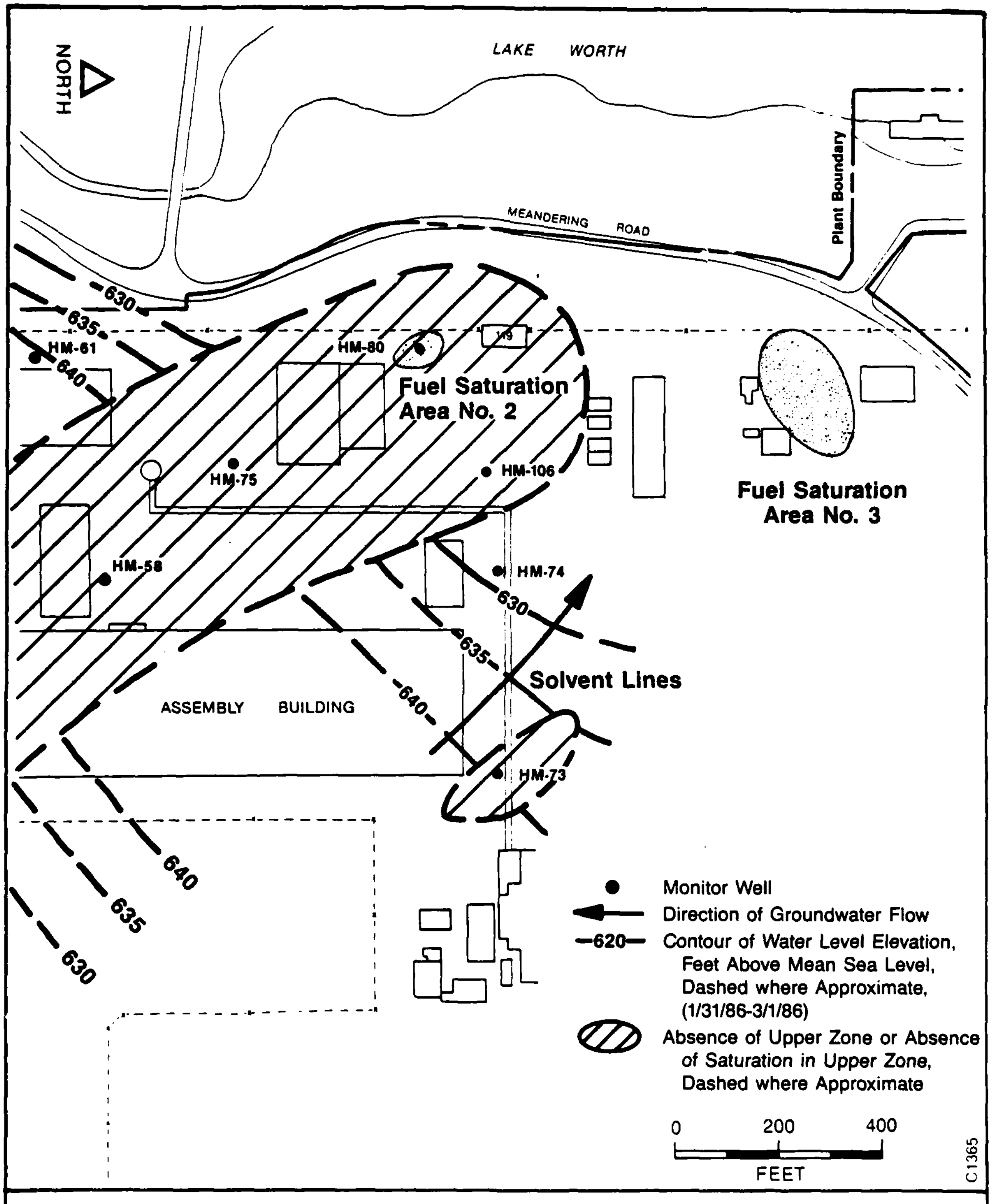

Figure 4.1.2-5. Potentiometric Surface Map of the Upper Zone in Area 2 (February, 1986), AF Plant 4, Texas

not present at the time of sampling. Where groundwater occurs in the upper zone, the elevation of the potentiometric surface generally decreases to the northwest, toward Lake Worth. At the Solvent Lines, the hydraulic gradient could be as high as 0.04 to the northwest; other areas have sparse control but probably have much lower gradients as well (based on projecting the hydraulic gradient calculated at the Solvent Lines to the northwest to Fuel Saturation Area 3).

Area 3 Upper Zone Potentiometric Surface Map

Figure 4.1.2-6 is a potentiometric surface contour map of the upper zone at Area 3. Most of the area is underlain by alluvium and fill of the upper zone. Groundwater elevations are highest in the southeast and northeast portions of the area, with a large east-central area of relatively constant groundwater elevations loosely defined by the 630 foot contour line. Closely spaced coutours have been drawn in the Landfill 3 area, corresponding to steeply sloping bedrock near Meandering Road Creek and probably buried bedrock channels near HM-38 and HM-19. The upper zone is absent in a few limited areas near FDTA 2, and in a larger area northeast of Building 15. Despite obvious variations in local groundwater flow patterns, most upper zone groundwater under Area 3 flows to the west and probably discharges to Meandering Road Creek. The Creek Seep at the southwest tip of Landfill 3 is an example of the surface discharge of groundwater in the area. Over much of the area, particularly in the vicinity of Landfill 1, hydraulic gradients are low, approximately 0.008. Much steeper hydraulic gradients are evident at HM-38 near the St-5 outfall and near FDTA 2.

Area 4 Upper Zone Potentiometric Surface Map

Water levels measured in February, 1986, at Area 4 illustrate a complex groundwater flow pattern controlled by bedrock topography (Figure 4.1.2-7). Much of the southern portion of the area is bedrock, providing a sharp groundwater flow boundary. For example, bedrock is either dry (SB-5 at FDTA 5 contained no water) or contains groundwater under different

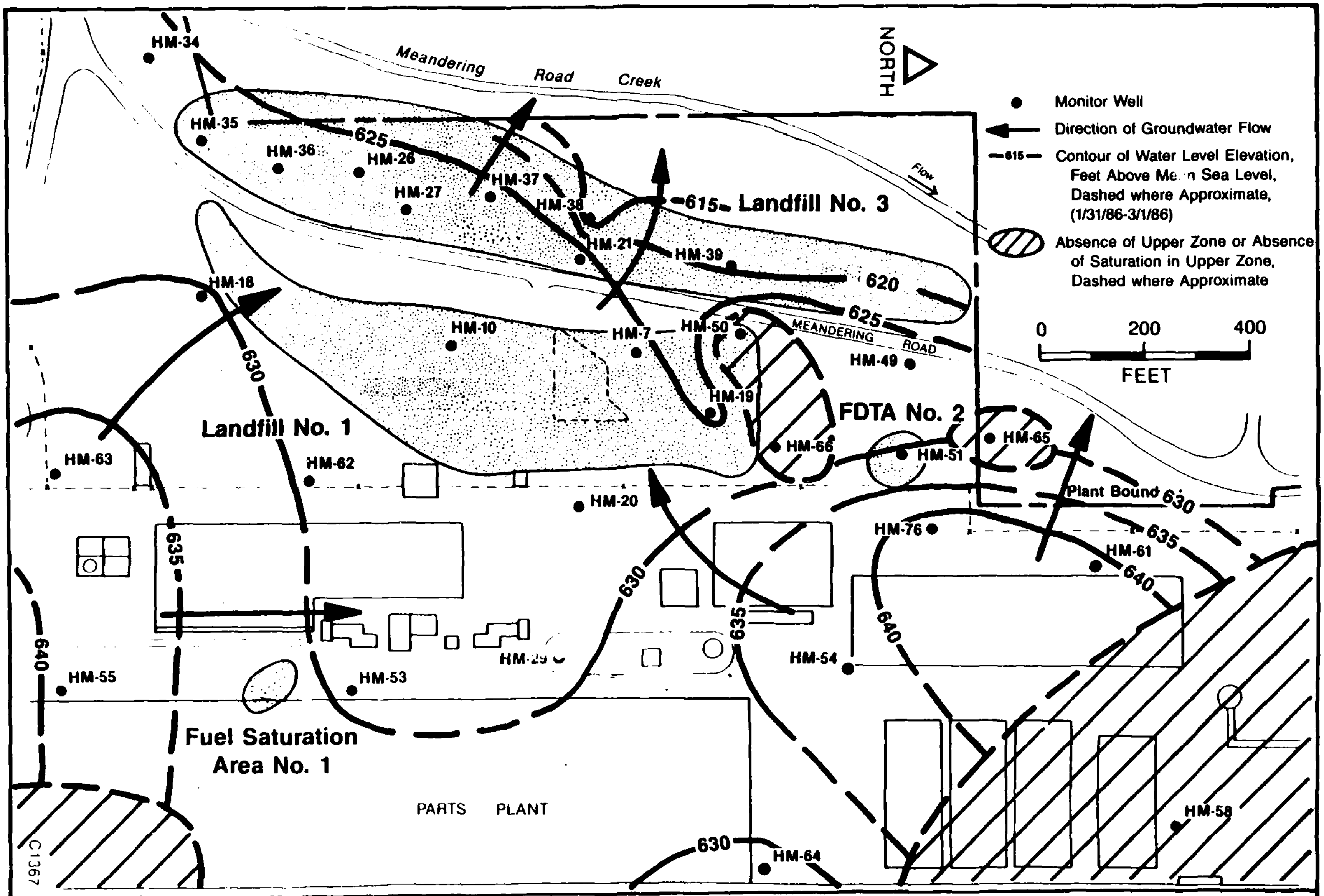

Figure 4.1.2-6. Potentiometric Surface Map of the Upper Zone in Area 3 (February, 1986), AF Plant 4, Texas

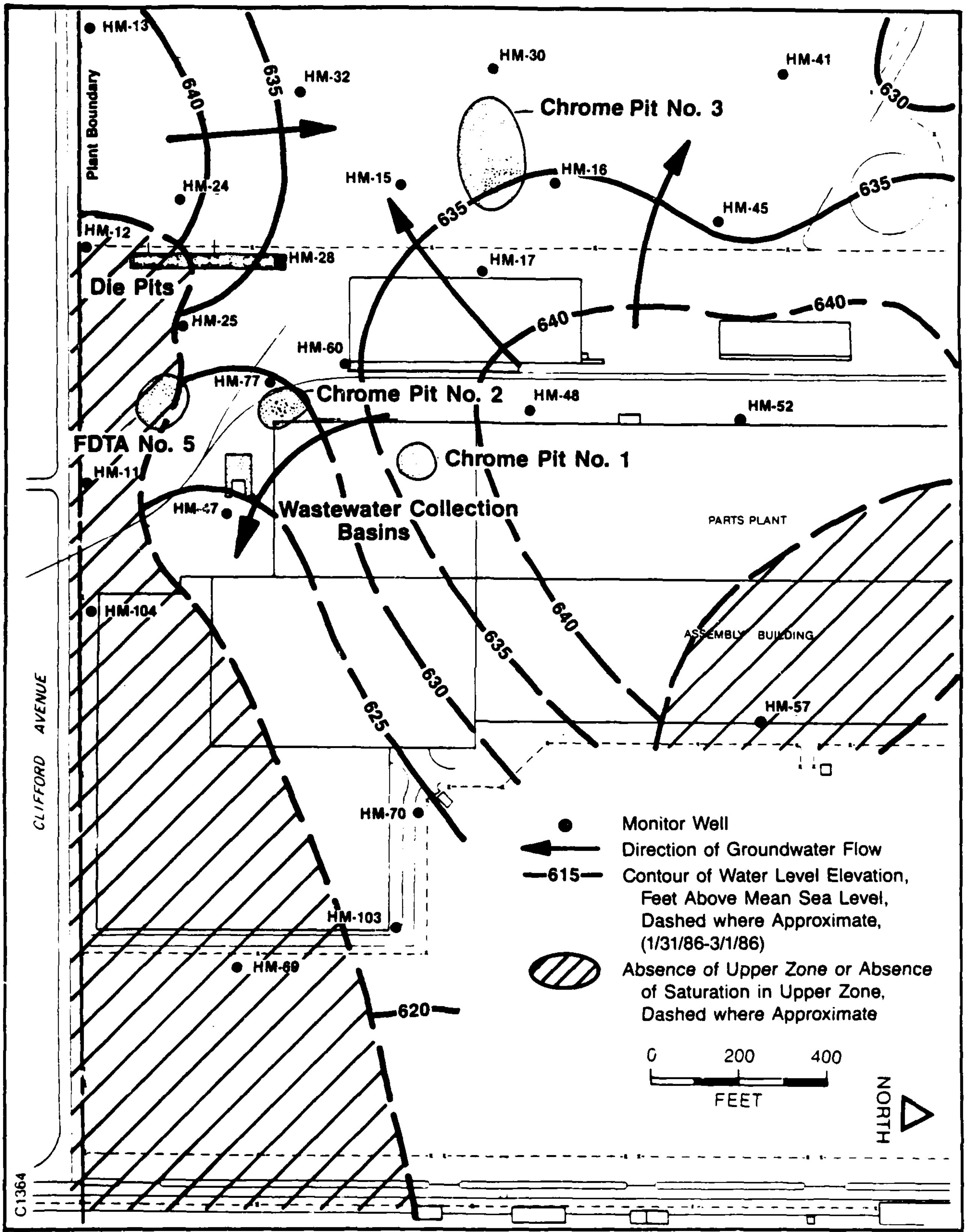

Figure 4.1.2-7. Potentiometric Surface Map of the Upper Zone in Area 4 (February, 1986) AF Plant 4, Texas

potentiometric conditions (comparison of water levels between HM-11 and HM-47). The western portion of the area is part of the Radar Range. Here groundwater elevations are highest at the Parts Plant and along Clifford Avenue. Thus groundwater elevations decrease to the west and north in the direction of groundwater flow. Toward the west, in the Radar Range, alluvial material is thick and potentiometric contour lines are widely spaced.

Groundwater elevations in the vicinity of FDTA 5 and Chrome Pit 1 begin to decrease to the east and south. Hargis & Associates (1985) reported the existence of a bedrock channel extending from this area eastward under the Warehouse Building and toward the East Parking Lot. Groundwater contour lines in the south part of the Assembly Building and Parts Plant appear to outline this channel, particularly the 625-foot contour line. Data for this area are sparse owing to the inaccessibility caused by the buildings. Groundwater flow in the East Parking Lot ultimately flows past Grants Lane to the east.

Area 5 Upper Zone Potentiometric Surface Map

Figure 4.1.2-8 illustrates the potentiometric surface of the upper zone in Area 5 during February 1986. Groundwater occurs at all locations in the area, but the upper zone occurs in the central and eastern portion of the area and along Meandering Road Creek. The Goodland Limestone and Walnut Formations crop out at the surface at HM-43, northward along Bomber Road, and at Landfill 4. East of this area alluvium of the upper zone reaches a thickness of nearly 50 feet.

Potentiometric contour lines at the Radar Range are widely spaced. Over most of the Radar Range the inferred direction of groundwater flow is to the northeast and north. However, precise groundwater flow directions are uncertain locally in the center of the Radar Range. The hydraulic gradient in the central part of the area is approximately 0.002 - 0.003 toward the north. Near FDTA 3, contours are closely spaced, illustrating a much steeper hydraulic gradient of approximately 0.05.

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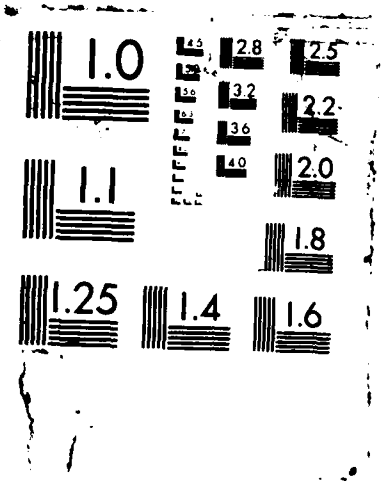
1.0
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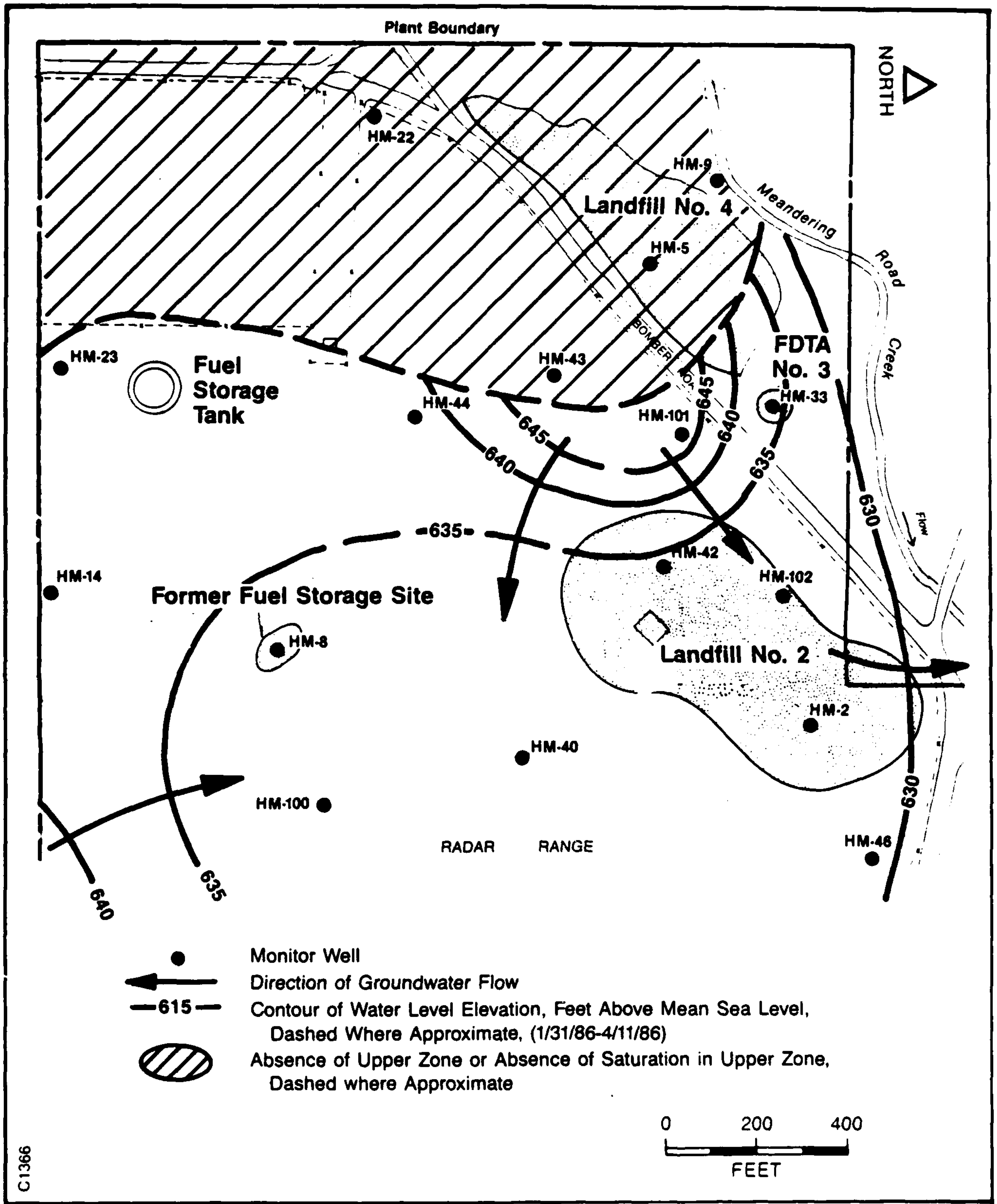

Figure 4.1.2-8. Potentiometric Surface Map of the Upper Zone in Area 5 (February-April, 1986) AF Plant 4, Texas

East Parking Lot Upper Zone Potentiometric Surface Map

Water level data collected in February 1986, for the East Parking Lot are shown in Figure 4.1.2-9. The southern portion of the parking lot and the area around the Warehouse Building were covered in the Area 4 discussion above. The potentiometric surface contour map shows decreasing elevations to the east, ranging from slightly greater than 630 feet MSL to less than 615 feet MSL along Grants Lane. Thus groundwater in the upper zone flows from the west to the east under a hydraulic gradient of approximately 0.002.

As discussed in earlier paragraphs, the upper zone and upper member of the Paluxy aquifer may be in contact where the Goodland/Walnut aquitards are believed to be absent. Water level data in the upper zone do not reveal the location or describe the characteristics of this phenomenon. The Corps of Engineers was engaged in a drilling and sampling program in the East Parking Lot as this report was being prepared.

4.2 Analytical Chemical Considerations

4.2.1 Regulatory and Human Health Criteria

To determine possible water quality effects on the local groundwater systems, concentrations of organic and inorganic compounds detected in groundwater samples were compared to various water criteria. These criteria, from federal drinking water regulations, standards, and guidelines, include Maximum Contaminant Levels (MCLs) and proposed Recommended Maximum Contaminant Levels (RMCLs) above zero (0), established by the EPA as part of national drinking water regulations. The RMCLs are non-enforceable health goals, set with an adequate margin of safety at levels that would result in no known or anticipated adverse health effects. The MCLs are enforceable standards set at levels as close to the RMCLs as feasible.

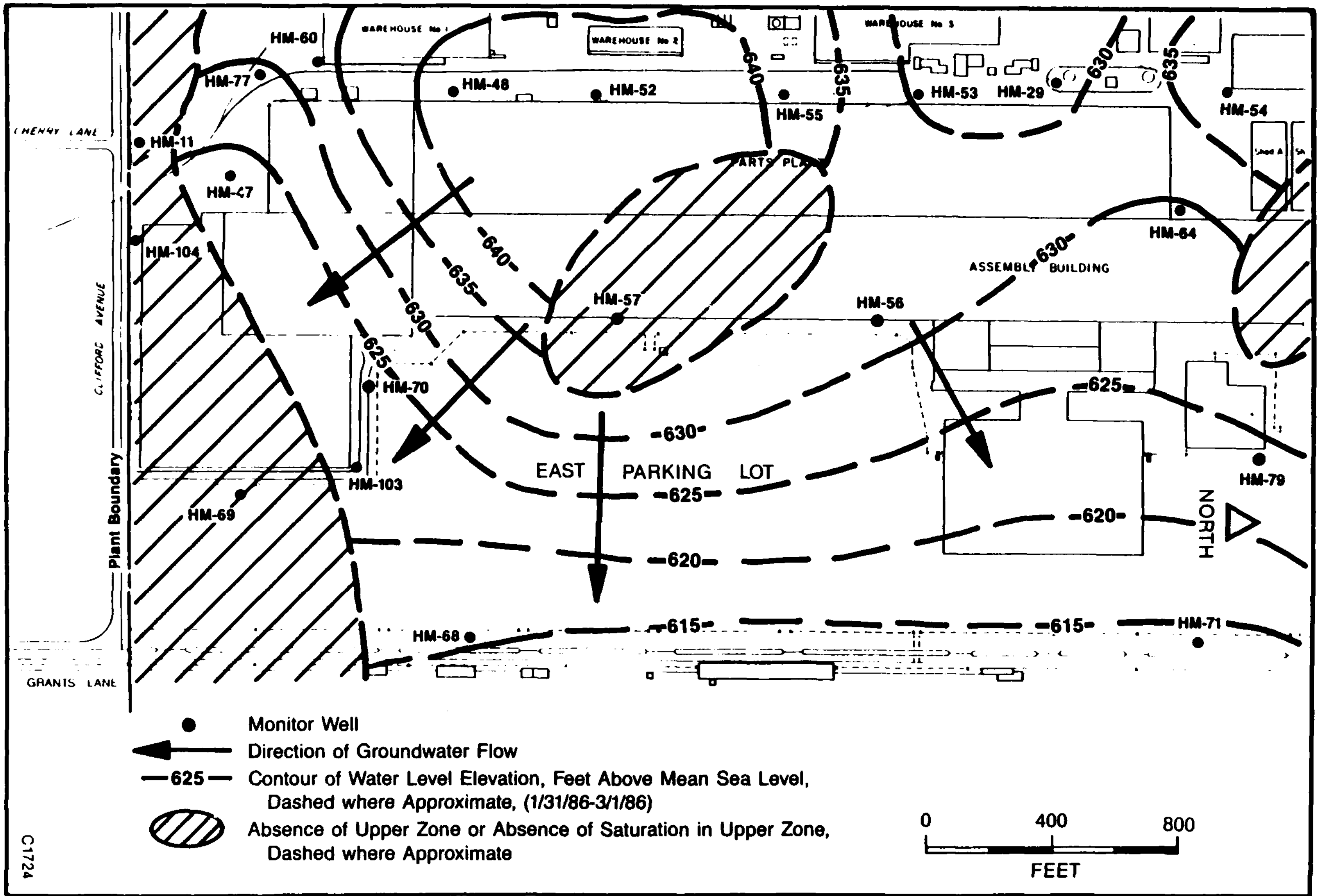

Figure 4.1.2-9. Potentiometric Surface Map of the Upper Zone in the East Parking Lot Area (February, 1986) AF Plant 4, Texas

Table 4.2.1-1 lists inorganic parameters detected and the corresponding federal primary drinking water standard (MCL). Table 4.2.1-2 lists EPA proposed MCLs, proposed RMCLs, and other criteria available for many of the organic compounds detected in groundwater analyses.

The body of literature concerning recommended or suggested guidelines is large and often contradictory. An attempt has been made to select criteria useful for the interpretation of IRP data. With the exception of the Safe Drinking Water Act standards (Table 4.2.1-1), the sole purpose of the criteria presented is to highlight contaminants of interest or of possible concern. Although these criteria do not now have the force of standards, they do provide a valid means for assessing the relative degree of contamination. For each site, parameters detected are compared to these standards and guidelines.

The status of the criteria for one parameter of potential concern, methylene chloride, is particularly ambiguous. The 1986 EPA Quality Criteria for Water recommend a value for "halomethanes" of 1.9 ug/L, corresponding to a 10^{-5} cancer risk. For methylene chloride, this level is substantially below what might be otherwise dismissed as inadvertent sample or laboratory contamination of no health or environmental significance. The State of California regulates methylene chloride at the substantially higher level of 40 ug/L. Although methylene chloride is a common industrial solvent, no RMCL exists for it. Methylene chloride exists at levels of potential concern at only one sampling site (well HM-38 at Landfill 3). In view of the ambiguity of the available documentation, methylene chloride is listed on the appropriate table in Section 4.3, but without an accompanying criterion.

Using human health criteria and standards is a stringent way to evaluate groundwater contamination at AF Plant 4. Since the shallow aquifer is not used as a drinking water supply source, contaminants in-situ will have

TABLE 4.2.1-1. REGULATORY STANDARDS FOR INORGANIC GROUNDWATER CONTAMINANTS

Parameter[1]	Maximum Contaminant Level (mg/L, except as noted)
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Selenium	0.01
Silver	0.05
Alpha radiation	15 pCi/L
Beta radiation	50 pCi/L
Gamma radiation	no standard[2]

[1] Primary Drinking Water MCLs; Regulatory Reference: 40 Code of Federal Regulations, Part 141.

[2] The Primary Drinking Water Regulations do not set a concentration standard for gamma radiation, but require analyses for specific elements and dose calculations if the beta radiation MCL is exceeded.

TABLE 4.2.1-2. GUIDELINES FOR ORGANIC COMPOUNDS DETECTED IN GROUNDWATER

Compound	Proposed MCLs[a] (ug/L)	Proposed RMCLs[b] (ug/L)	10^{-5} Cancer Risk (ug/L)	Toxicity (ug/L)
Vinyl Chloride	1			
Methylene Chloride - NO DATA				
Trichlorofluoromethane - NO DATA, NOT A PRIORITY POLLUTANT				
1,1-Dichloroethylene	7			
1,2-Dichloroethane	5			
trans-1,2-Dichloroethylene		70		
Chloroform	***[c]			
1,1,1-Trichloroethane	200			
Carbon tetrachloride	5			
Bromodichloromethane	***[c]			
1,2-Dichloropropane		6		
Trichloroethylene	5			
Bromoform	***[c]			
Tetrachloroethylene			8[f,g]	
Chlorobenzene		60		
Benzene	5			
Toluene		2000		
Ethyl Benzene		680		
1,3-Dichlorobenzene				400[e]
1,2-Dichlorobenzene		620		
1,4-Dichlorobenzene	750			
2,4-Dichlorophenol				3.09 mg/L[g]
2,4-Dimethylphenol				2120[g,i]
Phenol				3.5 mg/L[g]
Acenaphthene			****[d,g]	
Fluoranthene			****[d,g]	
Butyl benzyl phthalate				940[g,i]
bis[2-ethylhexyl]phthalate				15 mg/L[g]
di-n-butyl phthalate				35 mg/L[g]
Naphthalene				620[g,h]
Fluorene			****[d,g]	
Phenanthrene			****[d,g]	

(Continued)

TABLE 4.2.1-2. (Continued)

Compound	Proposed MCLs[a] (ug/L)	Proposed RMCLs[b] (ug/L)	10^{-5} Cancer Risk (ug/L)	Toxicity (ug/L)
N-nitrosodimethylamine			0.014[g]	
N-nitrosodiphenylamine			49[g]	
Isophorone			5.2 mg/L[g]	
Pyrene			****[d,g]	

[a] 50 Federal Register 46904, 13 November 1985.

[b] 50 Federal Register 47022, 13 November 1985.

[c] *** CFR 141.12 Primary Drinking Water MCL for all trihalomethanes, sum less than 100 ug/L.

[d] **** 28 ng/L. for all PNAs.

[e] EPA 440/5-80-039, Ambient Quality Criteria for Dichlorobenzenes.

[f] EPA 440/5-80-073, Ambient Quality Criteria for Tetrachloroethylene.

[g] EPA 440/5-86-001, Quality Criteria for Water 1986.

[h] Lowest Observed Effect Level - Chronic.

[i] Lowest Observed Effect Level - Acute.

no immediate human health consequences. Since these contaminants exit from the shallow groundwater system, however, they may encounter potential receptors. Where waters come to the land surface, either as seeps or as groundwater outflow to streams, the potential exists for exposure. Groundwater within the Paluxy Formation is used directly as a drinking water source. A formal assessment of the environmental and human health risks associated with the occurrence of contaminants is beyond the scope of this program; therefore, the use of human health standards and criteria is both reasonable and prudent.

No guidelines exist concerning the maximum allowable or recommended pollutant concentrations in soils for protection of human health and the environment. Table 4.2.1-3 lists the normal ranges of several heavy metal concentrations in soils. However, natural occurrences of metals can be far above or below the normal range, depending on local geologic conditions.

4.2.2 Quality Confirmation of Organic Chemical Data

As indicated in the Statement of Work (Appendix B), a second gas chromatographic column was needed to qualitatively verify the presence of many organic compounds in AF Plant 4 groundwater samples. The chemical analyses requiring second column confirmations are EPA Methods 601 (8010) and 602 (8020). All applicable organic chemical data were confirmed when quantitative results exceeded values specified by USAFOEHL. Table 4.2.2-1 shows these action limits for EPA 601 and 602 compounds.

The analytical methods noted above require a secondary chromatographic column to distinguish a particular compound from any interferences. The positive presence of a compound is reported when the retention times on both the primary and secondary gas chromatographic columns match standard values for that specific constituent. If the compound is not detected in the second column at the appropriate retention time, then the compound is not present or not detected.

TABLE 4.2.1-3. NORMAL RANGES OF HEAVY METAL CONCENTRATIONS FOUND IN SOILS

Metal	Normal Range (ppm)
Chromium	10-50
Lead	2-20
Arsenic	5-10
Selenium	0.2-0.6
Silver	0.04-0.1

Source: Rose, A.W., H.E. Hawkes, and J.S. Webb, 1979, Geochemistry in Mineral Exploration: Academic Press, New York, 675 p.

TABLE 4.2.2-1. ACTION LIMITS FOR SECOND COLUMN CONFIRMATION ON EPA 601 AND 602 ORGANIC COMPOUNDS

Compound	Concentration (ug/L)
Benzene	0.7
Carbon Tetrachloride	4.0
1,2-Dichloroethane	0.1
Methylene Chloride	4.0
Tetrachloroethylene	4.0
Trichloroethylene	1.0
Vinyl Chloride	1.0
Dichlorobenzene isomers	Sum greater than 10
All other organics	Greater than 10

Table 4.2.2-2 shows the method detection limits for EPA Methods 601 (volatile halocarbons by GC) and 624 (volatile organics by GC-MS). Table 4.2.2-3 shows method detection limits for EPA Method 602 (volatile aromatics by GC). Method detection limits for EPA Method 625 (acid and base/neutral extractables by GC-MS) are shown in Table 4.2.2-4.

TABLE 4.2.2-2. ANALYTES AND DETECTION LIMITS FOR METHODS 601, 8010, 624, AND 8240

Analyte	Detection Limits (ug/L)	
	Method 601 (8010)[a]	Method 624 (8240)[a]
Chloromethane	0.08	N/A
Bromomethane	1.2	N/A
Vinyl Chloride	0.18	N/A
Chloroethane	0.52	N/A
Methylene Chloride	0.25	2.8
Trichlorofluoromethane	0.4	N/A
1,1-Dichloroethylene	0.13	2.8
1,1-Dichloroethane	0.07	4.7
trans-1,2-Dichloroethylene	0.1	1.6
Chloroform	0.05	1.6
1,2-Dichloroethane	0.03	2.8
1,1,1-Trichloroethane	0.03	3.8
Carbon Tetrachloride	0.12	2.8
Bromodichloromethane	0.10	2.2
1,2-Dichloropropane	0.04	6.0
cis-1,3-Dichloropropylene	0.2	6.0
Trichloroethylene	0.12	1.9
Benzene	N/R	4.4
Dibromochloromethane	0.09	3.1
1,1,2-Trichloroethane	0.02	5.0
trans-1,3-Dichloropropylene	0.34	N/A
2-Chloroethyl vinyl ether	0.13	N/A
Bromoform	0.2	4.7
1,1,2,2-Tetrachloroethane	0.03	6.9
Tetrachloroethylene	0.03	4.1
Toluene	N/R	6.0
Chlorobenzene	0.25	6.0
Ethylbenzene	N/R	7.2
1,3-Dichlorobenzene	0.32	N/A
1,2-Dichlorobenzene	0.15	N/A
1,4-Dichlorobenzene	0.24	N/A

[a] Detection limits for Methods 8010 and 8240 are in ug/kg.

N/A = Not Available.

N/R = Not Required for Method.

TABLE 4.2.2-3. ANALYTES AND DETECTION LIMITS FOR METHODS 602 AND 8020

Analyte	Detection Limit (ug/L)[a]
Benzene	0.2
Toluene	0.2
Ethylbenzene	0.2
Chlorobenzene	0.2
1,4-Dichlorobenzene	0.3
1,2-Dichlorobenzene	0.4
1,3-Dichlorobenzene	0.4

[a] Detection limits for Method 8020 are in ug/kg.

TABLE 4.2.2-4. ANALYTES AND DETECTION LIMITS FOR METHODS 625 AND 8270

Analyte	Detection Limit (ug/L)[a]
ACIDS	
2,4,6-Trichlorophenol	2.7
4-Chloro-3-methylphenol	3.0
2-Chlorophenol	3.3
2,4-Dichlorophenol	2.7
2,4-Dimethylphenol	2.7
2-Nitrophenol	3.6
4-Nitrophenol	2.4
2,4-Dinitrophenol	42
2-Methyl-4,6-dinitrophenol	24
Pentachlorophenol	3.6
Phenol	1.5
BASE/NEUTRALS	
Acenaphthene	1.9
Benzidine	44
1,2,4-Trichlorobenzene	1.9
Hexachlorobenzene	1.9
Hexachloroethane	1.6
Bis(2-chloroethyl)ether	5.7
2-Chloronaphthalene	1.9
1,2-Dichlorobenzene	1.9
1,3-Dichlorobenzene	1.9
1,4-Dichlorobenzene	4.4
3,3'-Dichlorobenzidine	17
2,4-Dinitrotoluene	5.7
2,6-Dinitrotoluene	1.9
1,2-Diphenylhydrazine	N/A
Fluoranthene	2.2
4-Chlorophenyl phenyl ether	4.2
N-Nitrosodimethylamine	10
N-Nitrosodiphenylamine	1.9
N-Nitrosodi-n-propylamine	12
Bis(2-ethylhexyl)phthalate	2.5
Butyl benzyl phthalate	2.5
Di-n-butyl phthalate	2.5
Di-n-octyl phthalate	2.5
Diethyl phthalate	1.9
Dimethyl phthalate	1.6

(Continued)

TABLE 4.2.2-4. (Continued)

Analyte	Detection Limit (ug/L)[a]
BASE/NEUTRALS (Continued)	
Benzo(a)anthracene	7.8
Benzo(a)pyrene	2.5
Benzo(b)fluoranthene	4.8
Benzo(k)fluoranthene	2.5
Chrysene	2.5
Acenaphthylene	3.5
Anthracene	1.9
4-Bromophenyl phenyl ether	1.9
Bis(2-chloroisopropyl)ether	5.7
Bis(2-chloroethoxy)methane	5.3
Hexachlorobutadiene	0.9
Hexachlorocyclopentadiene	6.0
Isophorone	2.2
Naphthalene	1.6
Nitrobenzene	1.9
Benzo(ghi)perylene	4.1
Fluorene	1.9
Phenanthrene	5.4
Dibenzo(a,h)anthracene	2.5
Indeno(1,2,3-cd)pyrene	3.7
Pyrene	1.9

[a] Detection limits for Method 8270 are in ug/kg.

N/A = Not Available.

4.3 Discussion of Results and Significance of Findings

The following subsections discuss the results of the geophysical surveys, drilling, sampling and chemical analyses performed at AF Plant 4. Sites are discussed in the order in which they appear in the Delivery Order. Discussions of additional study topics from the delivery order follow the site discussions. Lithologic and well-completion logs for all wells and borings installed during this program are presented in Appendix E. Raw analytical data appear in Appendix A.

4.3.1 Site 1, Landfill 1

IRP Phase II Stage 1 work at Landfill 1 consisted of collecting and analyzing samples from existing wells and drains where data had been collected in previous investigations. These data revealed contamination in shallow groundwater at the landfill, which was partially excavated in 1983. Reportedly, the landfill had received mostly construction rubble, trash, and fill dirt. However, hazardous wastes such as solvents, thinners, and paints; contaminated oils and fuel; and chromate sludges and cyanide were disposed of in pits at the landfill and burned. The resulting sludges were dredged from the pits and deposited in the landfill. After the landfill was closed, a series of drainage pipes were installed to channel liquids to a stormwater outfall. The drainage system was later modified to route liquids to a sump. This drainage system is called French Drain No. 1. In 1983, the waste oil pits were excavated (from the land surface to bedrock) and 11,000 cubic yards of earth were removed. Following the excavation, a drain field (French Drain No. 2) was installed.

Figure 4.3.1-1 shows the locations of groundwater sampling points and the physical features of the site. The locations of Meandering Road Creek surface water samples are shown in Figure 4.3.1-2. Groundwater samples were collected and analyzed at HM-7, 10, 18, 20, 62, 63, P-4, P-7 Middle (P-7M), and P-7 Upper (P-7U). Monitor wells HM-18, 20, 62, and 63 are located hydraulically upgradient of the landfill. Monitor wells HM-19 and HM-50 are located within Landfill 1 but were sampled in association with FDTA 2, as required in

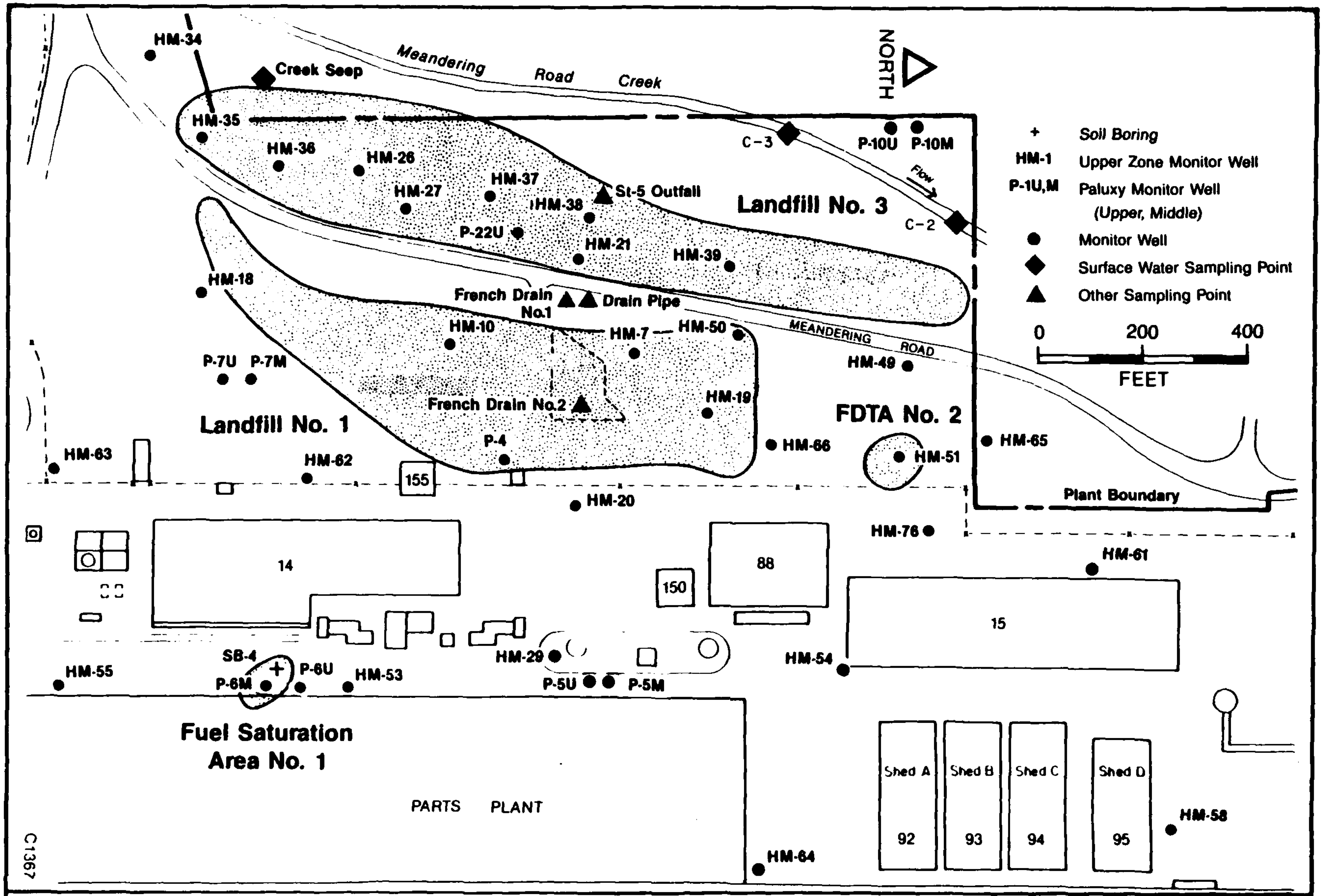

Figure 4.3.1-1. Phase II Activities at Site 1, Landfill 1, AF Plant 4, Texas

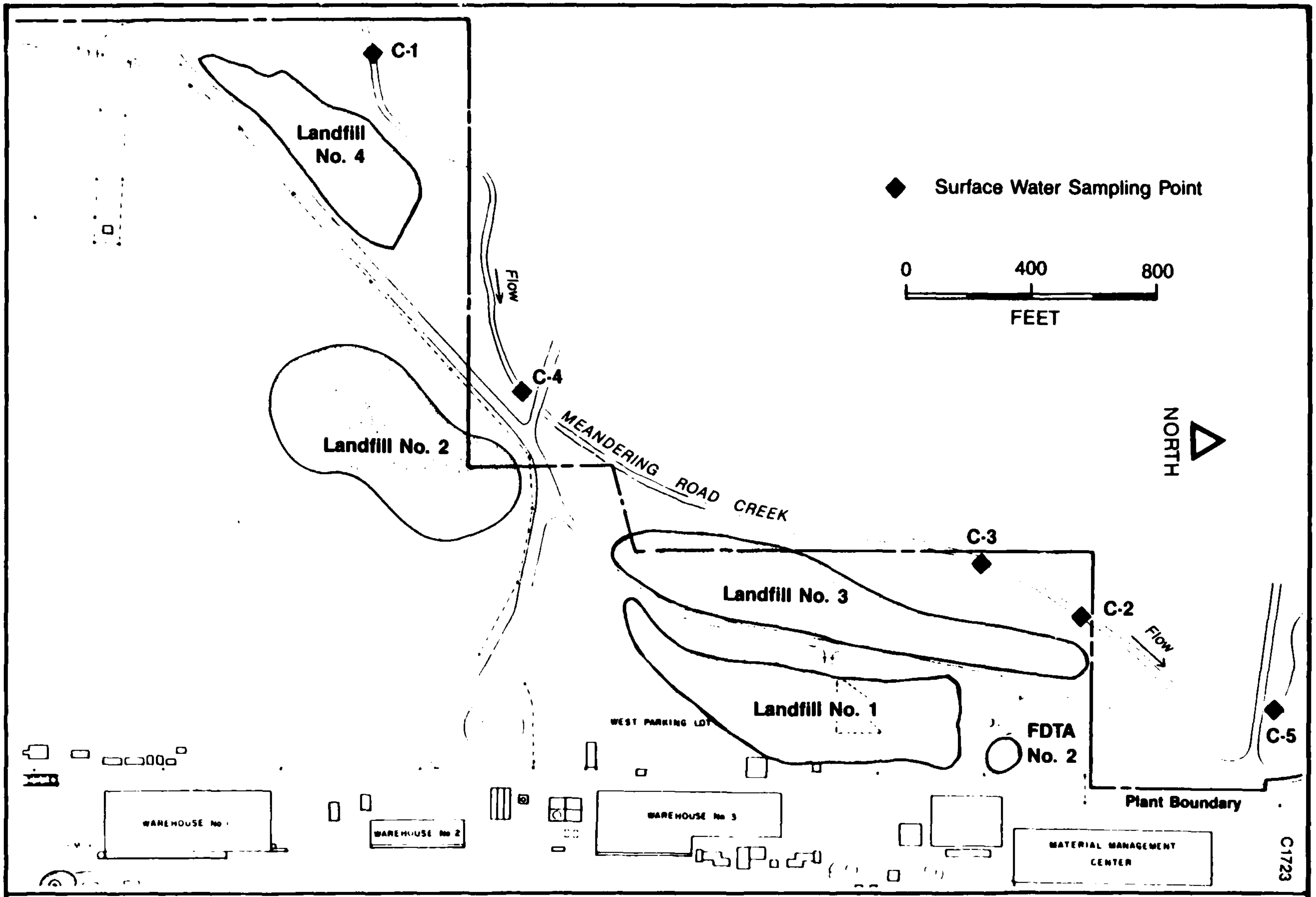

Figure 4.3.1-2. Surface Water Sampling Points, AF Plant 4, Texas

the statement of work. Surface water samples were collected and analyzed from Meandering Road Creek west of the landfill at the following locations: C-1, C-2, C-3, C-4, and C-5. The C-1 and C-4 locations are upstream of the landfill, while the other locations are downstream of the landfill and other disposal sites. Other water samples were collected and analyzed from French Drains 1 and 2, the drain pipe and the creek seep. St-5 outfall was dry at the time of sampling. Groundwater and surface water samples were analyzed for volatile organic compounds by EPA Methods 601 and 602, acid and base/neutral extractable compounds by EPA Method 625, and heavy metals by EPA Methods 200.7, 206.2, 239.2, 245.1, and 270.2.

4.3.1.1 Results of Investigation

The investigation conducted at Landfill 1 focused on the collection, analysis, and interpretation of groundwater quality samples. Results of these activities and descriptions of the topographic and geologic features of the site are discussed in the following paragraphs.

Topography

The land surface in the vicinity of Landfill 1 ranges from approximately 660 feet MSL at the southeast to 635 feet MSL on the west side of the landfill. The surface of the landfill is paved and used as an employee parking lot.

Geologic Features

Geologic information for Landfill 1 is available from the logs of borings of several monitor wells. In the Hargis and Associates (1985) report, definitions and logs of the formations were based on the following characteristics:

Alluvium: Unconsolidated poorly-sorted to well-sorted clay, silt, sand and gravel.

Goodland Limestone: Dense, thinly to massively bedded fossiliferous limestone interbedded with stiff clay and shale.

Walnut Formation: Indurated fossiliferous limestone and shell agglomerate with thin-bedded calcareous shale and clay. Black fissile shale encountered immediately above the shell agglomerate in several locations.

Paluxy Formation: Fine- to medium-grained, friable, white quartz sand interbedded with gray to blue-green silty clay and shale, and poorly cemented sandstone.

To make the lithologic logs from the previous investigation by Hargis and Associates comparable to those of this report, formation definitions have been based on the same characteristics.

The logs from Hargis and Associates (1985) and from this report (Appendix E) indicate that alluvial and terrace materials of the upper zone underlie the entire site. Thicknesses of these materials range from 13 feet at monitor well HM-7 to 33 feet at monitor well HM-62.

The Goodland Limestone was encountered only at HM-19, which recorded two feet of limestone. The Walnut Formation was present in all wells and ranged in thickness from two feet at HM-7 and HM-10 to 30 feet at P-4.

Of the four Paluxy wells located in the vicinity of Landfill 1, only P-4 fully penetrates the Paluxy Formation. At this well, the Paluxy Formation is approximately 170 feet thick. This description of geologic features at Landfill 1 is consistent with that of the Hargis and Associates (1985) report.

Occurrence of Groundwater

Groundwater at Landfill 1 occurs in both the materials of the upper zone and in the Paluxy Formation. Results of water level measurements are provided in Table 4.3.1-1. The water level map for the upper zone in this area of AF Plant 4 (Figure 4.1.2-6) was previously described in Section 4.1.2. Water levels in upper zone wells monitored for water quality at this site ranged from 639.96 feet MSL at HM-63 to 627.34 feet MSL at HM-7 during January-February 1986. Groundwater flow at Landfill 1 is generally to the west, toward Meandering Road Creek.

Water levels in the Paluxy (at P-4, P-7U, and P-7M) have been measured in the upper, middle, and lower members of the formation. Comparison of the water levels in the upper and middle members indicates that the direction of the hydraulic gradient is from the middle to the upper member. However, comparison of the higher water level measured in P-4 (which is screened through the entire thickness of the Paluxy, but representative of lower Paluxy water levels) to the P-7 levels suggests that the lower member of the Paluxy has the greatest hydraulic head, indicating that there is an overall upward vertical hydraulic gradient from the lower to the upper member of the Paluxy aquifer at this location. Groundwater flow in the Paluxy aquifer is to the southeast in the vicinity of AF Plant 4 (see Figures 4.1.2-2 and 4.1.2-3).

Results of an aquifer pumping test conducted at the P-7 wells indicate that the upper Paluxy is in hydraulic communication with the middle Paluxy in the vicinity of P-7 (Hargis & Associates, 1985).

Groundwater and Surface Water Quality

Groundwater samples were collected and analyzed from the following locations: HM-7, 10, 18, 20, 62, 63, P-4, P-7M, and P-7U. Surface water samples were collected from French Drains 1 and 2; the drain pipe; creek seep; and creek locations C-1, -2, -3, -4, and -5. Results of the water analyses and field measurements (pH, temperature, and conductivity) appear in Tables 4.3.1-2 and -3. Complete analytical reports for these analyses are shown in Appendix A.

TABLE 4.3.1-1. GROUNDWATER ELEVATIONS AT SITE 1, LANDFILL 1, AF PLANT 4, TEXAS (JANUARY THROUGH MARCH 1986)

Monitor Well	Elevation (feet MSL)	Date
HM-7	627.34	2-13-86
HM-10	628.93	2-7-86
HM-18	630.16	2-11-86
HM-20	628.68	1-31-86
HM-62	629.66	3-1-86
HM-63	639.96	2-7-86
P-4	570.15	1-30-86
P-7U	567.67	1-30-86
P-7M	568.27	1-30-86

TABLE 4.3.1-2. RESULTS OF GROUNDWATER SAMPLE ANALYSES, SITE 1, LANDFILL 1, AF PLANT 4, TEXAS

Date Sampled	Method Detection Limit	Monitor Well HM-7 2-13-86	HM-10 2-7-86	HM-18 2-11-86	HM-20 1-31-86	HM-62 3-1-86	HM-63 2-7-86	P-4 1-30-86	P-7M 1-30-86	P-7U 1-30-86
Field Parameters										
Temperature (°C)		15.5	21.5	20.5	22.0	21.0	19.2	22.0	22.0	19.0
pH		6.6	6.8	6.4	6.8	6.6	6.4	6.9	6.2	6.7
Conductivity (umhos)		1300	1900	450	1300	1200	900	900	680	840
Analytical Parameters[a]										
Metals (mg/L)										
Arsenic	0.002-0.005	0.038	ND	0.008*	ND	0.005*	0.075	ND	ND	ND
Barium	0.009	0.11	0.15	0.14	0.11	0.17	0.52	0.022	0.068	0.099
Cadmium	0.002	ND	ND@	0.002*	ND	ND	ND	ND	ND	ND
Chromium	0.005	0.02*	0.042	0.01*	0.14	0.069	0.031	0.01*	0.01*	.02*
Lead	0.001-0.002	0.006*	0.018	0.037@	ND	0.015	0.008*	ND	ND	0.016
Mercury	0.0002	ND	0.0002*	ND	ND	ND	ND	ND	ND	0.0003*
Selenium	0.002-0.004	ND@	ND	ND@	ND@	ND	ND	ND	ND	ND
Silver	0.002	0.004*	0.007*	ND	0.005*	0.013	0.015	0.011	0.014	0.017
Volatile Organics (ug/L)										
Method 601 (Halogenated Hydrocarbons)										
Concentration Factor		1	1	1	25	1	250	10	10	10
Vinyl Chloride	0.19	56	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	0.25	2.2	ND	ND	ND	ND	ND	ND	6.7	ND
Trichlorofluoromethane	0.4	ND	ND	ND	ND	ND	ND	ND	ND	0.64
1,1-Dichloroethylene	0.13	ND	ND	ND	ND	3.9	ND	ND	ND	ND
1,1-Dichloroethane	0.07	4.2	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethylene	0.10	11	ND**	ND	6.4	ND	ND**	ND**	3.2	ND
Chloroform	0.05	ND	ND	ND	ND	0.36	ND	ND	ND	ND
1,1,1-Trichloroethane	0.03	ND	ND	ND	240	17	ND	ND	ND	ND
Trichloroethylene	0.12	ND	37	ND	2300	8.0	4500	ND	ND	ND
1,2-Dichlorobenzene	0.15	17	ND	ND	ND	ND	ND	ND	ND	ND
Method 602 (Aromatic Compounds)										
Concentration Factor		1	1	1	1	1	25	1	1	1
Benzene	0.2	61	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	0.2	71	ND	0.59	ND	ND	ND	ND	ND	ND
Ethyl Benzene	0.2	590	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	0.3	44	ND	ND	ND	ND	ND	ND	ND	ND

(Continued)

TABLE 4.3.1-2. (Continued)

		Monitor Well								
Date Sampled	Method Detection Limit	HM-7 2-13-86	HM-10 2-7-86	HM-18 2-11-86	HM-20 1-31-86	HM-62 3-1-86	HM-63 2-7-86	P-4 1-30-86	P-7M 1-30-86	P-7U 1-30-86
Extractable Organics (ug/L)										
Method 625 Acid Concentration Factor		1	1	1	1	1	1	1	1	1
2,4-Dimethylphenol	2.7	68	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	1.5	2	ND	ND	11	ND	ND	ND	ND	ND
Method 625 Base/Neutral Concentration Factor		1	1	1	1	1	1	1	1	1
Acenaphthene	1.9	2	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	1.9	23	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	4.4	ND	ND	ND	ND	ND	ND	ND	ND	ND
bis(2-ethylhexyl) phthalate	2.5	3BL	ND	ND	25	ND	ND	ND	ND	ND
di-n-butyl phthalate	2.5	ND	4	ND	ND	ND	ND	ND	3	ND
Naphthalene	1.6	16	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected.
* = Value less than five times detection limit.
Errors may range up to 100 percent.
@ = Spike recovery not within acceptable limits.
Indicates interferent.
BL = Detected in reagent blank; background subtraction not performed.
** = Compound not confirmed by second-column analysis.
\- = Data not collected.
a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor.
Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.

TABLE 4.3.1-3. RESULTS OF SURFACE WATER SAMPLE ANALYSES, SITE 1, LANDFILL 1, AF PLANT 4, TEXAS

		Monitor Well								
Date Sampled	Method Detection Limit	C-1 1-29-86	C-2 1-29-86	C-3 1-30-86	C-4 1-30-86	C-5 1-29-86	FRDRN#1 2-12-86	FRDRN#2 2-12-86	CRSEEP 1-30-86	DRNPIPE 2-12-86
Field Parameters										
Temperature (°C)		12.0	12.0	9.0	19.0	19.0	-	21.0	15.0	-
pH		8.7	8.1	7.7	8.2	8.2	-	6.8	7.6	-
Conductivity (umhos)		920	1100	620	790	700	-	1400	820	-
Analytical Parameters[a]										
Metals (mg/L)										
Arsenic	0.002-0.005	ND	ND	ND	ND	ND	ND	ND	ND	0.007*
Barium	0.009	0.053	0.059	0.065	0.035	0.052	0.068	0.46	0.038	0.062
Cadmium	0.002	ND	0.003*●	ND	ND	ND	ND●	ND	ND	ND
Chromium	0.005	ND	0.02*	0.01*	ND	ND	0.006*	ND	0.067	0.008*
Lead	0.001-0.002	ND	ND	ND	ND	ND	ND	ND●	ND	ND●
Mercury	0.0002	ND	ND	ND	ND	0.0003*	ND	ND	ND●	ND
Selenium	0.002-0.004	ND	ND	ND	ND	ND	ND	ND●	ND	ND●
Silver	0.002	0.012	0.013	0.015	0.004*	0.008*	ND	ND	0.013	ND
Volatile Organics (ug/L)										
Method 601 (Halogenated Hydrocarbons)										
Concentration Factor		10	10	10	10	10	1000	100	10	1000
Vinyl Chloride	0.18	ND	ND	ND	ND	ND	1200	33	ND	970
trans-1,2-Dichloroethylene	0.1	ND	7.1	5.8	ND	ND	ND**	ND**	ND**	ND**
1,1,1-Trichloroethane	0.03	ND	ND	ND	ND	ND	ND	63	ND	ND
Trichloroethylene	0.12	ND	ND	ND	ND	ND	6700	2300	20	2300
Tetrachloroethylene	0.03	ND	ND	ND	ND	ND	ND	ND	ND	150
Method 602 (Aromatic Compounds)										
Concentration Factor		1	1	1	1	1	1000	50	1	1000
Toluene	0.2	ND	ND	ND	ND	ND	ND	ND	ND	900
Extractable Organics (ug/L)										
Method 625 Acid										
Concentration Factor		1	1	1	1	1	1	1	1	1
2,4-Dichlorophenol	2.7	ND	ND	ND	ND	ND	3	ND	ND	4
Phenol	1.5	2	2	3	ND	ND	2	2	ND	2

(Continued)

TABLE 4.3.1-3. (Continued)

	Method	Monitor Well								
Date Sampled	Detection Limit	C-1 1-29-86	C-2 1-29-86	C-3 1-30-86	C-4 1-30-86	C-5 1-29-86	FRDRN#1 2-12-86	FRDRN#2 2-12-86	CRSEEP 1-30-86	DRNPIPE 2-12-86
Method 625 Base/Neutral Concentration Factor		1	1	1	1	1	1	1	1	1
1,2-Dichlorobenzene	1.9	ND	ND	ND	ND	ND	220	ND	ND	240
1,4-Dichlorobenzene	4.4	ND	ND	ND	ND	ND	40	ND	ND	35
Bis(2-ethylhexyl) phthalate	2.5	5	ND	4	ND	5	17	ND	ND	4
Di-n-butyl phthalate	2.5	4	3.2	ND	ND	ND	6BL	6BL	ND	4BL
Naphthalene	1.6	ND	ND	ND	ND	ND	9	ND	ND	16
Pyrene	1.9	ND	ND	ND	ND	ND	ND	ND	ND	2
Fluoranthene	2.2	ND	ND	ND	ND	ND	ND	ND	ND	2

ND = Not detected.
* = Value less than five times detection limit.
Errors may range up to 100 percent.
@ = Spike recovery not within acceptable limits.
Indicates interferent.
BL = Detected in reagent blank; background subtraction not performed.
** = Compound not confirmed by second-column analysis.
\- = Data not collected, measurement omitted in field (FRNDRN #1) and deleted to prevent fouling of instrument (DRNPIPE).
a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor.
Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.

To evaluate the degree of groundwater contamination, analytical results from IRP Phase II Stage 1 sampling were compared to federal standards and guidelines. Tables 4.3.1-4 and -5 summarize of these comparisons.

4.3.1.2 Significance of Findings

This section discusses the significance of the investigations's findings, emphasizing the groundwater chemistry at the site. Hargis & Associates (1985) have previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates previous findings and trends identified by the Hargis report.

Significance of Metals in Groundwater and Surface Water

Surface water at sites associated with Landfill 1 and groundwater in the upper zone contained concentrations of heavy metals generally below federal MCLs. The exceptions are chromium, which was detected at levels exceeding the MCL of 0.05 mg/L at three locations, and arsenic, which was detected at levels exceeding the federal MCL of 0.05 mg/L at one location. The discovery of chromium in concentrations greater than the MCL is not surprising because of the known disposal of chromium-bearing sludges and wastes at the landfill. The concentration of chromium was 0.069 mg/L at HM-62, 0.14 mg/L at HM-20 and 0.067 mg/L in the creek seep.

Previous groundwater analyses have identified chromium in excess of MCL levels in HM-20. Similarly, arsenic, cadmium, and lead were detected in well HM-62 in excess of MCL levels. These earlier findings were not duplicated during the January-February 1986 sampling and analysis of groundwater.

TABLE 4.3.1-4. COMPARISON OF GROUNDWATER QUALITY AT SITE 1, LANDFILL 1, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location				
		HM-7	HM-10	HM-20	HM-62	HM-63
METALS (mg/L)						
Arsenic	0.05					0.075
Chromium	0.05			0.14	0.069	
ORGANIC COMPOUNDS (ug/L)						
Vinyl Chloride	1	56				
1,1,1-Trichloroethane	200			240		
Trichloroethylene	5		37	2300	8	4500
Benzene	5	61				
Acenaphthene	0.028	2				

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

TABLE 4.3.1-5. COMPARISON OF SURFACE WATER QUALITY AT SITE 1, LANDFILL 1, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location			
		FRDRN#1	FRDRN#2	CRSEEP	DRNPIPE
METALS (mg/L)					
Chromium	0.05			0.067	
ORGANIC COMPOUNDS (ug/L)					
Vinyl Chloride	1	1200	33		970
Trichloroethylene	5	6700	2300	20	2300
Tetrachloroethylene	8				150
Fluoranthene	0.028				2

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

Significance of Organic Compounds in Groundwater and Surface Water

Synthetic organic compounds were detected predominantly in upper zone ground water and in water draining from the landfill. Other minor occurrences of these compounds were noted in the Paluxy aquifer and in Meandering Road Creek. These findings are generally consistent with the results of earlier sampling and analysis conducted by Hargis & Associates.

Based on results from the HM-series wells, groundwater in the upper zone contains the highest concentrations of organic contaminants. Monitor well HM-7 displays concentrations of vinyl chloride (56 ug/L), and benzene (61 ug/L) in excess of MCL levels. Trichloroethylene (TCE) was detected in four of six upper zone wells, with the highest readings from HM-20 (2300 ug/L) and HM-63 (4500 ug/L). Water sampled from HM-18 appears to be the least affected by contamination; the only organic compound detected was toluene, at a concentration of 0.6 ug/L.

Water sampled from the French drains and the drainpipe showed the highest concentrations of organic compounds of any sampling point at Landfill 1. In particular, vinyl chloride (33 - 1200 ug/L) and TCE (2300 - 6700 ug/L) were detected at these three locations. Also, an unknown (non-method) compound eluting on both columns at retention times near that of trans-1,2-dichloroethylene was discovered. Several other contaminants, including toluene, tetrachloroethylene, and 1,1,1-trichloroethane were detected in these samples. Water sampled at these locations probably represents a mixture of landfill liquids and groundwater because of the high observed concentrations of organic compounds and the origin of the water from the drainfield under the landfill area.

Groundwater samples collected from three Paluxy aquifer wells revealed several organic compounds in the water. The sample from P-4, which is closest to the landfill and screened over multiple zones in the Paluxy, showed

328 ug/L of an unknown (non-method) compound eluting on both columns at retention times near that of trans-1,2-dichloroethylene. However, this was the only contaminant detected. In the other Paluxy wells, P-7U and P-7M, several contaminants were revealed but in very low concentrations that did not exceed federal criteria. Trans-1,2-dichloroethylene, undetected in the upper member of the Paluxy, was detected at a concentration of 3.2 ug/L in the lower member of the Paluxy.

Surface water samples collected from five locations along Meandering Road Creek had concentrations of metals below federal MCL levels and concentrations of organic compounds generally below the limits of detection. The upstream locations, C-1 and C-4, showed virtually no levels of contamination in the creek water. Samples sites C-2 and C-3, the closest locations to Landfill 1, showed very low levels of contaminants. At these locations, it is possible that a variety of disposal sites, specifically Landfill 3 and FDTA 2, could contribute contaminants to the surface water.

4.3.2 Site 3, Landfill 3

From about 1942 to 1945, Landfill 3 was used for disposal of miscellaneous wastes, including mixed oils and solvents. One pit (and possibly more) present in this area during the 1940s was used for holding and burning some of the liquid wastes. It is suspected that other wastes were disposed of on the ground and then buried. There was no apparent activity at this site from the late 1940s until 1966, when fill dirt and construction rubble were used to finish the filling and grading of the site.

The IRP Phase II Stage 1 activities at Landfill 3 consisted of performing a terrain conductivity survey, installing a Paluxy aquifer monitor well (P-22U), and collecting and analyzing groundwater samples. Upper zone monitor wells at this site include HM-21, 26, 27, 34, 35, 36, 37, 38, and 39. Paluxy well P-22U was also sampled. Figure 4.3.2-1 shows the locations of these sampling points. Samples were collected and analyzed for volatile organic compounds by EPA Methods 601 and 602, acid and base/neutral extractable compounds by EPA Method 625, and heavy metals by EPA Methods 200.7, 206.2, 239.2, 245.1, and 270.2.

4.3.2.1 Results of Investigation

The investigation at Landfill 3 focused on the performance of the terrain conductivity survey, the construction of the Paluxy monitor well, P-22U, and the collection and analysis of groundwater samples. Discussions of these activities and descriptions of the topography and geologic features of the site follow.

Topography

The land surface at Landfill 3 is generally flat, with elevations ranging from approximately 638 feet MSL to 630 feet MSL. The area is bounded on the east by Meandering Road and on the west by the slope break at Meandering

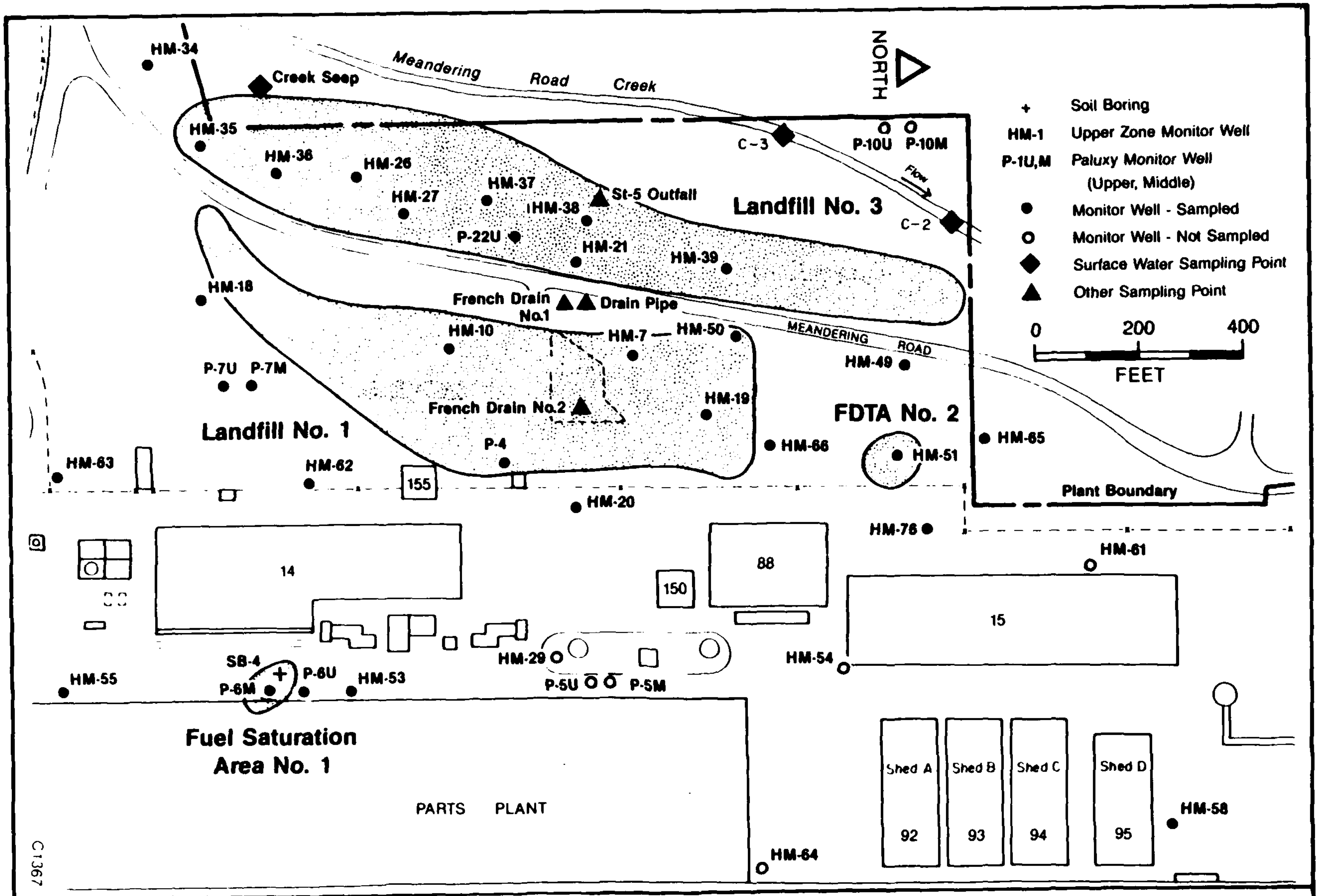

Figure 4.3.2-1. Phase II Activities at Site 3, Landfill 3, AF Plant 4, Texas

Road Creek. Construction rubble is visible in the steep slopes above the creek. The level of Meandering Road Creek is approximately 600 feet MSL in the area of Landfill 3. The landfill area itself is landscaped with grass and is sometimes used for parking overflow from the General Dynamics employee lots east of Meandering Road.

Geologic Features

Lithologic logs of nine upper zone wells (Hargis and Associates, 1985) and one Paluxy monitor well (Appendix E, this report) provide information on the subsurface features at Landfill 3.

The upper zone is relatively thin at this site, ranging in thickness from three feet at P-22U to 20 feet at HM-38. The Goodland Limestone was absent at all wells drilled in Landfill 3.

The Walnut Formation, composed of shell agglomerate and calcareous shale and clay, crops out along Meandering Road Creek just west of Landfill 3 and was encountered at all wells drilled at this site. The formation was fully penetrated only at P-22U, where it is 25 feet thick.

The upper member of the Paluxy Sand was fully penetrated during the construction of monitor well P-22U, where it is 26 feet thick.

Occurrence of Groundwater

At Landfill 3, groundwater occurs in both the materials of the upper zone and the Paluxy Formation. Table 4.3.2-1 gives results of water level measurements. The water level map for the upper zone in this area of AF Plant 4 (Figure 4.1.2-6) was described previously in Section 4.1.2. Water levels in the upper zone at this site ranged from 628.91 MSL at HM-34 at the south end of the landfill to 611.35 MSL at HM-38 in the west-central portion of the landfill. As shown in Figure 4.1.2-6, groundwater flow in the upper zone is

TABLE 4.3.2-1. GROUNDWATER ELEVATIONS AT SITE 3, LANDFILL 3, AF PLANT 4, TEXAS (JANUARY THROUGH FEBRUARY 1986)

Monitor Well	Elevation (feet MSL)	Date
HM-21	627.71	2-7-86
HM-26	627.39	1-31-86
HM-27	627.83	1-31-86
HM-34	628.91	2-27-86
HM-35	628.29	2-27-86
HM-36	627.74	2-27-86
HM-37	627.56	1-31-86
HM-38	611.35	2-21-86
HM-39	618.58	2-27-86
P-22 U	575.94	4-10-86

to the west, toward Meandering Road Creek. In some areas where upper zone deposits overlie the Walnut Formation, groundwater seeps from the upper zone have been observed. Quoting from Hargis & Associates (1985):

> Water level elevation contours in the upper zone beneath the West Parking Lot and west of Bomber Road suggest that groundwater from the upper zone discharges in the vicinity of wells HM-34, HM-35, and the St. 5 outfall...Field inspections of the Walnut Formation outcrops between well HM-9 and Lake Worth have confirmed the presence of other groundwater seeps west of HM-36 along Meandering Road Creek. In this area, Meandering Road Creek has cut approximately 15 to 20 feet into the Walnut Formation. The west bank of the creek is a steep cliff with limestone ledges, where underlying shale interbeds have been eroded. A depression in the top of the Walnut Formation occurs along the west bank in the area of the seeps. At the top of the west bank, upper zone deposits overlie the Walnut Formation. Groundwater apparently seeps from the upper zone deposits in the depression and trickles over the limestone ledges...Although groundwater discharge from the upper zone has not been observed elsewhere along the creek adjacent to the Plant, lithologic data from well HM-38 suggests that a buried subsurface tributary channel to the creek may occur in the vicinity of the St. 5 outfall. The tributary is buried by fill material and is a potential pathway for migration of upper zone groundwater.

Water levels in the upper Paluxy at AF Plant 4 are shown in Figure 4.1.2-2.

Terrain Conductivity Survey

A terrain conductivity survey using electromagnetic profiling was performed in November 1985. A grid was established, as described in Section 3.1.1, measuring approximately 2100 feet (north-south) by 250 feet (east-west). Electromagnetic profile readings were taken at 30 foot intervals on the grid.

Figure 4.3.2-2 illustrates the area of the survey. Survey results are presented in Appendix I. Ranges of conductivity in the area were generally 30 millimhos/meter to 45 millimhos/meter. Anomalous readings could be

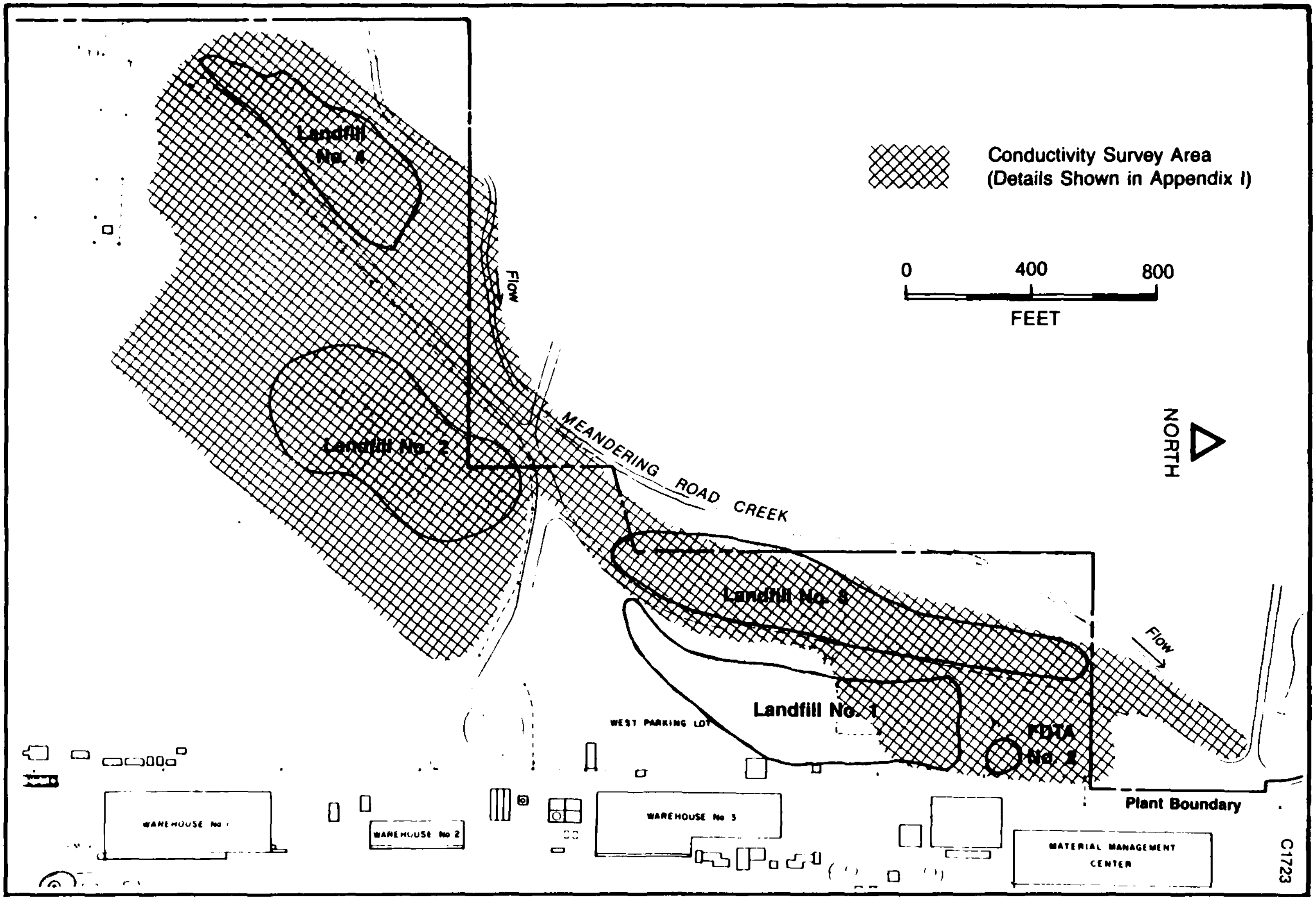

Figure 4.3.2-2. Location of Geophysical Survey, Site 3, Landfill 3, AF Plant 4, Texas

attributed to a number of sources, such as buried metal, variable thicknesses of fill material, or shallow contamination in water or soil.

The results of the terrain conductivity survey indicate a random pattern of anomalies that may be due to relict disposal features at Landfill 3. The recorded conductivity values for this area reflect no major conductivity trends; however, large anomalous areas may suggest moderate amounts of fill and high contamination, which has been documented in the drilling and groundwater sampling and analysis program. In addition, there are smaller areas interpreted to reflect high amounts of metal, moderate amounts of fill, and moderate amounts of fill with low contamination.

Groundwater Quality

Groundwater samples were collected and analyzed from the following locations: HM-21, 26, 27, 34, 35, 36, 37, 38, 39, and P-22U. All samples were analyzed for volatile organic compounds by EPA Methods 601 and 602, acid and base/neutral extractable compounds by EPA Method 625, and heavy metals by EPA Method 200.7, 206.2, 239.2, 245.1, and 270.2. Results of the groundwater analyses and field measurements (pH, temperature, and conductivity) are provided in Table 4.3.2-2. Complete analytical reports for these analyses appear in Appendix A.

To evaluate the degree of groundwater contamination, analytical results from IRP Phase II Stage 1 Sampling were compared to federal standards and guidelines. Table 4.3.2-3 provides a summary of this comparison.

4.3.2.2 Significance of Findings

This section discusses the significance of the findings of the investigation, emphasizing the groundwater chemistry at the site. Hargis & Associates (1985) have previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report

TABLE 4.3.2-2. RESULTS OF GROUNDWATER SAMPLE ANALYSES, SITE 3, LANDFILL 3, AF PLANT 4, TEXAS

	Method Detection Limit	Monitor Well										
		HM-21	HM-26	HM-27	HM-34	HM-34D	HM-35	HM-36	HM-37	HM-38	HM-39	P-22U
Date Sampled		2-7-86	1-31-86	1-31-86	2-27-86	2-27-86	2-27-86	2-27-86	1-31-86	2-21-86	2-27-86	4-10-86
Field Parameters												
Temperature (°C)		14.0	17.0	19.0	-	-	18.5	-	18.0	-	-	20.0
pH		6.8	6.6	7.0	-	-	6.7	-	6.7	-	-	6.6
Conductivity (umhos)		2000	2100	260	-	-	1000	-	2600	-	-	980
Analytical Parameters[a]												
Metals (mg/L)												
Arsenic	0.002-0.005	ND	ND	ND	0.040	0.062	0.006*	0.005*	ND	NA	0.13	0.008*
Barium	0.009	0.10	0.023	0.12	0.45	0.73	0.090	0.071	0.053	NA	0.77	0.093
Cadmium	0.002	ND	ND	0.003*	ND	ND	ND	ND	0.003*●	NA	0.003*	0.003*●
Chromium	0.005	0.007*	0.02*	0.13	0.053	0.088	0.065	0.055	0.02*	NA	0.14	0.015
Lead	0.001-0.002	0.004*	ND	0.009	0.022	0.024	0.030	0.010	ND●	NA	0.25●	0.036
Mercury	0.0002	0.0002*	ND	ND	ND	ND	ND	ND●	ND	NA	ND	0.0004*
Selenium	0.002-0.004	ND	ND	ND	ND	ND	ND	ND●	ND	NA	ND	ND
Silver	0.002	0.004*	0.012	0.019	0.011	0.011	0.009*	0.005*	0.016	NA	0.027	0.011
Volatile Organics (ug/L)												
Method 601 (Halogenated Hydrocarbons)												
Concentration Factor		100	50	10	1	1	1	1	25	10000	1	1
Vinyl Chloride	0.18	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	20
Methylene Chloride	0.25	ND	ND	ND	ND	ND	0.33	0.33	ND	160000	ND	ND
trans-1,2-Dichloroethylene	0.1	ND**	300	ND**	ND	ND	ND	0.74	ND**	120000	8.9	ND
1,2-Dichloroethane	0.03	ND	ND	ND	ND	ND	ND	ND	ND	24000	ND	ND
Trichloroethylene	0.12	ND	2000	390	ND	ND	ND	0.31	400	450000	0.16	46
Tetrachloroethylene	0.03	ND	ND	ND	ND	ND	0.07	0.08	ND	19000	ND	ND
1,2-Dichlorobenzene	0.15	ND	ND	ND	ND	ND	ND	ND	ND	300000	ND	ND
Method 602 (Aromatic Compounds)												
Concentration Factor		5	5	5	1	1	1	1	5	20000	1	1
Toluene	0.2	ND	ND	ND	1.5	130	55	ND	ND	0.6%	13	21
1,2-Dichlorobenzene	0.4	ND	ND	ND	ND	ND	ND	ND	ND	600000	ND	ND

(Continued)

TABLE 4.3.2-2. (Continued)

Date Sampled	Method Detection Limit	Monitor Well HM-21 2-7-86	HM-26 1-31-86	HM-27 1-31-86	HM-34 2-27-86	HM-34D 2-27-86	HM-35 2-27-86	HM-36 2-27-86	HM-37 1-31-86	HM-38 2-21-86	HM-39 2-27-86	P-22U 4-10-86
Extractable Organics (ug/L)												
Method 625 Acid Concentration Factor		1	1	1	1	1	1	1	1	5	1	1
Phenol	1.5	3	2	2	ND	ND	ND	ND	16	35	ND	2
Method 625 Base/Neutral Concentration Factor		1	1	1	1	1	1	1	1	5	1	1
Acenaphthene	1.9	ND	ND	ND	ND	ND	ND	ND	ND	250	ND	ND
1,4-Dichlorobenzene	4.4	ND	ND	ND	ND	ND	ND	ND	ND	4400	ND	ND
Bis(2-ethylhexyl)phthalate	2.5	ND	ND	3	ND	ND	ND	ND	ND	1200	ND	16
butyl benzyl phthalate	2.5	ND	ND	ND	ND	ND	ND	ND	ND	150	ND	ND
Di-n-butyl phthalate	2.5	3	ND	ND	ND	ND	ND	ND	ND	850BL	ND	5BL
Naphthalene	1.6	ND	ND	ND	ND	ND	ND	ND	ND	1400	ND	ND
Fluorene	1.9	ND	ND	ND	ND	ND	ND	ND	ND	190	ND	ND
Phenanthrene	5.4	ND	ND	ND	ND	ND	ND	ND	ND	590	ND	ND

a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.
\- = Data not collected, omitted in field (HM34 and 36), insufficient volume (HM 38 and 39).
NA = Not analyzed.
ND = Not detected.
* = Value less than five times detection limit. Errors may range up to 100 percent.
@ = Spike recovery not within acceptable limits. Indicates interferent.
** = Compound not confirmed by second-column analysis.
BL = Detected in reagent blank; background subtraction not performed.
D = Duplicate sample.

TABLE 4.3.2-3. COMPARISON OF WATER QUALITY AT SITE 3, LANDFILL 3, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location HM-26	HM-27	HM-34	HM-35	HM-36	HM-37	HM-38	HM-39	P-22U
METALS (mg/L)										
Arsenic	0.05			0.062					0.13	
Chromium	0.05		0.13	0.088	0.065	0.055			0.14	
Lead	0.05								0.25	
ORGANIC COMPOUNDS (ug/L)										
Vinyl Chloride	1									20
Methylene Chloride								160000		
1,2-Dichloroethane	5							24000		
trans-1,2-Dichloroethylene	70	300						120000		
Trichloroethylene	5	2000	390				400	450000		46
Tetrachloroethylene	8							19000		
Toluene	2000							6000000		
1,4-Dichlorobenzene	750							4400		
1,2-Dichlorobenzene	620							300000		
Acenaphthene	0.028							250		
Naphthalene	620							1400		
Fluorene	0.028							190		
Phenanthrene	0.028							590		

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

recognizes and incorporates previous findings and trends identified by the Hargis report.

Significance of Metals in Groundwater

Three metals, chromium, arsenic, and lead, were detected in upper zone groundwater in concentrations exceeding the federal MCL criteria. In particular, chromium, noted at these levels in five wells, ranged in concentration from 0.055 mg/L at HM-36 to 0.14 mg/L at HM-39. Hargis & Associates (1985) reported that chromium was observed in water from HM-36 during December 1984. These findings are also consistent with the presence of chromium in the creek seep (reported in Section 4.3.1.2) at the margin of Landfill 3. Metals in the upper member of the Paluxy aquifer at P-22U were reported at concentrations below federal MCL criteria.

The origin of chromium and the other metals in upper zone groundwater could be Landfill 3 or several other upgradient sources. Landfill 1 and 2 are possible nearby upgradient contributors of heavy metals. In addition, Chrome Pit 3 is a more distant upgradient source of chromium and other heavy metals.

Significance of Organic Compounds in Groundwater

A variety of volatile organic compounds exists in upper zone groundwater in all monitor wells at Landfill 3, an observation consistent with the results of previous monitoring (Hargis & Associates, 1985). In addition, acid and base/neutral compounds were detected in HM-38. Away from HM-38, the main contaminant at Landfill 3 is TCE. TCE ranged from "not detected" to 2,000 ug/L. Monitor well HM-38 contained much higher levels of these contaminants, as well as the highest level of phenol (35 ug/L) and a variety of base/neutral organic compounds.

These observations agree with those used by Hargis & Associates (1985) to suggest that groundwater contamination in upper zone wells in the vicinity of Landfill 3 may be the result of contaminant transport via the shallow groundwater flow system from the former Waste Oil Pits located upgradient at Landfill 1; however, the nature and magnitude of contaminants observed at HM-38 strongly suggest a local source of contamination at Landfill 3 in the vicinity of HM-38.

Two volatile organic compounds were detected in monitor well P-22U. These compounds are vinyl chloride (20 ug/L), and TCE (46 ug/L). Although vinyl chloride was not detected in upper zone groundwater during this sampling and analysis program, Hargis & Associates (1985) noted the previous occurrence of vinyl chloride in several upper zone monitor wells. With regard to the occurrence of contamination in the Paluxy aquifer, Hargis & Associates (1985) noted that contaminants were detected in the P-10 well suite, located west of Meandering Road Creek and upgradient of Landfill 3. The IRP Phase II Stage 1 sampling and analysis program also detected volatile organic compounds in P-10U. The Hargis report hypothesized that the Paluxy Formation west of the creek may be recharged by upper zone groundwater and creek underflow. The Walnut Formation aquitard has been deeply incised by the creek as it flows adjacent to Landfill 3. Quoting from the Hargis report (p. 72):

> The extent of contamination in the Paluxy Formation due to recharge from the upper zone in the vicinity of the P-10 well suite is unknown; however, movement of contaminants from this area toward the southeast is possible. Field inspection indicates that the source of the contaminants which are believed to enter the upper Paluxy Formation in the vicinity of the P-10 well suite may not be on-site. Water level elevation data for the Paluxy Formation indicate that contaminants from known on-site sources would be transported to the south-southeast, not the north-northwest toward the monitor well P-10 suite.

Thus the contamination observed in P-22U possibly may possibly be the result of a combination of the sources attributed to the contamination noted in P-10 and of the local movement of contaminated upper zone groundwater through the Walnut Formation.

4.3.3 Site 12, Chrome Pit 3

Work at Chrome Pit 3 consisted of collecting and analyzing samples from existing wells where data had been collected in previous investigations. These previous data revealed contamination in shallow groundwater at the site, which reportedly contained barium chromate sludge, dilute metal solutions, and drums of unidentified liquids. In 1983 and 1984, the pits were excavated and 8,900 cubic yards of earth were removed. Testing during excavation indicated that most of the contaminated soils were removed.

Groundwater samples were collected and analyzed at HM-30, 16, 15, 45, 17, 32, 41, and P-2. Figure 4.3.3-1 shows the locations of these sampling points and the physical features of the site.

4.3.3.1 Results of Investigation

The investigation conducted at Chrome Pit 3 focused on the collection, analysis, and interpretation of groundwater quality samples. Discussion of the results of these activities and descriptions of the topographic and geologic features of the site follow.

Topography

The ground surface in the vicinity of Chrome Pit 3 is relatively flat, with an elevation of approximately 658 feet MSL.

Geologic Features

Upper zone monitor well HM-1 was located within this site but has since been destroyed by excavation. The lithologic log of this well (Hargis and Associates, 1985) shows an upper zone thickness of 29 feet. Five feet of Goodland Limestone was encountered.

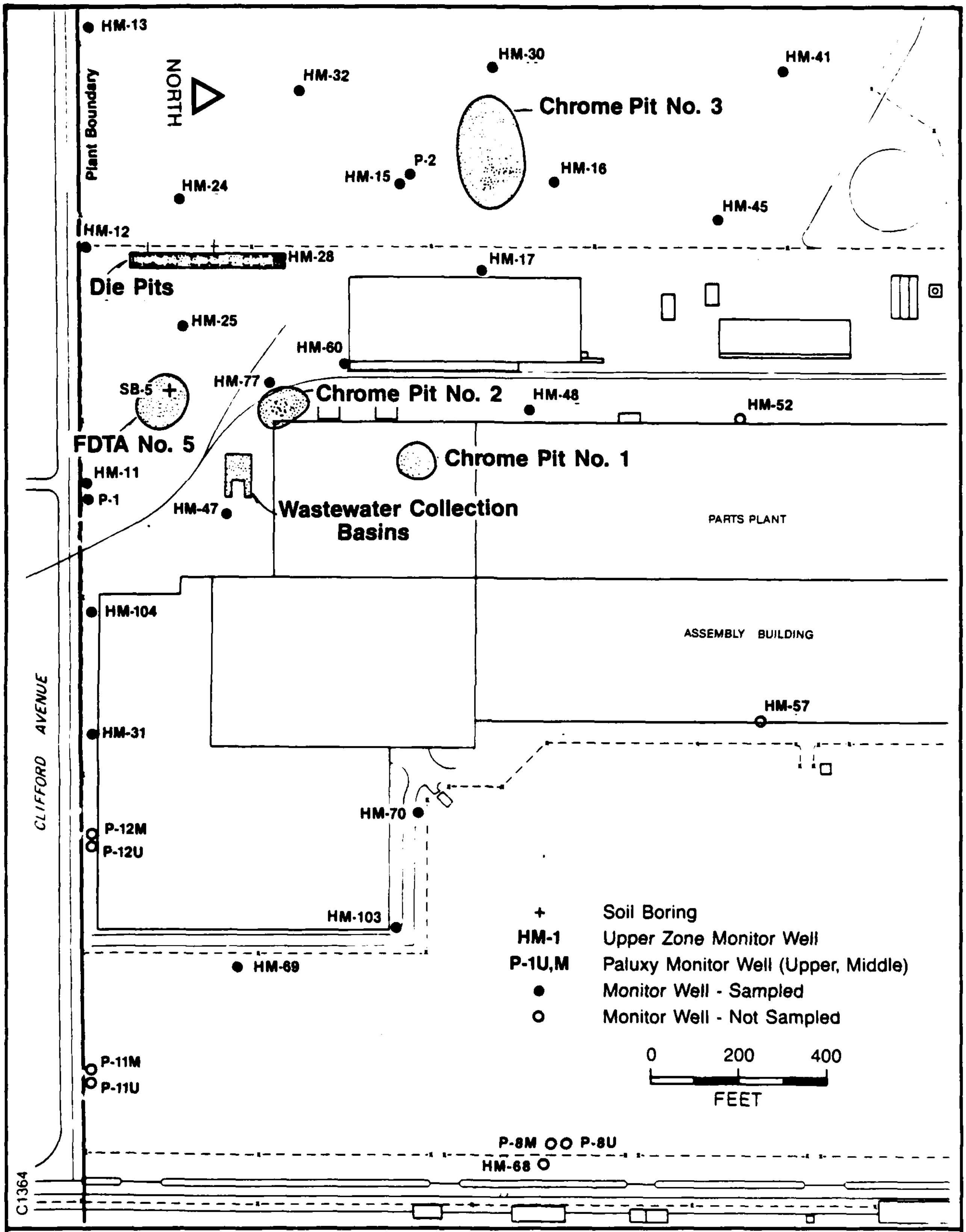

Figure 4.3.3-1. Phase II Activities at Site 12, Chrome Pit 3, AF Plant 4, Texas

Lithologic logs of monitor wells surrounding the site (Hargis and Associates, 1985) give additional information on subsurface features. The thickness of the upper zone in the wells surrounding the site ranges from 18 to 29 feet. The Goodland Limestone formation is absent at HM-13, HM-32, and HM-41, but where present it ranges in thickness from 6 feet at HM-30 to 18 feet at HM-17.

The thickness of the Walnut Formation at this site can be determined from the lithologic log of Paluxy monitor well P-2 (Hargis and Associates, 1985). The thickness of the Walnut Formation is 35 feet at this well.

Occurrence of Groundwater

Groundwater occurs at Chrome Pit 3 in both the materials of the upper zone and the Paluxy Formation. Table 4.3.3-1 gives results of water level measurements. The water level map for the upper zone in this area of AF Plant 4 (Figure 4.1.2-7) was described previously in Section 4.1.2. Water levels in the upper zone at this site ranged from 638.42 feet MSL at HM-17 to 630.21 feet MSL at HM-41. The groundwater elevation at P-2 was measured at 561.98 feet MSL.

As shown in Figure 4.1.2-7, groundwater in the upper zone at this location flows predominantly to the west. Groundwater flow in the Paluxy Formation at AF Plant 4, discussed in Section 4.1.2, is predominantly to the southeast.

Groundwater Quality

Groundwater samples were collected and analyzed from the following locations: HM-30, 16, 15, 45, 17, 32, 13, 41 and P-2. All samples were analyzed for volatile organic compounds by EPA Methods 601 and 602, acid and base/neutral extractable compounds by EPA Method 625, and heavy metals by EPA Methods 200.7 206.2, 239.2, 245.1, and 270.2. Results of groundwater analyses and field measurements (pH, temperature, and conductivity) are shown in Table 4.3.3-2. Complete analytical reports for these analyses appear in Appendix A.

TABLE 4.3.3-1. GROUNDWATER ELEVATIONS AT SITE 12, CHROME PIT 3, AF PLANT 4, TEXAS (FEBRUARY 1986)

Monitor Well	Elevation (feet MSL)	Date
HM-13	643.93	2-19-86
HM-15	633.58	2-25-86
HM-16	635.52	2-11-86
HM-17	638.42	2-11-86
HM-30	633.52	2-13-86
HM-32	633.96	2-14-86
HM-41	630.21	2-25-86
HM-45	634.19	2-25-86
P-2	561.98	2-19-86

TABLE 4.3.3-2. RESULTS OF GROUNDWATER SAMPLE ANALYSES, SITE 12, CHROME PIT 3, AF PLANT 4, TEXAS

	Method	Monitor Well								
	Detection	HM-13	HM-15	HM-16	HM-17	HM-30	HM-32	HM-41	HM-45	P-2
Date Sampled	Limit	2-19-86	2-25-86	2-11-86	2-11-86	2-13-86	2-14-86	2-25-86	2-25-86	2-19-86
Field Parameters										
Temperature (°C)		22.5	-	16.8	21.0	18.0	16.0	21.0	21.0	20.0
pH		7.0	-	6.8	6.6	6.8	7.0	6.8	6.8	7.2
Conductivity (umhos)		890	-	1400	900	910	600	690	1000	710
Analytical Parameters[a]										
Metals (mg/L)										
Arsenic	0.002-0.005	ND	NA	0.038	ND●	ND	ND	ND	0.009*	ND
Barium	0.009	0.11	NA	0.12	0.034	0.087	0.068	0.11	0.095	0.089
Cadmium	0.002	ND	NA	ND	0.002*	ND	ND	ND	ND●	ND
Chromium	0.005	0.2*	NA	0.21	ND	ND	ND	ND	0.02*	0.01*
Lead	0.001-0.002	0.031	NA	0.10	0.02●	ND●	0.009●	ND	0.009	ND
Mercury	0.0002	ND	NA	ND	0.0003*	ND	ND	ND	0.0002*	ND
Selenium	0.002-0.004	ND	NA	0.007*	ND	ND●	ND●	ND	ND	ND●
Silver	0.002	0.006*	NA	ND	ND	ND	0.003*	0.004*	0.006*●	0.002*
Volatile Organics (ug/L)										
Method 601 (Halogenated Hydrocarbons)										
Concentration Factor		1	250	250	500	10	1	1	10	1
Methylene Chloride	0.25	ND	ND	ND	ND	ND	0.50	ND	ND	ND
1,2-Dichloroethylene	0.13	ND	ND	ND	ND	ND	ND	ND	32	ND
trans-1,2-Dichloroethylene	0.10	ND	ND	ND	ND	ND	ND	ND	ND**	ND
Chloroform	0.05	0.46	ND	ND	ND	ND	1.1	ND	ND	ND
1,1,1-Trichloroethane	0.03	ND	ND	ND	ND	ND	ND	ND	10	ND
Trichloroethylene	0.12	ND	5900	10000	15000	180	ND	2.7	130	ND
Tetrachloroethylene	0.03	ND	ND	ND	ND	ND	0.08	ND	3.0	ND
Method 602 (Aromatic Hydrocarbons)										
Concentration Factor		1	50	25	250	1	1	1	1	1
Toluene	0.2	2.0	ND	ND	ND	0.78	6.1	0.84	ND	10
Extractable Organics (ug/L)										
Method 625 Acid										
Concentration Factor		1		1	1	1	1	1	1.4	1
Phenol	1.5	ND	NA	ND	ND	2	2	ND	ND	2
Method 625 Base/Neutral										
Concentration Factor		1		1	1	1	1	1	1.4	1
Bis(2-ethylhexyl)phthalate	2.5	ND	NA	12BL	ND	ND	ND	ND	ND	ND
Di-n-butyl phthalate	2.5	ND	NA	4BL	3BL	ND	ND	ND	ND	ND

ND = Not detected.
NA = Not analyzed.
* = Value less than five times detection limit. Errors may range up to 100 percent.
● = Spike recovery not within acceptable limits. Indicates interferent.
BL = Detected in reagent blank; background subtraction not performed.
** = Compound not confirmed by second-column analysis.
a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.
\- = Data not collected, insufficient volume.

To evaluate the degree of groundwater contamination, analytical results from IRP Phase II Stage 1 sampling were compared to federal standards and guidelines. Table 4.3.3-3 summarizes this comparison.

4.3.3.2 Significance of Findings

This section discusses the significance of the findings of the investigation, emphasizing the groundwater chemistry at the site. Hargis & Associates (1985) have previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates previous findings and trends identified by the Hargis report.

Significance of Metals in Groundwater

Chromium and lead were detected in upper zone groundwater in concentrations exceeding the federal MCL criteria in HM-16. The concentration of chromium detected at this well was 0.21 mg/L and the concentration of lead was 0.10 mg/L. Concentrations of chromium in excess of MCL levels would be expected at this site because of the known disposal of barium chromate sludge in Chrome Pit 3. Metals in the Paluxy aquifer at P-2 were reported at concentrations below federal MCL criteria. The Hargis and Associates (1985) report contains no data for metals concentrations for this site; therefore, no comparisons can be made.

Significance of Organic Compounds in Groundwater

A number of organic compounds are present in the groundwater in monitor wells at Chrome Pit 3. Two compounds, 1,1-dichloroethylene and trichloroethylene, were detected at levels exceeding the federal MCL criteria. High levels of trichloroethylene were reported in groundwater from monitor wells HM-15, HM-16, HM-17, HM-30, and HM-45. These levels ranged from 130 ug/L at HM-45 to 15000 ug/L at HM-17.

TABLE 4.3.3-3. COMPARISON OF WATER QUALITY AT SITE 12, CHROME PIT 3, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location				
		HM-15	HM-16	HM-17	HM-30	HM-45
METALS (mg/L)						
Chromium	0.05		0.21			
Lead	0.05		0.10			
ORGANIC COMPOUNDS (ug/L)						
1,1-Dichloroethylene	7					32
Trichloroethylene	5	5900	10000	15000	180	130

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

These findings are generally consistent with earlier analyses by Hargis & Associates except for monitor well HM-30, which had much higher levels of TCE reported in 1983-85. Monitor well HM-17 had the highest concentration of TCE among the wells sampled in the Phase II program (15000 ug/L), followed by HM-16 and HM-15 with TCE concentrations of 10000 ug/L and 5,900 ug/L, respectively. The presence of TCE in the groundwater at Site 12 indicates that drums of unidentified liquids reportedly disposed of at Site 12 probably contained solvents.

Water sampled from HM-45 revealed the concentration of 1,1-dichloroethene to be 32 mg/L, which is over the federal MCL criteria for this compound.

Water samples collected from the only Paluxy well in Site 12 revealed no organic compounds in excess of the federal MCL criteria.

4.3.4 Site 17, Former Fuel Storage Site

Site 17 was the former location of a 100,000-gallon, above-ground JP-4 storage tank from the early 1940's until it was relocated in 1962. Sampling at this site in 1982 confirmed that soils and upper zone groundwater were contaminated by fuels and other organic compounds.

Site activities during this study consisted of installing an upper zone monitor well (HM-100), and collecting and analyzing soil and groundwater samples. Existing upper zone monitor wells also sampled at this site include HM-8 and -14. Figure 4.3.4-1 shows the locations of these sampling points. Soil obtained during the drilling of monitor well HM-100 and groundwater from the three wells were collected and analyzed for hydrocarbon fuels by EPA Method 418.1.

4.3.4.1 Results of Investigation

This investigation focused on the construction of the upper zone monitor well HM-100 and on the collection and analysis of soil and groundwater samples. A discussion of the results of these activities and descriptions of the topographic and geologic features of the site follow.

Topography

This site is located at the southwest corner of the AF Plant 4 facility, near the center of the Radar Range. The land surface across the site is flat, with an elevation of approximately 670 feet MSL.

Geologic Features

The lithologic logs of HM-8, HM-14 (Hargis and Associates, 1985) indicate that the upper zone in the vicinity of the Former Fuel Storage Site is 49 feet thick at both wells. The lithologic log of HM-100 (Appendix E, this report) also indicates an upper zone thickness of at least 49 feet. At

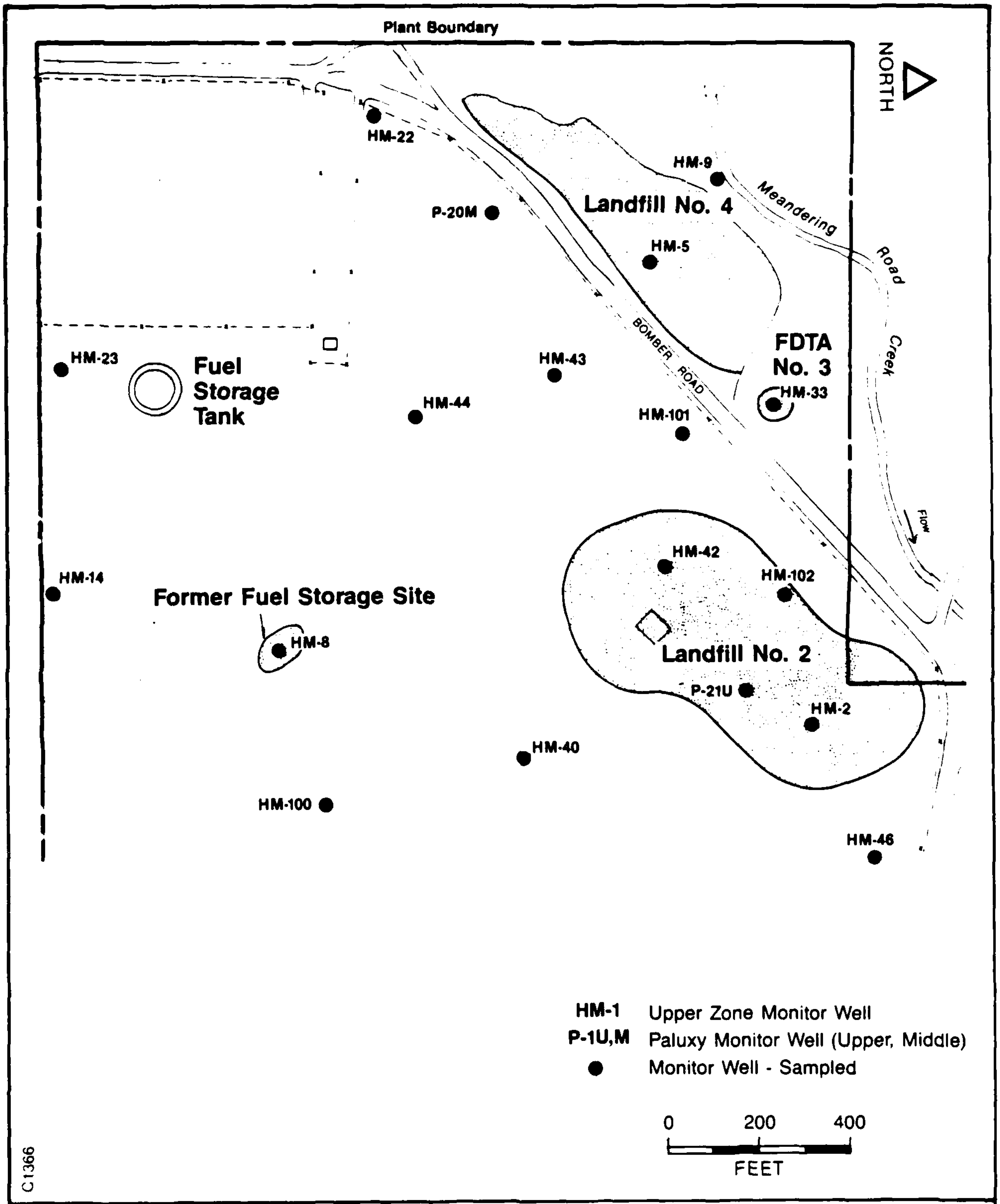

Figure 4.3.4-1. Phase II Activities at Site 17, Former Fuel Storage Site, AF Plant 4, Texas

HM-100 the upper zone consists of six feet of clay underlain by layers of sand and silt.

The Goodland Limestone was absent at all locations. The Walnut Formation was encountered during the construction of HM-14 but was absent at HM-8 and HM-100.

This description of geologic features at the Former Fuel Storage Site is consistent with that of the Hargis and Associates (1985) report.

Occurrence of Groundwater

Groundwater at the Former Fuel Storage Site occurs in the materials of the upper zone. Table 4.3.4-1 shows the results of water level measurements. The water level map for the upper zone in this area of AF Plant 4 (Figure 4.1.2-8) was described previously in Section 4.1.2. Water levels in the upper zone at this site ranged from 635.28 feet MSL at HM-14 to 634.02 feet MSL at HM-100. As shown in Figure 4.1.2-8, the piezometric surface in this area is, for the most part, flat.

Groundwater Quality

Groundwater samples were collected and analyzed from the following locations: HM-8, 14, and 100. All samples were analyzed for hydrocarbon fuels by EPA Method 418.1. Results of the groundwater analyses and field measurements (pH, temperature, and conductivity) are given in Table 4.3.4-2. Complete analytical reports for these analyses appear in Appendix A.

4.3.4.2 Significance of Findings

This section discusses the significance of the findings of this investigation, emphasizing the groundwater and soil chemistry at the site. Hargis & Associates (1985) have previously discussed the significance of

TABLE 4.3.4-1. GROUNDWATER ELEVATIONS SITE 17, AT FORMER FUEL STORAGE SITE AF PLANT 4, TEXAS (FEBRUARY THROUGH APRIL 1986)

Monitor Well	Elevation (feet MSL)	Date
HM-8	634.82	2-13-86
HM-14	635.28	2-19-86
HM-100	634.02	4-11-86

TABLE 4.3.4-2. RESULTS OF SOILS AND GROUNDWATER SAMPLE ANALYSES, SITE 17, FORMER FUEL STORAGE SITE, AF PLANT 4, TEXAS

		Monitor Well			Soil Analysis		
	Method Detection	HM-8	HM-14	HM-100	HM-100-A (11-12)	HM-100-B (25-26)	HM-100-C (35-36)
Date Sampled	Limit	2-13-86	2-19-86	4-11-86	1-20-86	1-20-86	1-20-86
Field Parameters							
Temperature (°C)		18.0	21.5	14.5			
pH		6.8	6.7	6.5			
Conductivity (umhos)		900	900	750			
Analytical Parameters							
Hydrocarbon Fuels (mg/L)	1	ND	ND	ND			
Hydrocarbon Fuels (mg/kg)	4-6				ND	ND	ND

ND = Not detected.

groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates previous findings and trends identified by the Hargis report.

Significance of Hydrocarbon Fuels in Groundwater and Soil

Hydrocarbon fuels were below instrument detection limits in soil and groundwater samples, indicating a lack of contamination at the site. These findings are consistent with those of Hargis & Associates (1985).

4.3.5 Site 2, Landfill 2

Landfill 2 originally consisted of some low areas and a livestock watering hole. Most of this site was reportedly filled with construction rubble, plaster, and fill dirt during the early 1940s. Tires and lumber were reportedly disposed of, and later burned there. Although there are no records of hazardous materials being disposed of at the site, it is possible that small quantities of hazardous wastes could be present.

Activities at Landfill 2 consisted of performing a terrain conductivity survey, installing a Paluxy aquifer monitor well (P-21U), and collecting and analyzing groundwater samples. Upper zone monitor wells at this site include HM-2, 22, 40, 42, 43, 44, and 46. Figure 4.3.5-1 shows the locations of these sampling points. Samples were collected and analyzed for volatile organic compounds by EPA Methods 601 and 602, acid and base/neutral extractable compounds by EPA Method 625, and heavy metals by EPA Methods 200.7, 206.2, 239.2, 245.1, and 270.2.

4.3.5.1 Results of Investigation

The IRP Phase II Stage 1 investigation at this site consisted of a geophysical survey, the construction of the Paluxy monitor well P-21U, and the collection and analysis of groundwater samples. A discussion of the results of these activities and descriptions of the topographic and geologic features of the site follow.

Topography

The land surface at Landfill 2 is flat to slightly sloping, with an elevation of approximately 665 feet MSL along the southern and western portions of the landfill to 640 feet MSL near Bomber Road. The site is part of the Radar Range at the southwestern portion of AF Plant 4. Most of the site is landscaped with grass.

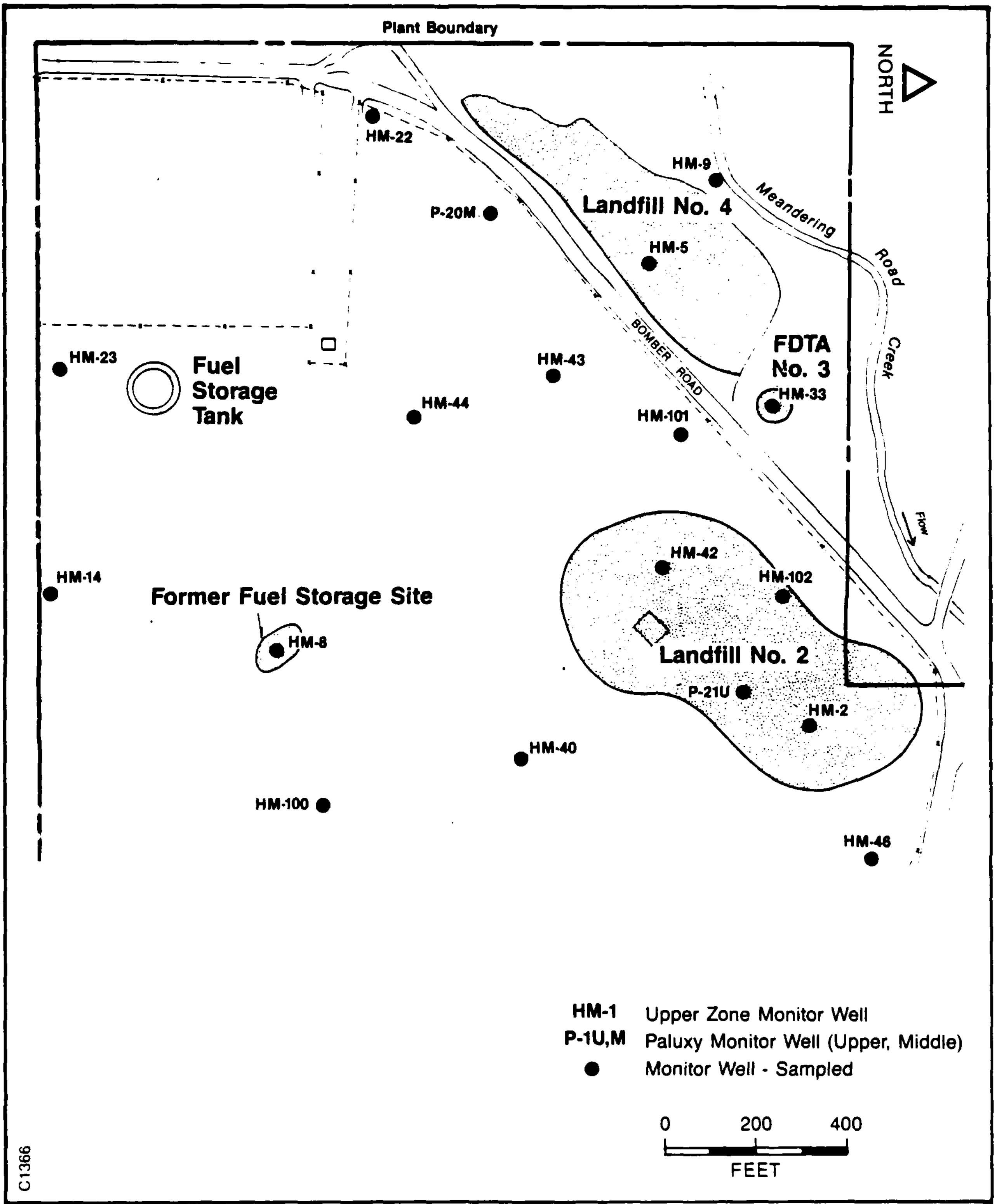

Figure 4.3.5-1. Phase II Activities at Site 2, Landfill 2, AF Plant 4, Texas

Geologic Features

Monitor wells located within the boundaries of Landfill 2 are HM-2, HM-42, HM-102, and P-21U. Monitor well HM-102 was constructed at the northwestern margin of Landfill 2. Although this well was initially designated to detect contamination, if any, attributable to FDTA 3, the placement of HM-102 has also served to help define geologic and groundwater quality conditions at Landfill 2.

According to lithologic logs of drilling operations (Hargis and Associates, 1985 and Appendix E, this report) the thickness of the upper zone at this site ranges from 31 feet at HM-102 to 44 feet at HM-42. At all of these locations, the Walnut Formation directly underlies the upper zone.

Paluxy well P-21U, penetrates both the Walnut Formation and the upper member of the Paluxy Sand. Thicknesses of these formations are 40 feet and 25 feet, respectively.

Monitor well HM-102 was constructed at the northwestern margin of Landfill 2. According to the geologic log from drilling and well construction operations, the thickness of the upper zone at HM-102 is 31 feet. The alluvial material coarsens with depth, with coarse sand and gravel encountered at the base of the upper zone. At this location, the Walnut Formation directly underlies the upper zone.

Occurrence of Groundwater

Groundwater occurs in both the materials of the upper zone and in the Paluxy Formation. Table 4.3.5-1 gives the results of water level measurements. Water levels in the upper zone ranged from 668.06 feet MSL at HM-22

TABLE 4.3.5-1. GROUNDWATER ELEVATIONS AT SITE 2, LANDFILL 2, AF PLANT 4, TEXAS (FEBRUARY THROUGH APRIL 1986)

Monitor Well	Elevation (feet MSL)	Date
HM-2	631.67	2-20-86
HM-22	668.06	2-20-86
HM-40	633.39	2-25-86
HM-42	633.80	2-20-86
HM-43	655.12	2-20-86
HM-44	636.17	2-25-86
HM-46	630.97	2-20-86
HM-102	632.15	4-9-86
P-21U	569.32	4-10-86

south of the landfill (actually closer and more representative of conditions at Landfill 4) to 630.97 feet MSL at HM-46 at the northeastern portion of the landfill. Groundwater flow in the upper zone is to the northeast, generally parallel to Meandering Road Creek. The appearance of the water level contours in the upper zone resembles the pattern of the elevation contours at the base of the upper zone. Hargis & Associates (1985) reported that the direction of groundwater flow in the upper zone is to the north or northeast beneath most of the Radar Range. A small seep ("Radar Range Seep") near the north edge of Landfill 2 (north part of the Radar Range and south of Bomber Road) was also noted by Hargis & Associates (1985).

Geophysical Survey

A geophysical survey consisting of electromagnetic profiling was performed in November 1985. A grid was established, as described in Section 3.1.1. The area of the survey grid was approximately 1800 feet by 800 feet. Electromagnetic profile readings were taken at 30 foot intervals on the grid.

The location of the survey is illustrated in Figure 4.3.5-2. Ranges of conductivity in the area were generally 30 millimhos/meter to 60 millimhos/meter. Conductivity values generally increased from the northeast to the southwest. Anomalous readings could be attributed to a number of sources, such as buried metal, variable thicknesses of fill material, or shallow contamination in water or soil. A moderately large zone in the northeastern part of the survey area indicated moderately high amounts of fill material. Near HM-43, however, high conductivity values may possibly reflect shallow soil contamination.

Groundwater Quality

Groundwater samples were collected and analyzed from the following locations: HM-2, 22, 40, 42, 43, 44, 46, and P-21U. All samples were analyzed for volatile organic compounds by EPA Methods 601 and 602, acid and

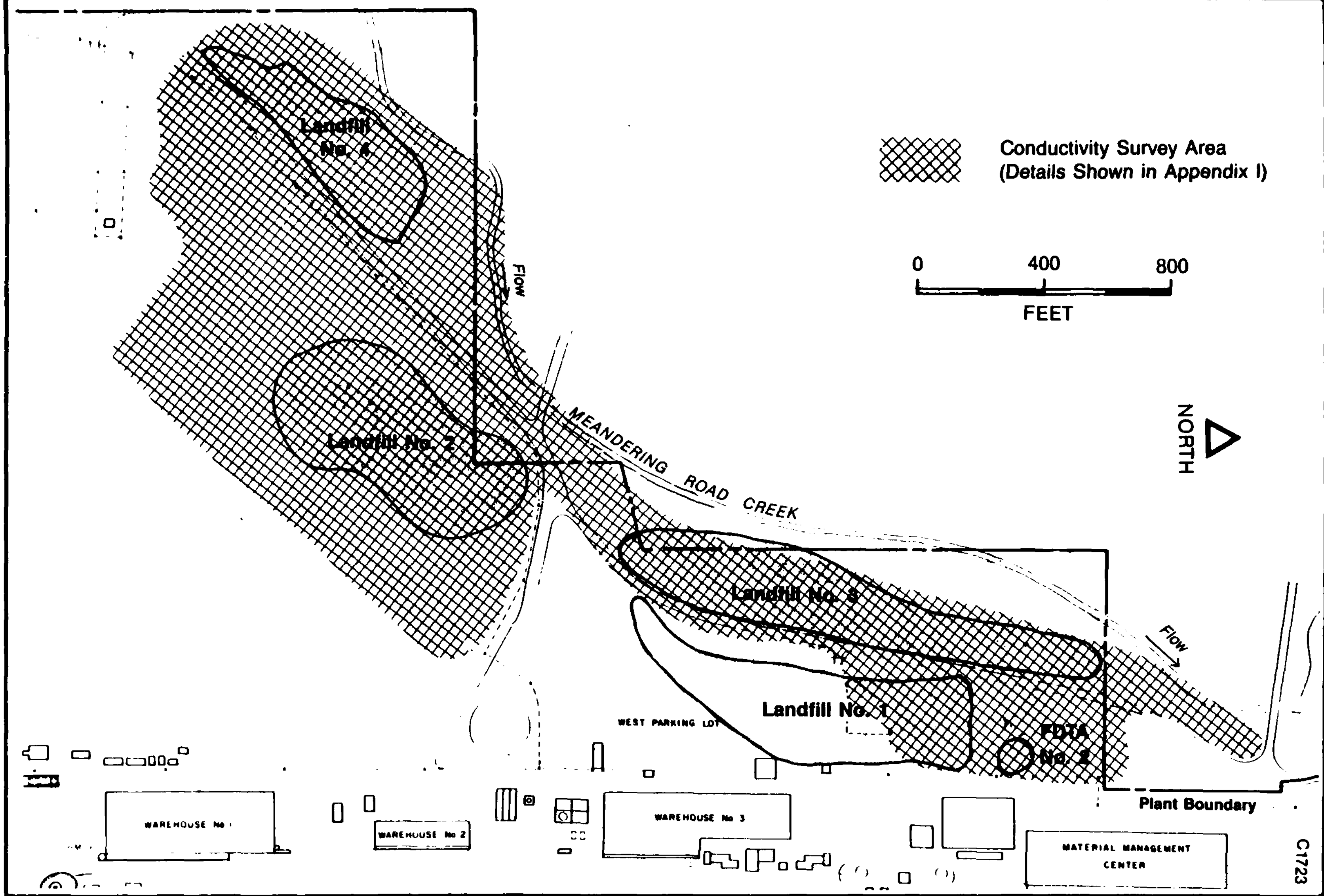

Figure 4.3.5-2. Location of Geophysical Survey, Site 2, Landfill 2, AF Plant 4, Texas

base/neutral extractable compounds by EPA Method 625, and heavy metals by EPA Methods 200.7, 206.2, 239.2, 245.1, and 270.2. Table 4.3.5-2 shows the results of the groundwater analyses and field measurements (pH, temperature, and conductivity). Complete analytical reports for these analyses appear in Appendix A.

To evaluate the degree of groundwater contamination, analytical results from IRP Phase II Stage 1 sampling were compared to federal standards and guidelines. Table 4.3.5-3 summarizes this comparison.

4.3.5.2 Significance of Findings

This section discusses of the significance of the findings of this investigation, emphasizing the groundwater chemistry at the site. Hargis & Associates (1985) previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates previous findings and trends identified in the Hargis report.

Significance of Metals in Groundwater

Two metals, chromium and lead, were detected in upper zone groundwater at concentrations exceeding the federal MCL criteria. In particular, chromium was noted at these levels in three wells, HM-22, HM-42, and HM-46 at concentrations ranging from 0.054 ug/L at HM-22 to 0.093 ug/L at HM-46. Lead was detected above the MCL criteria at HM-46 at a concentration of 0.070 mg/L. Hargis & Associates (1985) reported that chromium was observed in water from HM-46 and from the Radar Range seep. Metals in the upper member of the Paluxy aquifer at P-21U were reported at concentrations below federal MCL criteria.

The origin of chromium and lead in upper zone groundwater could be Landfill 2 or some unknown upgradient source. Chrome Pit 3 is hydraulically upgradient of portions of Landfill 2 and could represent a source of chromium and other heavy metals.

TABLE 4.3.5-2. RESULTS OF GROUNDWATER SAMPLE ANALYSES, SITE 2, LANDFILL 2, AF PLANT 4, TEXAS

	Method Detection Limit	Monitor Well							
		HM-2	HM-22	HM-40	HM-42	HM-43	HM-44	HM-46	P-21U
Date Sampled		2-20-86	2-20-86	2-25-86	2-20-86	2-20-86	2-25-86	2-20-86	4-10-86
Field Parameters									
Temperature (°C)		21.0	21.0	-	21.0	21.0	20.5	19.5	19.0
pH		6.9	7.1	-	7.0	7.0	7.0	7.0	7.4
Conductivity (umhos)		710	2200	-	570	550	640	700	520
Analytical Parameters[a]									
Metals (mg/L)									
Arsenic	0.002-0.005	0.004*	0.015	0.029	ND	0.004*	ND	0.047	ND(.02)
Barium	0.009	0.13	0.32	0.13	0.066	0.067	0.074	0.48	0.067
Cadmium	0.002	ND	ND	ND	ND	ND	ND	ND	0.002*
Chromium	0.005	0.025	0.054	0.02*	0.069	0.028	0.01*	0.093	ND
Lead	0.001-0.002	0.035	0.014●	0.013	0.038	0.031	0.006	0.070	0.023
Mercury	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	0.002-0.004	ND	ND●	ND@	ND@	ND	ND	ND	ND (.03)
Silver	0.002	0.010	0.019	0.004*	0.003*	0.011	0.005*	0.017	ND
Volatile Organics (ug/L)									
Method 601 (Halogenated Hydrocarbons) Concentration Factor		1	1	1	1	1	1	1	1
Methylene Chloride	0.25	0.57	0.45	ND	0.65	0.40	ND	ND	ND
Tetrachloroethylene	0.03	ND	ND	0.09	ND	ND	ND	ND	ND
Method 602 (Aromatic Compounds) Concentration Factor		1	1	1	1	1	1	1	1
Toluene	0.2	0.56	0.97	0.61	12	ND	0.73	ND	12
Extractable Organics (ug/L)									
Method 625 Acid Concentration Factor		1	1	1	1.2	1	1	2	1
Phenol	1.5	ND	ND	ND	4	2	3	ND	ND
Method 625 Base/Neutral Concentration Factor		1	1	1	1.2	1	1	1	1
Bis(2-ethylhexyl)phthalate	2.5	3	ND	ND	ND	ND	ND	ND	5
Di-n-butyl phthalate	2.5	3BL	5BL	ND	ND	3BL	ND	ND	12BL

* = Value less than five times detection limit.
Errors may range up to 100 percent.
@ = Spike recovery not within acceptable limits. Indicates interferent.
BL = Detected in reagent blank; background subtraction not performed.
\- = Data not collected, measurement omitted in field.
a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor.
Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.
ND = Not detected, values in parentheses are actual sample detection limits.

TABLE 4.3.5-3. COMPARISON OF WATER QUALITY AT SITE 2, LANDFILL 2, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location					
		HM-22	HM-42	HM-43	HM-44	HM-46	P21U
METALS (mg/L)							
Chromium	0.05	0.054	0.069			0.093	
Lead	0.05					0.070	
Selenium	0.01						0.03

* See Table 4.2.1-1 for source of criteria.

Significance of Organic Compounds in Groundwater

Monitoring of upper zone wells in the vicinity of Landfill 2 has not detected significant numbers or levels of organic compounds. Results of the sampling and analysis of HM-102, although not reported in this section, confirm that no levels of organic compounds in excess of MCL criteria were found. This agrees with the data presented by Hargis and Associates (1985), which indicated no organic contamination of the upper zone groundwater at Landfill 2.

The IRP Phase II Stage 1 sampling and analysis program detected toluene (12 ug/L) in P-21U. The source of the toluene in the well is not certain, since no identified sources exist directly upgradient of the well. However, toluene was the only volatile organic compound detected in the well.

4.3.6 Site 4, Landfill 4

From about 1956 to the early 1980s Landfill 4 was used to dispose of clean construction rubble. Other types of wastes may have been disposed of at this site from about 1966 to 1973.

Activities at Landfill 4 consisted of installing one upper zone well (HM-101) and one Paluxy monitor well (P-20M) and collecting and analyzing groundwater samples. Upper zone monitor wells at this site include HM-5, 9, and 101. Figure 4.3.6-1 shows the locations of these sampling points. Samples were collected and analyzed for volatile organic compounds by EPA Methods 601 and 602, acid and base/neutral extractable compounds by EPA Method 625, and heavy metals by EPA Methods 200.7, 206.2, 239.2, 245.1, and 270.2.

4.3.6.1 Results of Investigation

The investigation at Landfill 4 focused on the construction of the Paluxy monitor well P-20M and the upper zone well HM-101 and the collection and analysis of groundwater samples. A discussion of the results of these activities and descriptions of the topographic and geologic features of the site follow.

Topography

This landfill is located near the southwest boundary of the AF Plant 4 facility, in the area west of Meandering Road. The fill site was formerly part of the low area bordering Meandering Road Creek. The land surface generally slopes toward the creek (northwest) and elevations vary from about 660 feet to 640 feet MSL across the site.

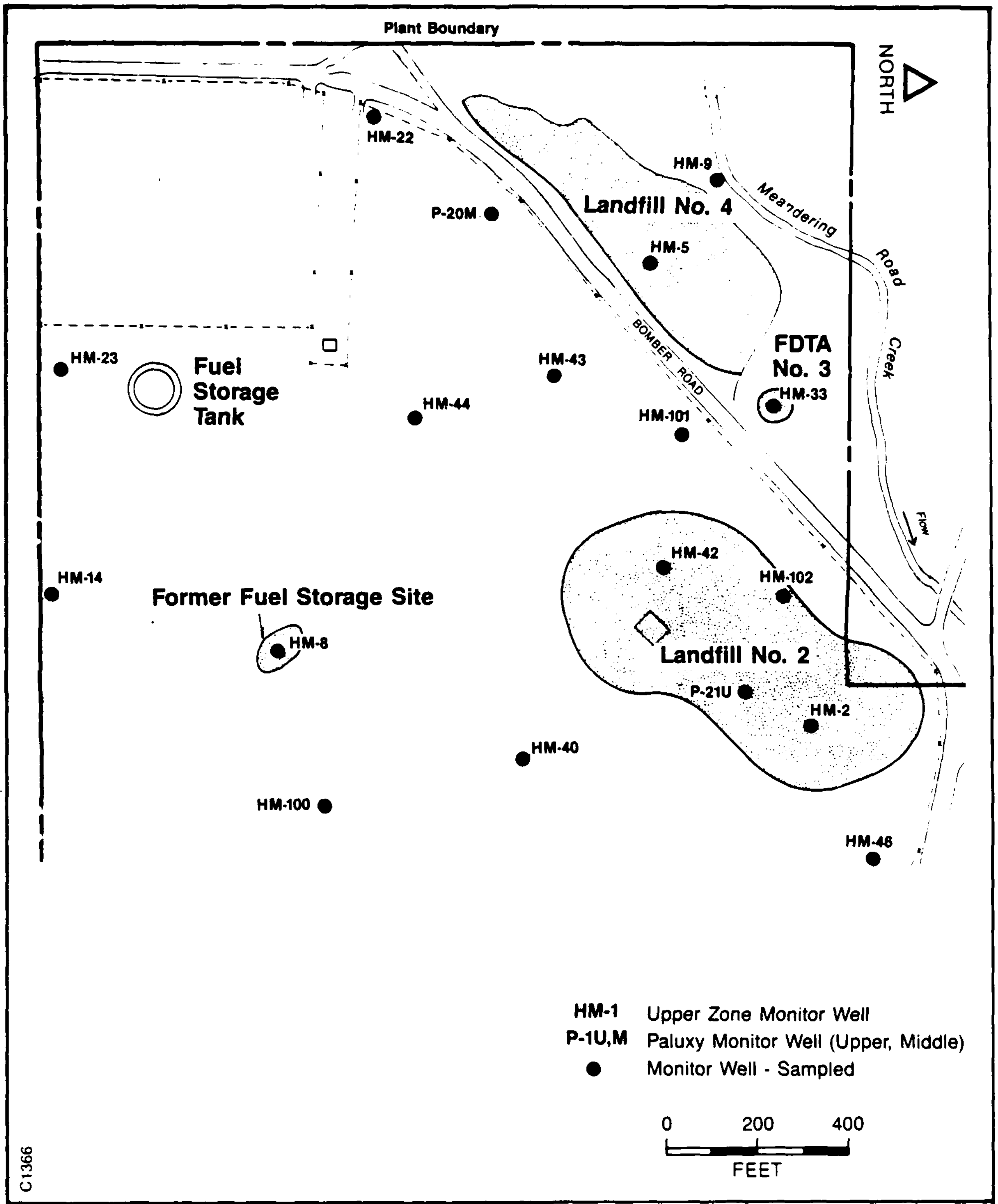

Figure 4.3.6-1. Phase II Activities at Site 4, Landfill 4, AF Plant 4, Texas

Geologic Features

Monitor well HM-5 is located within the boundaries of Landfill 4. The lithologic log of this well (Hargis and Associates, 1985) indicates an upper zone thickness of 26 feet.

Additional information is provided by the lithologic logs of monitor wells HM-9, HM-101, and P-20M, which surround the site. These logs (Hargis and Associates, 1985 and Appendix E, this report) indicate that the upper zone thins to the southwest while the Walnut Formation thins to the north.

The Goodland Limestone was encountered only at monitor well P-20M, approximately 400 feet south of Landfill 4, where it was 38 feet thick. The Walnut Formation and the upper member of the Paluxy Sand were also fully penetrated at P-20M. The thicknesses of the two units here are 33 feet and 39 feet, respectively.

This description of geologic features at Landfill 4, while generally consistent with that of the Hargis and Associates (1985) report, adds information regarding the presence of the Goodland Limestone and the Paluxy Sand gained from the installation of two new monitor wells at this site.

Occurrence of Groundwater

Groundwater at Landfill 4 occurs in both the materials of the upper zone and in the Paluxy Formation. Table 4.3.6-1 presents results of water level measurements. The water level map for the upper zone in this area of AF Plant 4 (Figure 4.1.2-8) was discussed previously in Section 4.1.2. Water levels in the upper zone monitor wells at this site ranged from 650.67 feet MSL at HM-5 to 633.79 feet MSL at HM-9 during January and February 1986. As shown in Figure 4.1.2-8, groundwater flow is to the north-northeast, toward Meandering Road Creek. The water level in the middle member of the Paluxy

TABLE 4.3.6-1. GROUNDWATER ELEVATIONS AT SITE 4, LANDFILL 4 AF PLANT 4, TEXAS (FEBRUARY THROUGH APRIL 1986)

Monitor Well	Elevation (feet MSL)	Date
HM-5	650.67	2-12-86
HM-9	633.79	2-27-86
HM-101	646.35	4-18-86
P-20	563.96	4-19-86

Formation, measured at P-20M, is 563.96 feet MSL. Groundwater levels in the middle Paluxy at AF Plant 4 are shown in Figure 4.1.2-3.

Groundwater Quality

Groundwater samples from HM-5, HM-9, HM-101, and P-20M were collected and analyzed for volatile organic compounds by EPA Methods 601 and 602, for acid and base/neutral extractable compounds by EPA Method 625, and for heavy metals by EPA Methods 200.7, 206.2, 239.2, 245.1, and 270.2. Table 4.3.6-2 gives results of the groundwater analysis and field measurements. Complete analytical reports for these analyses appear in Appendix A.

To evaluate the degree of groundwater contamination, analytical results from IRP Phase II Stage 1 sampling were compared to federal standards and guidelines. Table 4.3.6-3 summarizes the results of this comparison.

4.3.6.2 Significance of Findings

This section discusses the significance of the findings of the investigation, emphasizing the groundwater chemistry at the site.

Significance of Metals in Groundwater

Analyses of groundwater from HM-101 revealed concentrations of chromium and silver slightly in excess of federal MCL criteria. However, because of poor spike recovery (indicating the presence of an interferent) the analytical results for silver may be lower than the actual concentration. A similar situation exists for cadmium in HM-101. Although the observed concentration is below the MCL, the actual concentration may approach or exceed the MCL. A potential error is associated with the detected level of chromium (0.24 mg/L), since this value is less than five times the detection limit. Metals in HM-5, HM-9, and P-20M were reported at concentrations below federal MCL criteria.

TABLE 4.3.6-2. RESULTS OF GROUNDWATER SAMPLE ANALYSES, SITE 4, LANDFILL 4, AF PLANT 4, TEXAS

Data Sampled	Method Detection Limit	Monitor Well HM-5 2-12-86	 HM-9 2-27-86	 HM-101 4-18-86	 P-20M 4-19-86	 P-20MD 4-19-86
Field Parameters						
Temperature (°C)		14.0	14.5	-	21.0	21.0
pH		6.4	6.8	7	7.6	7.6
Conductivity (umhos)		1600	3200	1200	440	440
Analytical Parameters[a]						
Metals (mg/L)						
Arsenic	0.002-.005	0.011	0.01*	ND(.02)	ND	ND
Barium	0.009	0.032	0.039	0.26	0.057	0.041
Cadmium	0.002	ND	ND●	ND(.02)●	ND	0.003*
Chromium	0.005	0.02*	0.01*	0.2*	0.013	0.005*
Lead	0.001-0.002	0.048	0.004*	0.044	0.009	0.013
Mercury	0.0002	ND	ND	ND	0.0002*	ND
Selenium	0.002-0.004	ND	ND	ND	ND●	ND
Silver	0.002	0.008*	0.020	0.13●	ND	0.007*
Volatile Organics (ug/L)						
Method 601 (Halogenated Hydrocarbons)						
Concentration Factor		1	1	1	1	1
Trichloroethylene	0.12	0.16	ND	ND	ND	ND
Method 602 (Aromatic Compounds)						
Concentration Factor		1	1	1	1	1
Toluene	0.2	ND	ND	ND	7.4	11
Extractable Organics (ug/L)						
Method 625 Acid[b]						
Concentration Factor		1	1	1	1	1
Method 625 Base/Neutral						
Concentration Factor		1	1	1	1	1
Bis(2-ethylhexyl)phthalate	2.5	ND	ND	4	5	6
Di-n-butyl phthalate	2.5	3BL	ND	4BL	4	3

* = Value less than five times detection limit.
Errors may range up to 100 percent.
● = Spike recovery not within acceptable limits.
Indicates interferent.
BL = Detected in reagent blank; background subtraction not performed.
\- = Data not collected, measurement omitted in field.
a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.
b = No compounds were detected by this analysis.
ND = Not detected, values in parentheses are actual sample detection limits.

TABLE 4.3.6-3. COMPARISON OF WATER QUALITY AT SITE 4, LANDFILL 4, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location HM-101
METALS (mg/L)		
Chromium	0.05	0.2
Silver	0.05	0.13

* See Table 4.2.2-1 for source of criteria.

Significance of Organic Compounds in Groundwater

Monitoring of wells in the vicinity of Landfill 4 has not detected significant numbers or levels of organic compounds. These findings agree with the data presented by Hargis and Associates (1985).

4.3.7 Zone 1 (Site 13, Die Pits; Site 11, Chrome Pit 2; Site 8, FDTA 5)

These three sites have been combined into one zone. Descriptions are given below.

Site 13, Die Pits

These pits were used for disposal of chromate sludges, metal solutions, and other chemical wastes until 1962, when the site was graded and the entire die yard was paved. The site of the original pits was excavated in 1983-84. Soils from other parts of the die yard were not analyzed at that time.

Site 11, Chrome Pit 2

Miscellaneous liquid and solid wastes, in addition to chromate solutions, were reportedly disposed of at this site. The actual location of this site could not be accurately confirmed during the Phase I (Records Search) investigation.

Site 8, FDTA 5

Previous groundwater analyses indicated elevated levels of organic compounds at this site, which consisted of a shallow pit into which waste fuels, oils, or chemicals were deposited and ignited for training exercises. It is located in the die yard area south of Warehouse 1 and has been graded and paved.

The IRP Phase II Stage I activities at Zone 1 consisted of the collection and analysis of groundwater samples. Monitor wells at this site include HM-11, 12, 24, 25, 28, 60, 77, and P-1. Figure 4.3.7-1 shows the locations of these sampling points and the physical features of the sites.

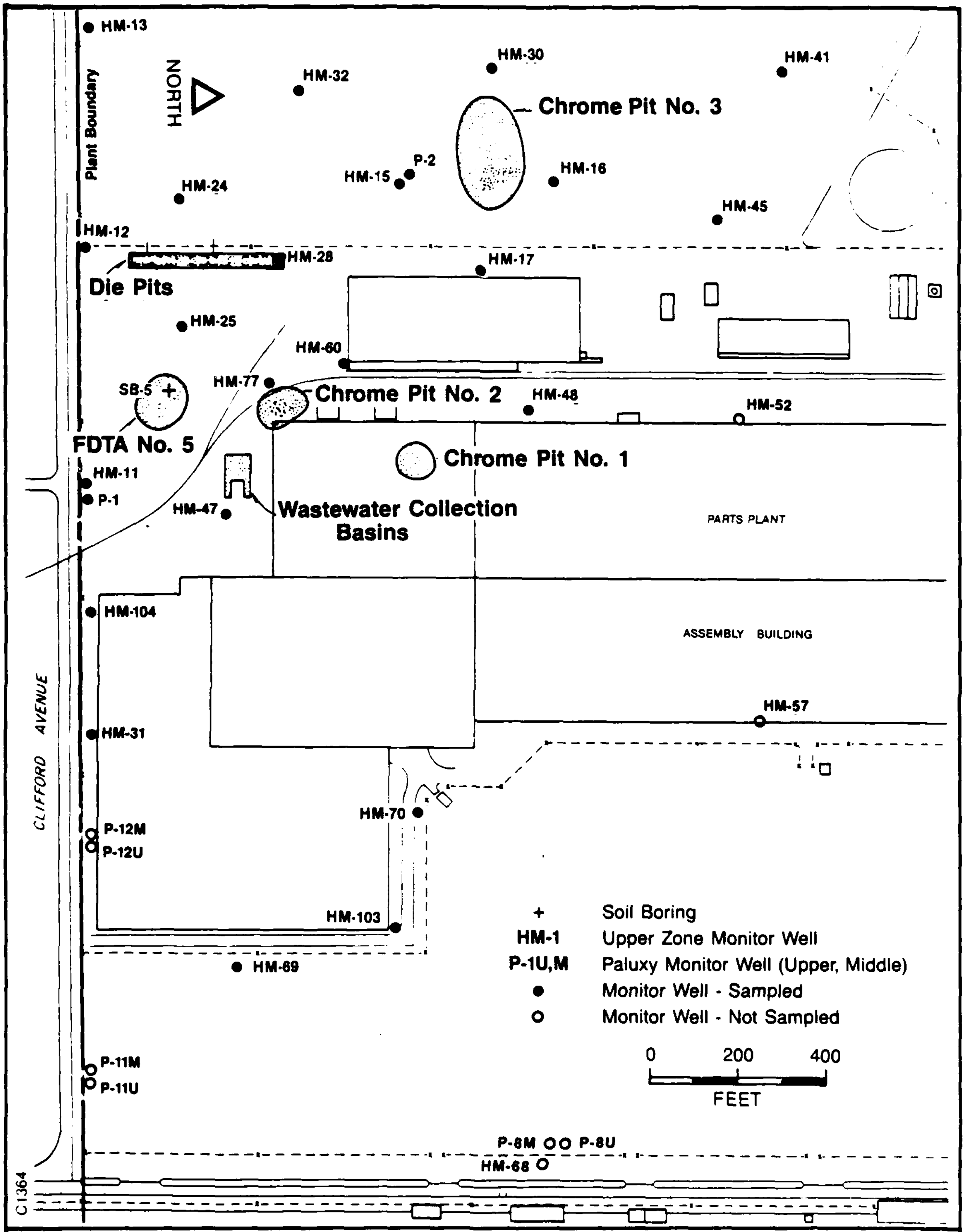

Figure 4.3.7-1. Phase II Activities at Zone 1 (Site 8, Fire Department Training Area 5; Site 11, Chrome Pit 2; and Site 13, Die Pits), AF Plant 4, Texas

Additionally, soil boring SB-5 was drilled in the area of FDTA 5. Based on color, odor, and OVA readings, soil samples were collected from split spoons, as described in Section 3.1.3, and submitted for analysis of hazardous constituents, as reported in Section 3.4. Originally, the purpose of the borehole was to allow for the installation of an upper zone monitor well; however, no water was noted in the borehole even after it had remained open for two days. Therefore, the borehole was grouted from the total depth to the land surface.

4.3.7.1 Results of Investigation

The investigation conducted at Zone 1 focused on the collection, analysis, and interpretation of groundwater quality samples. Results of these activities and descriptions of the topographic and geologic features of the site follow.

Topography

The Die Pits are located just southwest of Warehouse No. 1. The ground surface is flat and the surface elevation is about 652 feet MSL.

Chrome Pit 2 is located about 600 feet east of the Die Pits. The ground surface is flat at this site also and the surface elevation is 652 feet MSL.

FDTA 5 is located just south of Chrome Pit 2. The ground surface is flat and the surface elevation is 652 feet MSL.

Geologic Features

Monitor wells HM-3a, HM-3b, and HM-4a were installed within the Die Pits site but have since been destroyed by excavation. Drill logs of these wells indicate an upper zone composed of about ten feet of fill material overlying the Goodland Limestone.

Monitor wells HM-12, HM-24, HM-25, and HM-28 are located near the Die Pits. Examination of the lithologic logs found in the Hargis and Associates report (1985) indicates an upper zone thickness ranging from five to 28 feet and a range of Goodland Limestone thickness from eight feet at HM-28 to 28 feet at HM-12.

This description of the geologic features at the Die Pits site differs somewhat from that of the Hargis and Associates report (1985). The Hargis report gave the thickness of the upper zone as 18 to 40 feet and that of the Goodland Limestone as 6 to 18 feet. The Walnut Formation was encountered during the construction of all monitor wells at this site.

Monitor well HM-77 is located at Chrome Pit 2. The lithologic log (Hargis and Associates, 1985) shows an upper zone thickness of 30 feet. The upper zone is directly underlain by the Walnut Formation.

Upper zone monitor well HM-25 is located due west of FDTA 5. The lithologic log of this well (Hargis and Associates, 1985) indicates an upper zone thickness of 29 feet. No Goodland Limestone was encountered.

Occurrence of Groundwater

Groundwater in Zone 1 occurs in both the materials of the upper zone and in the Paluxy Formation. Table 4.3.7-1 gives results of water level measurements. The water level map for the upper zone in this area of AF Plant 4 (Figure 4.1.2-7) was discussed previously in Section 4.1.2. Water levels in the upper zone in this area ranged from 644.42 feet MSL at HM-11 to 629.94 feet MSL at HM-77. As shown in Figure 4.1.2-7, groundwater flow in the upper zone is to the northeast in Zone 1. The groundwater elevation at P-1 was measured at 558.44 feet MSL. Groundwater flow in the Paluxy is discussed in Section 4.1.2.

TABLE 4.3.7-1. GROUNDWATER ELEVATIONS AT ZONE 1, (SITES 13, 11 and 8) AF PLANT 4 TEXAS, (FEBRUARY 1986)

Monitor Well	Elevation (feet MSL)	Date
HM-11	644.42	2-10-86
HM-12	641.82	2-14-86
HM-24	642.52	2-19-86
HM-25	634.89	2-11-86
HM-28	632.52	2-6-86
HM-60	634.75	2-6-86
HM-77	629.94	2-6-86
P-1	558.44	2-6-86

Groundwater Quality

Groundwater samples from HM-11, 12, 24, 25, 28, 60, 77, and P-1 were collected and analyzed for volatile organic compounds by EPA Methods 601 and 602, for acid and base/neutral extractable organic compounds by EPA Method 625, and for heavy metals by EPA Methods 200.7, 206.2, 239.2, 245.1 and 270.2.

Table 4.3.7-2 shows the results of the groundwater analyses. Complete analytical reports for these analyses appear in Appendix A.

To evaluate the degree of groundwater contamination, analytical results from IRP Phase II Stage 1 sampling events were compared to federal standards and guidelines. Table 4.3.7-3 summarizes the results of this comparison.

4.3.7.2 Significance of Findings

This section discusses the significance of the findings of this investigation, emphasizing the groundwater chemistry at the site. Hargis & Associates (1985) previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates those findings and trends identified in the Hargis report.

Significance of Metals in Groundwater

Two metals, arsenic and chromium, were reported at concentrations in excess of federal MCL criteria. Arsenic was detected in water sampled from HM-25 at 0.140 mg/L. Chromium was detected in water from HM-28 at 0.120 mg/L.

The Hargis report detected chromium at approximately the same concentration but arsenic was below the instrument detection limit.

TABLE 4.3.7-2. RESULTS OF GROUNDWATER SAMPLE ANALYSES, ZONE 1 (SITES 13, 11 AND 8), AF PLANT 4, TEXAS

Date Sampled	Method Detection Limit	Monitor Well HM-11 2-10-86	HM-12 2-14-86	HM-24 2-19-86	HM-25 2-11-86	HM-28 2-6-86	HM-28D 2-6-86	HM-60 2-6-86	HM-77 2-6-86	P-1 2-6-86
Field Parameters										
Temperature (°C)		18.0	19.5	22.0	16.5	17.0	17.0	19.5	19.0	21.0
pH		7.3	6.8	6.5	6.5	7.0	7.0	7.0	7.2	7.4
Conductivity (umhos)		660	21.00	3100	950	1000	1000	920	850	720
Analytical Parameters[a]										
Metals (mg/L)										
Arsenic	0.002-0.005	ND	0.007*	ND	0.14	ND	NA	0.01*	ND	ND
Barium	0.009	0.040	0.017	0.090	0.47	0.054	NA	0.17	0.099	0.076
Cadmium	0.002	ND	ND●	ND	ND	ND	NA	ND	ND	ND
Chromium	0.005	0.006*	0.008*	0.02*	ND	0.12	NA	0.048	ND	0.007*
Lead	0.001-0.002	0.028	0.010	0.027	0.035	0.003*	NA	0.005*	0.003*	ND●
Mercury	0.0002	ND	ND	ND	ND	ND	NA	ND	ND	0.0002*
Selenium	0.002-0.004	ND	ND	ND	ND	ND	NA	ND	ND	0.003*
Silver	0.002	0.006*	0.007*●	0.013	ND	0.003*	NA	ND	ND	ND
Volatile Organics (ug/L)										
Method 601 (Halogenated Hydrocarbons) Concentration Factor		1	1	1	25	50		25	1	1
Vinyl Chloride	0.18	ND	ND	ND	16	ND	NA	ND	ND	ND
Methylene Chloride	0.25	ND	0.92	2.5	ND	ND	NA	ND	ND	ND
trans-1,2-Dichloroethylene	0.10	ND**	ND	ND	ND**	ND**	NA	ND	ND**	ND
Chloroform	0.05	ND	ND	37	ND	ND	NA	ND	ND	ND
1,2-Dichloropropane	0.04	ND	ND	9.6	13	ND	NA	ND	ND	ND
Trichloroethylene	0.12	26	0.23	7.0	ND	600	NA	400	3.9	ND
Tetrachloroethylene	0.03	1.3	ND	0.98	ND	ND	NA	ND	ND	ND
Chlorobenzene	0.25	ND	ND	ND	4700	ND	NA	ND	ND	ND
1,2-Dichlorobenzene	0.15	ND	ND	ND	190	ND	ND	NA	ND	ND
1,4-Dichlorobenzene	0.24	ND	ND	ND	870	ND	NA	ND	ND	ND
Method 602 (Aromatic Hydrocarbons) Concentration Factor		1	1	1	25	10		10	1	1
Benzene	0.2	ND	ND	ND	470	ND	NA	ND	ND	ND
Toluene	0.2	4.1	1.2	23	ND	ND	NA	ND	ND	ND
Chlorobenzene	0.2	ND	ND	ND	9000	ND	NA	ND	ND	ND
1,2-Dichlorobenzene	0.4	ND	ND	ND	370	ND	NA	ND	ND	ND
1,4-Dichlorobenzene	0.3	ND	ND	ND	730	ND	NA	ND	ND	ND

(Continued)

TABLE 4.3.7-2. (Continued)

Date Sampled	Method Detection Limit	Monitor Well HM-11 2-10-86	HM-12 2-14-86	HM-24 2-19-86	HM-25 2-11-86	HM-28 2-6-86	HM-28D 2-6-86	HM-60 2-6-86	HM-77 2-6-86	P-1 2-6-86
Extractable Organics (ug/L)										
Method 625 Acid Concentration Factor		1	1	1	1	1	1	1	1	1
Phenol	1.5	ND	ND	ND	4	ND	ND	ND	2	2
2-Chlorophenol	3.3	ND	ND	ND	5	ND	ND	ND	ND	ND
Method 625 Base/Neutral Concentration Factor		1	1	1	1	1	1	1	1	1
1,2-Dichlorobenzene	1.9	ND	ND	ND	210	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	4.4	ND	ND	ND	210	ND	ND	ND	ND	ND
N-nitrosodiphenylamine	1.9	ND	ND	3	ND	ND	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	2.5	6BL	ND	8	5BL	4	3	ND	ND	ND
Di-n-butyl phthalate	2.5	ND	ND	3BL	5BL	ND	ND	ND	3	ND
Naphthalene	1.6	ND	ND	ND	52	ND	ND	ND	ND	ND
Hydrocarbon Fuels (mg/L)	1	NA	NA	NA	NA	NA	NA	NA	ND	NA
Oil and Grease (mg/L)	1	NA	NA	NA	NA	NA	NA	NA	ND	NA

ND = Not detected.
NA = Not analyzed.
* = Value less than five times detection limit.
Errors may range up to 100 percent.
@ = Spike recovery not within acceptable limits.
Indicates interferent.
BL = Detected in reagent blank; background subtraction not performed.
** = Compound not confirmed by second-column analysis.
a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor.
Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.
D = Duplicate sample.

TABLE 4.3.7-3. COMPARISON OF WATER QUALITY AT ZONE 1, (SITES 13, 11, AND 8), AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location HM-11	HM-24	HM-25	HM-28	HM-60
METALS (mg/L)						
Arsenic	0.05			0.14		
Chromium	0.05				0.12	
ORGANIC COMPOUNDS (ug/L)						
Vinyl Chloride	1			16		
1,2-Dichloropropane	6		9.6	13		
Trichloroethylene	5	26	7		600	400
Chlorobenzene	60			4700		
Benzene	5			470		
1,4-Dichlorobenzene	750			870		

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

Significance of Organic Compounds in Groundwater

A number of organic compounds exist in upper zone groundwater at levels in excess of federal MCL criteria. Trichloroethylene was detected at HM-11, HM-24, HM-28, and HM-60. These levels ranged from just over the MCL criteria at HM-24, where the concentration of TCE was 7 ug/L, to 600 ug/L at HM-28. Groundwater sampled from HM-25 contained levels of vinyl chloride, 1,2-dichloropropane, chlorobenzene, benzene, and 1,4-dichlorobenzene in excess of federal MCL criteria. In addition, 1,2-dichlorobenzene was detected at 190 ug/L at HM-25. An unknown compound with a retention time near that of trans-1,2-dichloroethylene was detected at HM-25 and HM-28.

These findings are generally consistent with the results of earlier analyses conducted by Hargis and Associates (1985) with the exception of monitor well HM-25. The Hargis report identified trans-1,2-dichloroethylene in concentrations ranging from 40 ug/L (August, 1984) to 260 ug/L (June, 1983). In addition, instead of the high concentrations of vinyl chloride Radian found at HM-25, the Hargis study reported this substance as not detected. Since the Hargis study did not analyze for 1,4-dichlorobenzene, no comparisons could be made.

4.3.8 Site 15, Fuel Saturation Area 2

Between the 1970s and early 1980s, the soils at Fuel Saturation Area 2 became saturated by fuels from leaking buried fuel lines. IRP Phase II Stage I activities at Fuel Saturation Area 2 consisted of drilling three boreholes along the length of a buried fuel line, collecting a groundwater sample from an existing upper zone monitor well (HM-80), and observing the monitor well for the existence of a fuel lens. Monitor well HM-80 was sampled for volatile organics by EPA Methods 601 and 602 and for hydrocarbon fuels by EPA Method 418.1. Soil samples were collected and analyzed for halogenated volatiles and aromatics by EPA Method 8010 and 8020 and for hydrocarbon fuels by EPA Method 418.1. Figure 4.3.8-1 shows the locations of groundwater and soil sampling points along with the physical features of the site.

4.3.8.1 Results of Investigation

The investigation focused on the collection and analysis of samples and the interpretation of data on soil and groundwater quality. Results of these activities and descriptions of the topographic and geologic features of the site follow.

Topography

Fuel Saturation Area 2 is located just northwest of the Paint Shop (Building 176). The ground surface, essentially flat, has an elevation of approximately 648 feet MSL.

Geologic Features

Monitor well HM-80 and soil borings SB-1, -2, and -3 are located in the vicinity of Fuel Saturation Area 2. The lithologic log of HM-80 (Hargis and Associates, 1985) reveals the presence of approximately 18 feet of Goodland Limestone overlain by 6 feet of concrete and fill. SB-1, -2, and -3 are located just west of the site. Lithologic logs of these soil borings

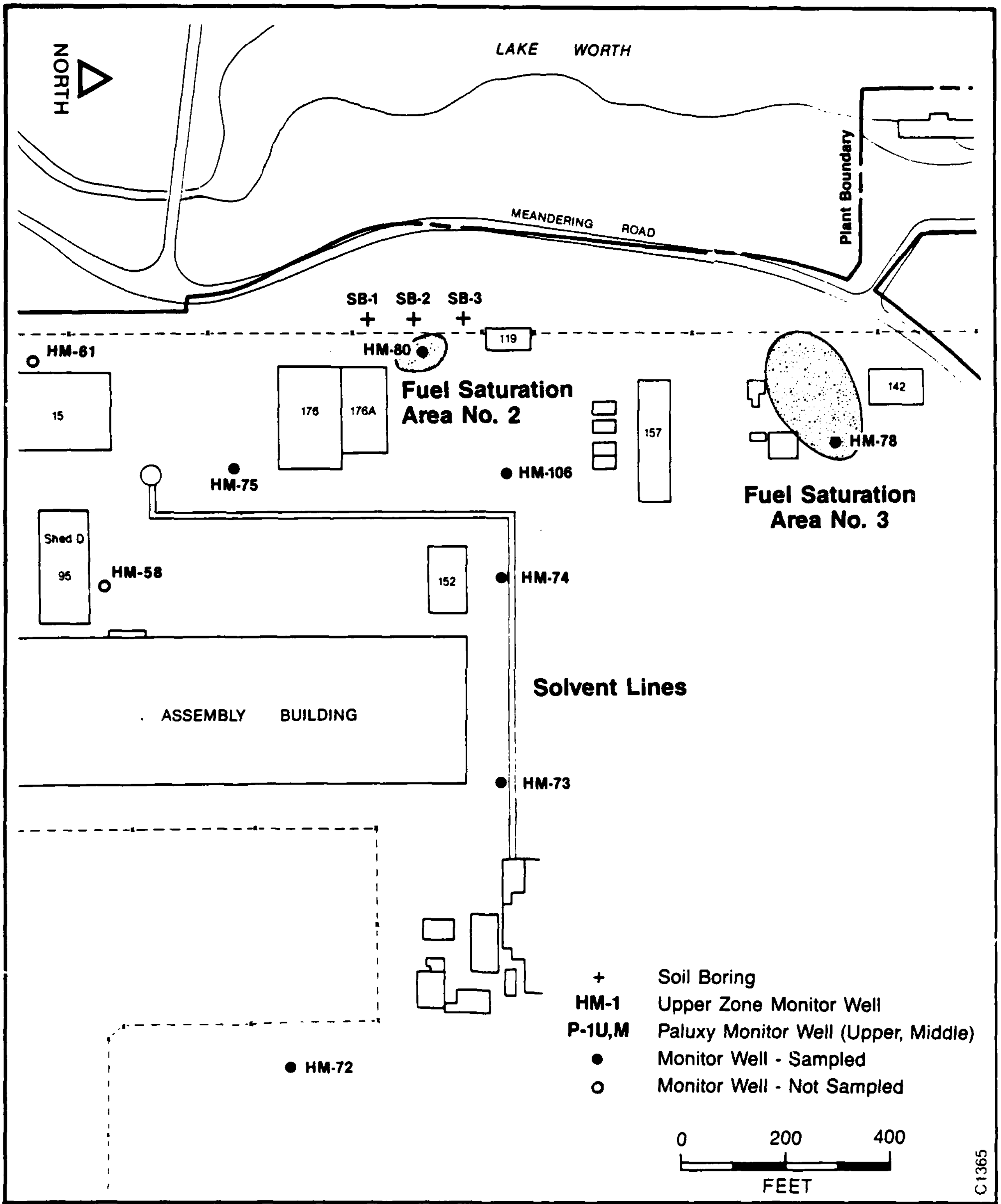

Figure 4.3.8-1. Phase II Activities at Site 15, Fuel Saturation Area 2, AF Plant 4, Texas

(Appendix E, this report) reveal an upper zone thickness of four to five feet at all three soil boring locations. Goodland Limestone was encountered at all three soil boring locations, ranging in thickness from 14 feet at SB-2 to 10 feet at SB-3. About three feet of Walnut Formation was encountered during the drilling of SB-1, -2, and -3.

Occurrence of Groundwater

Because the upper zone is absent at this location, the uppermost occurrence of groundwater is found in the Goodland Limestone at this site. The water level elevation in monitor well HM-80 was 638.99 feet MSL. The water level map for the upper zone in this area of AF Plant 4 (Figure 4.1.2-5) was discussed previously in Section 4.1.2. However, because upper zone sediments are not present at well HM-80, water level contours for the upper zone are not drawn through the area of FSA 2. Groundwater flow in this area is to the north-northwest, toward Meandering Road Creek.

Groundwater Quality

Groundwater samples were collected from monitor well HM-80 and analyzed for volatile organic compounds by EPA Methods 601 and 602 and for hydrocarbon fuels by EPA Method 418.1. Table 4.3.8-1 gives results of the groundwater analyses. Complete analytical reports for these analyses appear in Appendix A.

4.3.8.2 Significance of Findings

This section discusses the significance of the findings of this investigation, emphasizing the groundwater chemistry at the site. Hargis & Associates (1985) previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, the present report recognizes and incorporates those findings and trends identified by the Hargis report.

TABLE 4.3.8-1. RESULTS OF GROUNDWATER SAMPLE ANALYSES, SITE 15, FUEL SATURATION AREA 2, AF PLANT 4, TEXAS

Date Sampled	Method Detection Limit	Monitor Well HM-80 2-5-86
Field Parameters		
Temperature (°C)		19.5
pH		6.8
Conductivity (umhos)		2000
Analytical Parameters[a]		
Volatile Organics (ug/L)		
Method 601 (Halogenated Hydrocarbons) Concentration Factor = 1		
1,2-Dichloropropane	0.04	1.7
Method 602 (Aromatic Compounds)[b] Concentration Factor = 1		
Hydrocarbon Fuels (mg/L)	1	ND

ND = Not detected.

a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.

b = No compounds were detected by this analysis.

Significance of Organic Compounds in Groundwater

IRP Phase II Stage 1 sampling and analysis of the single monitor well at this site (HM-80) detected only 1,2-dichloropropane, which was present at a level below the MCL criteria. No fuel lens was observed in the well. Hydrocarbon fuels were below the instrument detection limit in the groundwater sample. These results are consistent with those of the previous sampling and analysis conducted by Hargis and Associates.

Significance of Organic Compounds in Soils

Table 4.3.8-2 presents the results of soil sample analyses for this site. Organic compounds were detected at low levels except for soil sampled at location SB-2 at 5 to 6 feet. This soil sample had a concentration of hydrocarbon fuels of 4600 mg/kg. However, the concentration decreased at increased depths.

TABLE 4.3.8-2. RESULTS OF SOIL SAMPLE ANALYSES, SITE 15, FUEL SATURATION AREA 2, AF PLANT 4, TEXAS

		Soil Boring (depth - feet)					
Date Sampled	Method Detection Limit	SB-1-A (4-5) 1-24-86	SB-1-C (14-14.5) 1-24-86	SB-2-A (5-6) 1-24-86	SB-2-B (10-11) 1-24-86	SB-2-C (10-11) 1-24-86	SB-3-A (9-10) 1-26-86
Analytical Parameters[a]							
Hydrocarbon Fuels (mg/kg)	4-6	ND	ND	4600	ND	ND	ND
Volatile Organics (mg/kg)							
Method 8010 (Halogenated Hydrocarbons) Concentration Factor		12.5	12.5	12.5	12.5	12.5	12.5
1,1-Dichloroethylene	0.013	ND	ND	0.012	ND	ND	ND
Chloroform	0.005	ND(2.8)	ND(2.8)	ND	ND	ND	ND
Tetrachloroethylene	0.003	ND(1.6)	ND(1.6)	ND	ND(2.1)	ND(2.1)	ND(2.1)
Trichloroethylene	0.019	ND	ND	ND	ND(1.6)	ND(1.6)	ND(1.6)
Method 8020 (Aromatic Compounds) Concentration Factor		125	125	125	125	125	125
Toluene	0.0002	ND(0.68)	ND(0.68)	ND(0.68)	ND(0.68)	ND(0.83)	ND(0.83)
Benzene	0.0002	ND	ND	ND	ND	ND(0.11)	ND(0.11)
Ethylbenzene	0.0002	ND	ND	ND	ND	ND(0.14)	ND(0.14)

ND = Not detected, values in parentheses are actual sample detection limits.

a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor except when species of interest were found in the extractant. The resultant detection limits are reported in parentheses in mg/kg. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.

4.3.9 Site 20, Wastewater Collection Basins

This site consists of two concrete-lined waste basins, each with an approximate capacity of 85,000 gallons. The basins are used to collect and settle suspended solids from plant wastewaters and have been in use since approximately 1966. The Phase I investigation determined that several spills of vapor degreaser from tanks in the Process Building occurred here. Spilled liquids may have flowed to the basin via floor drains in the Process Building. Phase II Stage I studies were conducted to determine if underlying soil and upper zone groundwater have been affected by the spills.

Activities at Site 20 consisted of installing an upper zone monitor well (HM-104) southeast of the basins, collecting groundwater samples from four existing monitor wells and the newly installed well, and determining the location and depth of the buried sanitary and industrial waste lines. Soil samples from HM-104 were not submitted for chemical analysis. The need for soil sampling along the waste lines, based on groundwater analysis, was also evaluated. Upper zone monitor wells at this site include HM-31, 47, 69, 70, and 104. Figure 4.3.9-1 shows the locations of the sampling points. Samples were collected and analyzed for volatile organic compounds by EPA Methods 601 and 602, for acid and base/neutral extractable compounds by EPA Method 625, for heavy metals by EPA Methods 200.7, 206.2, 239.2, 245.1, and 270.2, for oil and grease by EPA Method 413.2, and for hydrocarbon fuels by EPA Method 418.1.

The sanitary sewer line runs on an east-west line through the site. The storm drain is on a northwest-southeast line located approximately 75 feet south of the Wastewater Collection Basins. The depths of these lines are not specified on the underground utilities maps provided by General Dynamics. There is no reason to suspect that the sanitary sewer or the storm drain would carry high levels of hazardous contaminants. Although contaminants were present in the existing site monitor wells, the levels do not suggest massive releases of contaminants; therefore, no soil sampling along these waste lines is deemed necessary.

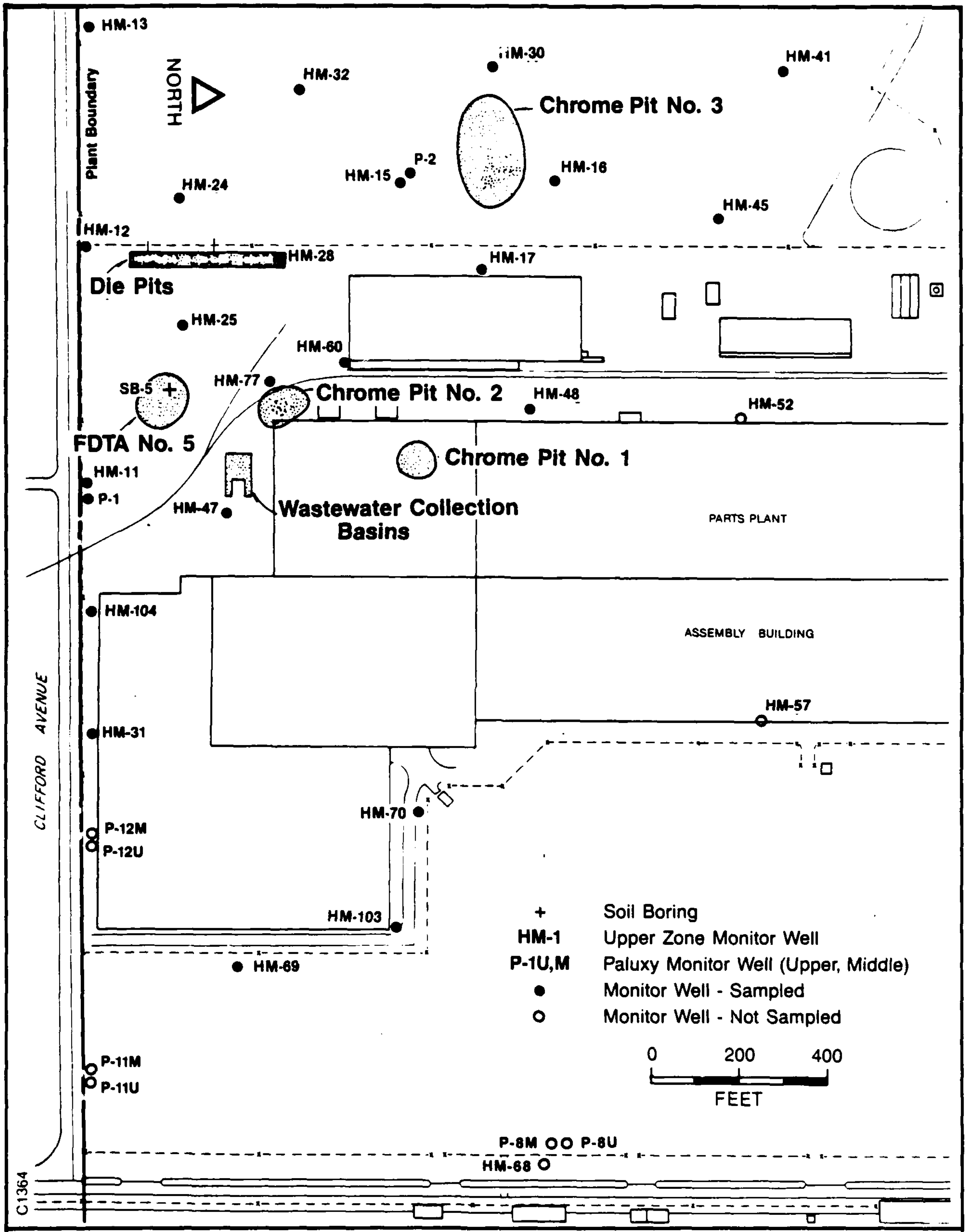

Figure 4.3.9-1. Phase II Activities at Site 20, Wastewater Collection Basins, AF Plant 4, Texas

4.3.9.1 Results of Investigation

The investigation focused on the installation of the upper zone monitor well, HM-104, and on the collection and analysis of groundwater samples. Discussion of the results of these activities and descriptions of the topographic and geologic features of the site follow.

Topography

This site is located just south of Building 181. The ground surface is almost flat, but slopes very slightly to the south. The surface elevation on the south side of the concrete-lined basins is about 652 feet MSL.

Geologic Features

Monitor well HM-47 is located about 50 feet east of the Wastewater Collection Basins. The lithologic log of this well (Hargis and Associates, 1985) indicates an upper zone thickness of 28 feet. The upper zone consists primarily of clayey silt and sand and gravel. The Goodland Limestone is two feet thick. Six feet of Walnut Formation were encountered.

The log of well HM-104, installed during this study, indicates an upper zone thickness of ten feet underlain by 26 feet of Goodland Limestone. About three feet of Walnut Formation were encountered.

This description of the subsurface features at the Wastewater Collection Basins is consistent with that of the Hargis and Associates report (1985).

Occurrence of Groundwater

Water levels in upper zone wells are reported in Table 4.3.9-1. The water level map for the upper zone in this area of AF Plant 4 (Figure 4.1.2-7)

TABLE 4.3.9-1. GROUNDWATER ELEVATIONS AT SITE 20, WASTEWATER COLLECTION BASINS, AF PLANT 4, TEXAS (FEBRUARY THROUGH APRIL 1986)

Monitor Well	Elevation (feet MSL)	Date
HM-31	-	(not measured)
HM-47	620.95	2-6-86
HM-69	630.97	2-21-86
HM-70	624.72	2-19-86
HM-104	622.59	4-10-86

was discussed previously in Section 4.1.2. During January to August 1986, water levels in monitor wells ranged from 630.97 feet MSL at HM-69 to 622.59 feet MSL at HM-104. As shown in Figure 4.1.2-7, groundwater flow is to the southeast in this area.

Groundwater Quality

Groundwater samples were collected from HM-31, 47, 69, 70 and 104 and analyzed for heavy metals by EPA Methods 200.7, 206.2, 239.2, 245.1, and 270, for volatile organic compounds by EPA Methods 601 and 602, for acid and base/neutral extractable compounds by EPA Method 625, for oil and grease by EPA Method 413.2, and for hydrocarbon fuels by EPA Method 418.1. Table 4.3.9-2 gives results of the groundwater analyses. Complete analytical reports for these analyses appear in Appendix A.

To evaluate the degree of groundwater contamination, analytical results from IRP Phase II Stage 1 sampling were compared to federal standards and guidelines. Table 4.3.9-3 summarizes the results this comparison.

4.3.9.2 Significance of Findings

This section discusses the significance of the findings of this investigation, emphasizing the groundwater chemistry at the site. Hargis & Associates (1985) previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates those findings and trends identified by the Hargis report.

Significance of Metals in Groundwater

Three metals (arsenic, chromium, and lead) were detected at this site in concentrations exceeding federal MCL criteria. All were detected in samples taken either from HM-70 or from a duplicate sample from that well. Arsenic was detected at HM-70 at a concentration of 0.062 mg/L. Chromium was

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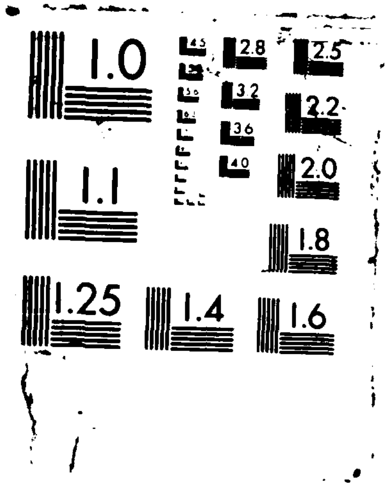
1.0
4.5
2.8
2.5
3.2
2.2
3.6
2.0
4.0
1.1
1.8
1.25
1.4
1.6

TABLE 4.3.9-2. RESULTS OF GROUNDWATER SAMPLE ANALYSES, SITE 20, WASTEWATER COLLECTION BASINS, AF PLANT 4, TEXAS

	Method Detection Limit	Monitor Well						
		HM-31	HM-47	HM-47D	HM-69	HM-70	HM-70D	HM-104
Date Sampled		2-14-86	2-6-86	2-6-86	2-21-86	2-19-86	2-19-86	4-10-86
Field Parameters								
Temperature (°C)		22.0	19.0	19.0	19.5	23.0	23.0	22.0
pH		7.0	7.0	7.0	7.0	6.9	6.9	6.7
Conductivity (umhos)		950	950	950	710	840	840	1600
Analytical Parameters[a]								
Metals (mg/L)								
Arsenic	0.002-0.005	ND	ND	ND	ND	ND	0.062	ND
Barium	0.009	0.031	0.51	0.53	0.054	0.092	0.082	0.045
Cadmium	0.002	ND	ND	ND	ND	ND	ND	ND
Chromium	0.005	ND	0.02*	0.02*	0.032	0.075	0.064	0.009*
Lead	0.001-0.002	0.004*@	ND	ND	0.045	0.040	0.068	ND
Mercury	0.0002	ND	ND	0.0003*	ND	ND	ND	0.002
Selenium	0.002-0.004	ND@	ND	0.003*	ND	ND	ND	0.003*
Silver	0.002	ND	0.003*	ND	0.011	0.01*	0.011	0.005*
Volatile Organics (ug/L)								
Method 601 (Halogenated Hydrocarbons)								
Concentration Factor		100	1000	1000	1	1000	1000	1
Methylene Chloride	0.25	ND	ND	ND	0.63	ND	ND	ND
Trichlorofluoromethane	0.40	ND	ND	ND	19	ND	ND	ND
trans-1,2-Dichloroethylene	0.10	ND**	ND**	ND**	ND**	ND	ND	ND
Trichloroethylene	0.12	2400	11000	12000	3.2	11000	11000	ND
Chlorobenzene	0.25	ND	310	770	ND	ND	ND	ND
Method 602 (Aromatic Compounds)								
Concentration Factor		100	1000	1000	1	1	1	1
Toluene	0.2	ND	ND	ND	ND	ND	ND	0.74
1,1,2,2-Tetrachloroethane	0.03	ND	ND	ND	0.18	ND	ND	ND
Chlorobenzene	0.2	ND	740	710	ND	ND	ND	ND
Method 624								
Concentration Factor						1		
Tetrachloroethylene	1.9	NA	NA	NA	NA	6500	NA	NA
Extractable Organics (ug/L)								
Method 625 Acid								
Concentration Factor		1						
Phenol	1.5	2	NA	NA	NA	NA	NA	NA
Method 625 Base/Neutral								
Concentration Factor		1						
bis(2-ethylhexyl)phthalate	2.5	2	NA	NA	NA	NA	NA	NA
Hydrocarbon Fuels (mg/L)	1	ND	ND	ND	ND	ND	ND	ND
Oil and Grease (mg/L)	1	4	1*	1*	ND	1*	ND	1*

a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.
NA = Not analyzed.
ND = Not detected.
* = Value less than five times detection limit. Errors may range up to 100 percent.
@ = Spike recovery not within acceptable limits. Indicates interferent.
** = Compound not confirmed by second-column analysis.
D = Duplicate.

TABLE 4.3.9-3. COMPARISON OF WATER QUALITY AT SITE 20, WASTEWATER COLLECTION BASINS, AF PLANT 4, WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location		
		HM-31	HM-47	HM-70
METALS (mg/L)				
Arsenic	0.05			0.062
Chromium	0.05			0.075
Lead	0.05			0.068
ORGANIC COMPOUNDS (ug/L)				
Trichloroethylene	5	2400	12000	11000
Chlorobenzene	60		770	
Tetrachloroethylene	8			6500

* See Tables 4.2.2-1 and 4.2.2-2 for source of criteria.

found in groundwater from HM-70 and in a duplicate sample from that monitor well at concentrations of 0.075 mg/L and 0.064 mg/L, respectively. Lead was detected at a concentration of 0.068 mg/L in a duplicate sample from HM-70. Hargis & Associates (1985) detected similar levels of arsenic and chromium from HM-70 in 1985, but detected lead at levels below federal MCL criteria. Chrome Pit 2 is a possible upgradient source of chromium and other heavy metals.

Significance of Organic Compounds in Groundwater

An unknown compound with the same retention time as trans-1,2-dichloroethylene was detected at high levels on the first column from groundwater samples from HM-31 and 47. Hargis & Associates (1985) reported high levels of trans-1,2-dichloroethylene in these wells. Groundwater samples from monitor wells HM-31, 47, and 70 revealed high concentrations of trichloroethylene, ranging from 2400 ug/L in HM-31 to 12000 ug/L in HM-47. Chlorobenzene was also detected in HM-47 at a concentration of 770 ug/L. Tetrachlorethylene was detected in HM-70 at a concentration of 6500 ug/L. These results are generally consistent with those of Hargis & Associates (1985), except for monitor well HM-47, which was found to have TCE concentrations ranging from 27,000 ug/L in 1984 to 3,900 ug/L in 1985. The probable source of the TCE found in upper zone groundwater at this site is the vapor degreaser spilled from tanks in the Process Building located nearby and upgradient of the well.

4.3.10 Site No. 16, Fuel Saturation Area 3

From the mid-1970s until the early 1980s (CH2M Hill, 1984), this site reportedly became saturated by fuels from leaking buried fuel lines.

IRP Phase II Stage 1 activities at this site included the collection of groundwater samples from monitor well HM-78 to determine the presence of a fuel lens. Figure 4.3.10-1 shows the location of well HM-78.

4.3.10.1 Results of Investigation

The IRP Phase II Stage 1 investigation focused on the collection and analysis of groundwater samples from HM-78. Discussions of the results of these activities and descriptions of the topographic and geologic features of the site follow.

Topography

This site is located just southwest of Building 142. The land surface elevation varies from about 642 feet to 644 feet MSL, north to south across the site.

Geologic Features

Upper zone monitor well HM-78 is located within the boundaries of Fuel Saturation Area 3. The lithologic log (Hargis and Associates, 1985) indicates an upper zone thickness of about 20 feet. At the base of the upper zone, four feet of clayey limestone gravel were encountered. About four feet of Walnut Formation were encountered at this location, and Goodland Limestone was absent.

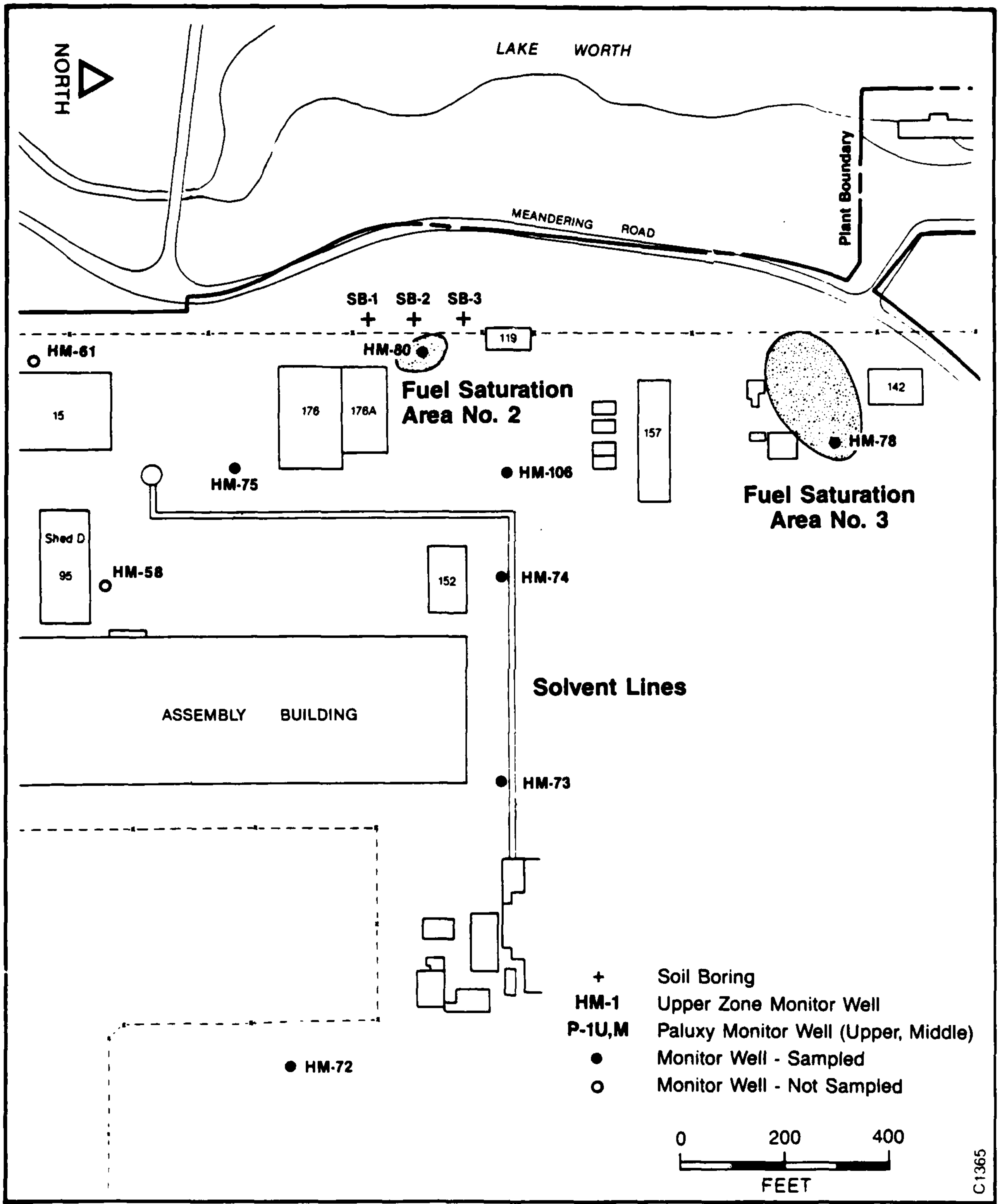

Figure 4.3.10-1. Phase II Activities at Site 16, Fuel Saturation Area 3, AF Plant 4, Texas

Occurrence of Groundwater

Limited water level data from upper zone wells near this site suggest a groundwater elevation between 620 and 624 feet MSL in the vicinity of the site and a generally northwestward flow direction (see Figure 4.1.2-5).

Groundwater Quality

Groundwater was sampled at well HM-78 on 5 February 1986. The sample was analyzed for volatile organic compounds (EPA Methods 601 and 602) and hydrocarbon fuels (EPA Method 418.1). To prevent fouling of the instrument and loss of data at subsequent sampling events, field measurements of temperature, pH and conductivity were not obtained because of the visual evidence of significant contamination of the well. Table 4.3.10-1 gives results of the groundwater analyses. Complete analytical reports for these analyses appear in Appendix A.

4.3.10.2 Significance of Findings

This section discusses the significance of the findings of this investigation, emphasizing the groundwater and soil chemistry at the site. Hargis & Associates (1985) previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates those findings and trends identified in the Hargis report.

Significance of Organic Compounds in Groundwater

To evaluate the degree of groundwater contamination, detected organic parameters were compared to their proposed federal MCLs and RMCLs, as available. The results of this comparison show that benzene, at 8400 ug/L, is the only compound exceeding its proposed MCL. The reported concentration of hydrocarbon fuels was 26 mg/L. No fuel lens was observed at the time of the sampling event, even though one was anticipated.

TABLE 4.3.10-1. RESULTS OF GROUNDWATER SAMPLE ANALYSES, SITE 16, FUEL SATURATION AREA 3, PLANT 4, TEXAS

Date Sampled	Method Detection Limit	Monitor Well HM-78 2-5-86
Field Parameters		
Temperature (°C)		-
pH		-
Conductivity (umhos)		-
Analytical Parameters[a]		
Volatile Organics (ug/L)		
Method 601 (Halogenated Hydrocarbons)		
Concentration Factor		1
Vinyl Chloride	0.18	0.33
Methylene Chloride	0.25	0.32
Trichlorofluoromethane	0.40	2.5
trans-1,2-Dichloroethylene	0.10	ND**
Trichloroethylene	0.12	0.96
Method 602 (Aromatic Compounds)		
Concentration Factor		1000
Benzene	0.2	8400
Hydrocarbon Fuels (mg/L)	1	26

ND = Not detected.
** = Compound not confirmed by second-column analysis.
- = Data not collected, omitted to prevent fouling instrument.
a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.

Concentrations of hydrocarbon fuels at HM-78 were not reported in the Hargis report. In addition to the high levels of benzene reported here, the Hargis report identified high concentrations of chlorodibromomethane, ethylbenzene, and toluene in groundwater from HM-78. The absence of a fuel lens at the time of sampling disagrees with the previously reported fuel lens.

4.3.11 Site No. 9, FDTA 6

FDTA 6 was the designated FDTA from the late 1950s until 1980, when it was closed. This site consisted of a 50-foot diameter gravel-lined ring surrounded by a low, earthen berm. Before 1970, training exercises were conducted twice a year at this site. After 1970, exercises were conducted at monthly intervals. Approximately 250 gallons of waste fuels and oils were reportedly used for each exercise. In addition, it is suspected that larger quantities of waste fuels and oils were deposited in the FDTA between exercises (CH2M Hill, 1984).

In 1983 FDTA 6 was excavated and removed as part of the hazardous waste remedial action program conducted at the plant. The excavated material was analyzed and disposed of at approved hazardous waste disposal sites (CH2M Hill, 1984).

IRP Phase II Stage 1 investigative activities entailed hand augering, collection of soil samples, and the collection of one groundwater sample from Paluxy monitor well P-3. Soil samples were analyzed for acid and base/neutral extractable compounds (EPA Method 8240 and 8270), for halogenated and aromatic volatiles (EPA Methods 8010 and 8020), for hydrocarbon fuels (EPA Method 418.1), and for oil and grease (EPA Method 413.2). The groundwater sample was analyzed for volatile organic compounds, acid and base/neutral extractable compounds, hydrocarbon fuels, and oil and grease. Figure 4.3.11-1 shows the locations of sampling points.

4.3.11.1 Results of Investigation

The investigation at this site included hand augering and the collection and analysis of soil samples, and the collection and analysis of a groundwater sample from well P-3. A discussion of the results of these activities and descriptions of the topographic and geologic features of the site follow.

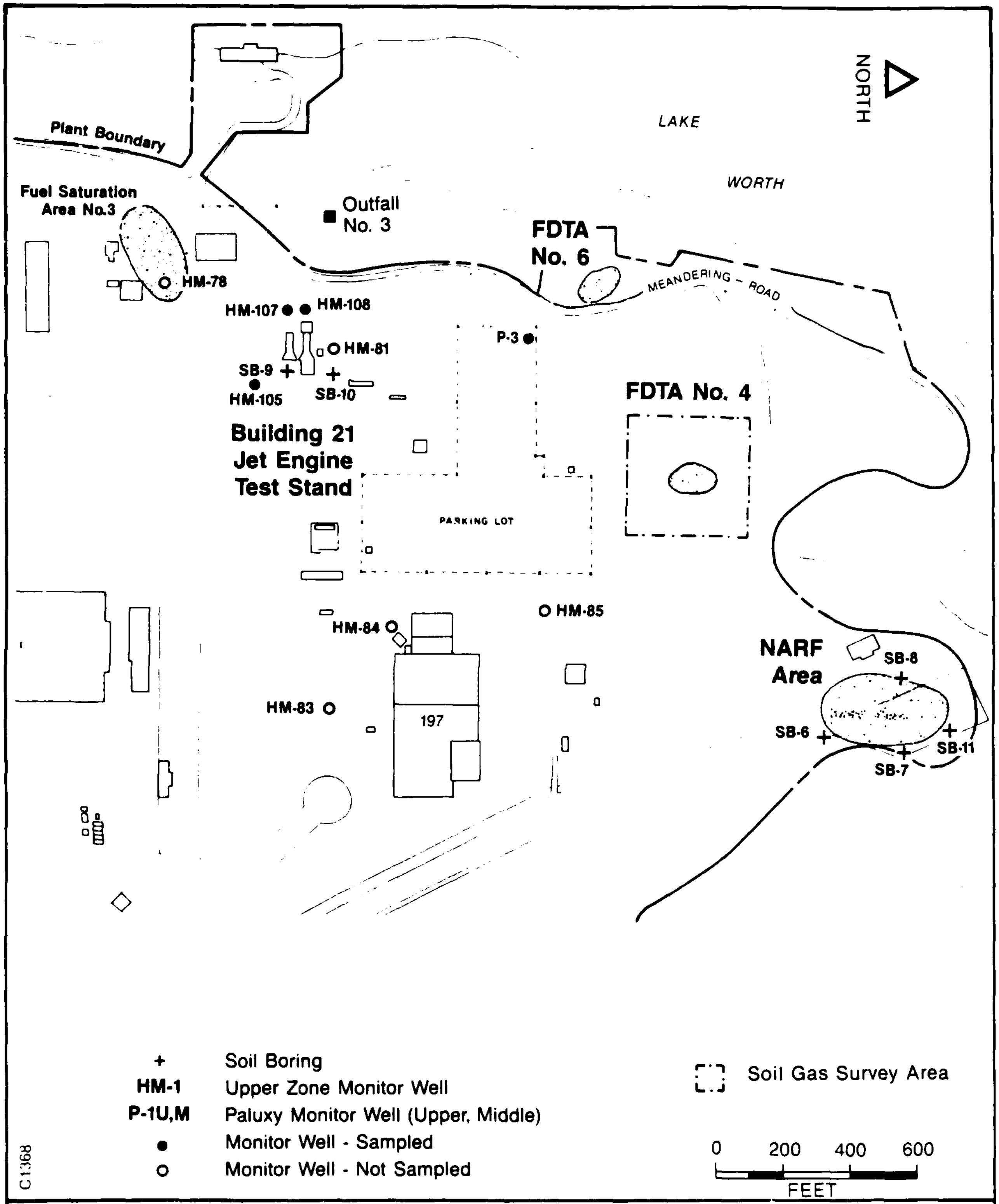

Figure 4.3.11-1. Phase II Activities at Site 9, Fire Department Training Area 6, AF Plant 4, Texas

Topography

This former Fire Department Training Area is located west of Meandering Road and north of the North Parking Lot. The ground slopes westward toward Meandering Road Creek and surface elevations are generally between 620 feet and 630 feet MSL.

Geologic Features

No monitor wells have been installed at FDTA 6. Information on test hole TH-26 at this site is provided by Hargis and Associates (1985). At TH-26 the upper zone consists of two feet of fill. The Walnut Formation was encountered at two feet below land surface. The Goodland Limestone was not encountered.

Occurrence of Groundwater

On 4 February 1986, the static water level was measured in Paluxy well P-3, the only well associated with FDTA 6. The groundwater elevation was 591.03 feet MSL. However, since this well is screened through the upper, middle, and lower sections of the aquifer, this water level cannot be correlated with groundwater elevations in other Paluxy wells screened across individual zones. The projection of contours on the potentiometric surface of the upper Paluxy (Figure 4.1.2-2), however, suggest a generally southeastward flow direction in this area.

Groundwater Quality

The groundwater sample from well P-3 was collected on 4 February 1986 and analyzed for acid and base/neutral extractables (EPA Method 625); for volatile organics (EPA Methods 601 and 602); for hydrocarbon fuels (EPA Method 418.1); and for oil and grease (EPA Method 413.2). In addition, the water sample was field-checked for temperature, pH and conductivity. Table 4.3.11-1 summarizes the results of these analyses. Complete lab reports for all analyses appear in Appendix A. All positive analytical results were compared to

TABLE 4.3.11-1. RESULTS OF GROUNDWATER SAMPLE ANALYSES, SITE 9, FIRE DEPARTMENT TRAINING AREA 6, AF PLANT 4, TEXAS

Date Sampled	Method Detection Limit	Monitor Well P-3 2-4-86
Field Parameters		
Temperature (°C)		20.0
pH		6.8
Conductivity (umhos)		720
Analytical Parameters[a]		
Volatile Organics (ug/L)		
Method 601 (Halogenated Hydrocarbons)[b] Concentration Factor = 1		
Method 602 (Aromatic Compounds)[b] Concentration Factor = 1		
Extractable Organics (ug/L)		
Method 625 Acid Concentration Factor = 1		
Phenol	1.5	2
Method 625 Base/Neutral Concentration Factor = 1		
Di-n-butyl phthalate	2.5	3BL
Hydrocarbon Fuels (mg/L)	1	ND
Oil and Grease (mg/L)	1	ND

ND = Not detected.
BL = Detected in reagent blank; background subtraction not performed.
a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.
b = No compounds were detected by this analysis.

federal MCLs and guidelines to evaluate the degree of groundwater contamination. Results of this comparison are discussed in Section 4.3.11.2.

4.3.11.2 Significance of Findings

A discussion of the significance of the analytical results obtained for soil and groundwater samples collected in the Phase II Stage 1 effort follows. These data are compared to data from earlier efforts, where available, and any apparent trends are noted.

Significance of Organic Contaminants in Groundwater

A comparison of organic analyses from well P-3 groundwater samples with federal proposed MCLs and RMCLs revealed no exceedances. None of the regulated compounds were present in detectable quantities. Low concentrations of phenol (2 ug/L) and di-n-butyl phthalate (3 ug/L) were identified. However, di-n-butyl phthalate was detected in the blank. Therefore, its presence in the groundwater sample may be spurious. Results of the groundwater analyses indicate that local groundwater quality has not been degraded by past fire training activities in this area. These observations are generally consistent with those of the Hargis and Associates (1985) report.

Significance of Organic Compounds in Soil

On 12 May 1986, six shallow (6 to 18 inches) soil samples were collected from hand-augered borings in the vicinity of FDTA No. 6. Figure 4.3.11-2 illustrates the locations of the borings. Each sample was analyzed for acid and base/neutral extractable organics; hydrocarbon fuels; and for oil and grease. Table 4.3.11-2 summarizes the results of all positive analyses.

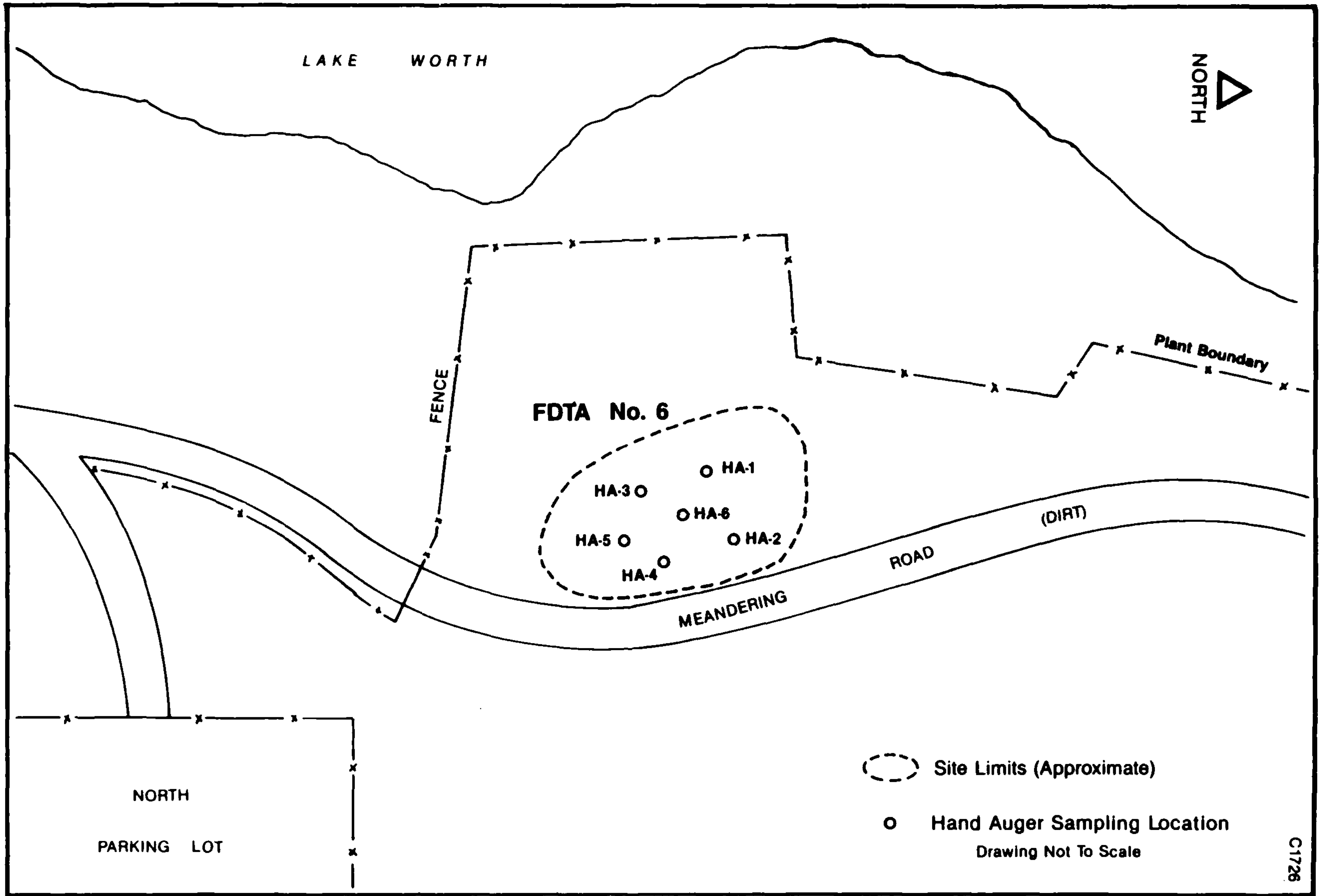

Figure 4.3.11-2. Phase II Hand Augering Activities at Site 9, Fire Department Training Area 6, AF Plant 4, Texas

TABLE 4.3.11-2. RESULTS OF SOIL SAMPLE ANALYSES, SITE 9, FIRE DEPARTMENT TRAINING AREA 6, AF PLANT 4, TEXAS

		Soil Boring (depth-inches)					
Date Sampled	Method Detection Limit	HA-1 (8) 5-12-86	HA-2 (8) 5-12-86	HA-3 (6) 5-12-86	HA-4 (12-18) 5-12-86	HA-5 (10-15) 5-12-86	HA-6 (11-15) 5-12-86
Analytical Parameters[a]							
Hydrocarbon Fuels (mg/kg)	4-6	2600	4000	3800	230	14000	ND
Oil and Grease (mg/kg)	4-6	4700	5600	5600	830	13000	ND
Volatile Organics (mg/kg)							
Method 8010 (Halogenated Hydrocarbons)							
Concentration Factor		12.5	12.5	12.5	12.5	12.5	12.5
1,1,1-Trichloroethane	0.00003	.020	.021	.022	ND	ND	ND
Method 8020 (Aromatic Compounds)[b]							
Concentration Factor		2500	2500	2500	2500	250000	2500
Extractable Organics (mg/kg)							
Method 8270 Acids[b]							
Concentration Factor		37	36	37	39	120	41
Method 8270 Base/Neutrals							
Concentration Factor		37	36	37	39	120	41
Bis (2-ethylhexyl) phthalate	0.0025	2.5	3.1	ND	0.15	ND	ND
Di-n-butyl phthalate	0.0025	ND	0.95	1.5	0.10	0.71	ND
Di-ethyl phthalate	0.0019	ND	0.22	ND	ND	ND	ND
Naphthalene	0.0016	ND	ND	ND	ND	2.3	ND
Phenanthrene	0.0054	ND	ND	ND	ND	0.83	ND

ND = Not detected.

a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.

b = No compounds were detected by this analysis.

Five of the six shallow soil samples collected at this site show evidence of residual contamination associated with past fire training activities. Sample HA-6 most closely reflects background soil conditions; all analytical parameters were below detection. The remaining samples contained hydrocarbon fuels in concentrations ranging from 230 to 14,000 mg/kg and a similar range of oil and grease concentrations (830 to 13,000 mg/kg). Several phthalate species were detected in concentrations from 0.15 to 3.1 mg/kg, and naphthalene and phenanthrene were detected in sample HA-5 at concentrations of 2.3 and 0.83 mg/kg, respectively. The only volatile compound detected was 1,1,1-trichloroethane. It was identified at 0.020 to 0.022 mg/kg in the three shallowest soil samples (HA-1, HA-2, and HA-3).

The moderate levels of organic contaminants associated with the soils reflect the environmental effects of past waste disposal activities. However, these contaminants are apparently being retained within the soils.

4.3.12 Site 6, FDTA 3

During the mid-1960s, FDTA 3 was reportedly the site of routine fire department training exercises which used about 250 gallons per exercise of waste fuels and oils.

Activities at this site included the installation of upper zone monitor well HM-102 and the collection of groundwater samples from monitor wells HM-33 and HM-102. Figure 4.3.12-1 shows the locations of these wells. Groundwater samples were analyzed for volatile organic compounds by EPA Methods 601 and 602, for hydrocarbon fuels by EPA Method 418.1, and for oil and grease by EPA Method 413.2.

4.3.12.1 Results of Investigation

A discussion of the results of IRP Phase II Stage 1 activities at FDTA 3 and descriptions of the topographic and geologic features of the site follow.

Topography

FDTA 3 is located northeast of Landfill 4 between Bomber Road and Meandering Road Creek. The land surface slopes slightly toward the creek. Surface elevations in the general vicinity vary from about 650 feet to 640 feet MSL.

Geologic Features

Monitor well HM-33 is located at FDTA 3. The lithologic log of this well (Hargis and Associates, 1985) reveals an upper zone thickness of 20 feet, consisting of about 18 feet of fill and two feet of clay. Approximately 2.5 feet of Goodland Limestone and six feet of Walnut Formation were encountered.

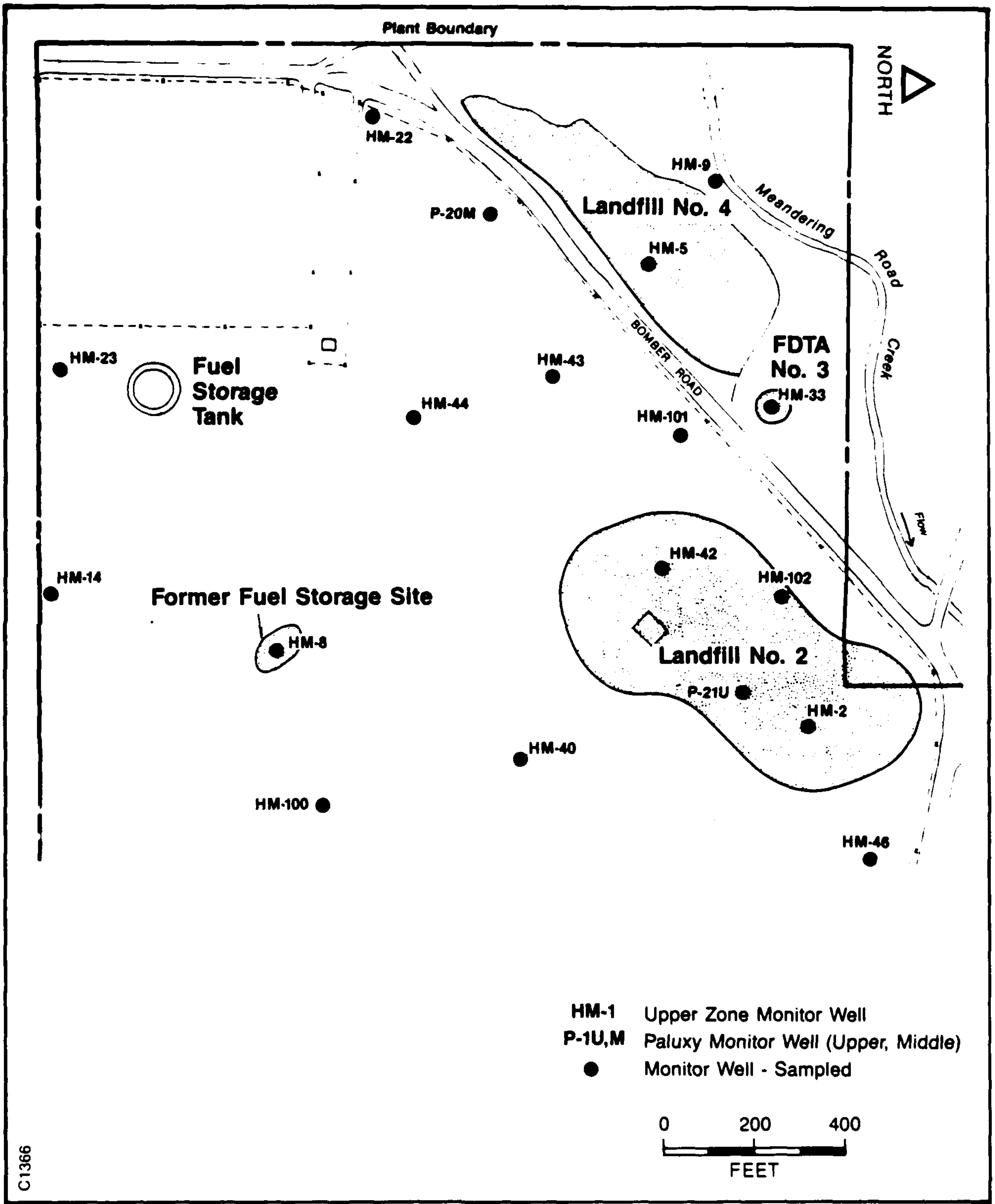

Figure 4.3.12-1. Phase II Activities at Site 6, Fire Department Training Area 3, AF Plant 4, Texas

Monitor wells HM-101 and HM-102, which were installed south and east of the site, yielded additional information on the geologic features at this site. The lithologic logs of these wells (Appendix E) show that the Goodland Limestone is absent south of FDTA 3 at HM-101; however, at HM-102, 28 feet of Goodland Limestone (consisting of shale and sand and limestone gravel) were encountered.

Occurrence of Groundwater

Static water levels in the upper zone were measured in HM-33 (located within the suspected boundaries of FTDA 3) and in HM-102, installed about 850 feet east of the site as part of this study. The groundwater elevation in HM-33 was 635.37 feet MSL on 8 February 1986. The elevation in HM-102 was 632.15 feet MSL on 9 April 1986. These data are insufficient to define groundwater flow direction. Figure 4.1.2-8 is the water level map for the upper zone in this area of AF Plant 4 which suggests a northerly groundwater flow direction through the site.

Groundwater Quality

Before this investigation, toluene was detected at a concentration of 8 ug/L in a sample from HM-33 collected in August 1984. For this study, groundwater samples were collected from monitor well HM-33 and from newly installed HM-102 on 2 February 1986 and 9 April 1986, respectively. The samples, including a duplicate split from HM-33 (HM-33D) were analyzed for volatile organic compounds (EPA Methods 601 and 602), for hydrocarbon fuels (EPA Method 418.1) and for oil and grease (EPA Method 413.2). Temperature, pH and conductivity were also measured in the field. Table 4.3.12-1 summarizes all positive analyses. Complete lab reports appear in Appendix A.

TABLE 4.3.12-1. RESULTS OF GROUNDWATER SAMPLE ANALYSES, SITE 6, FIRE DEPARTMENT TRAINING AREA 3, AF PLANT 4, TEXAS

	Method Detection Limit	Monitor Well		
Date Sampled		HM-33 2-28-86	HM-33D 2-28-86	HM-102 4-9-86
Field Parameters				
Temperature (°C)		20.0	20.0	20.0
pH		6.9	6.9	6.5
Conductivity (umhos)		900	900	630
Analytical Parameters[a]				
Volatile Organics (ug/L)				
Method 601 (Halogenated Hydrocarbons)				
Concentration Factor		1	1	1
Methylene Chloride	0.25	ND	0.34	ND
Method 602 (Aromatic Compounds)				
Concentration Factor		1	1	1
Toluene	0.2	ND	0.64	0.95
Hydrocarbon Fuels (mg/L)	1	ND	ND	ND
Oil and Grease (mg/L)	1	ND	ND	1*

ND = Not detected.
* = Value less than five times detection limit. Errors may range up to 100 percent.
D = Duplicate sample.
a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.

4.3.12.2 Significance of Findings

This section discusses the significance of the findings of this investigation, emphasizing the groundwater and soil chemistry at the site. Hargis & Associates (1985) previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates those findings and trends identified by the Hargis report.

Significance of Organic Compounds in Groundwater

None of the organic parameters analyzed exceeded federal MCL criteria. Oil and grease, and hydrocarbon fuels concentrations were at or below the detection limit (1 mg/L) in all samples analyzed. Methylene chloride and toluene were the only volatile organic compounds detected. Both compounds were identified at low levels (<1 ug/L) in one split of the duplicate samples from HM-33. Toluene was also detected at a concentration of 0.95 ug/L in the sample from well HM-102.

As previously mentioned, toluene was initially detected in a sample from well HM-33 in 1984. However, the concentration was almost an order-of-magnitude higher than determined in this study. Also, considering the generally northward flow direction through the site, it is unlikely that the presence of toluene in well HM-102 is related to past fire training activities. Well HM-102 is located just within the boundary of Landfill 2, which represents a more likely source of the observed low-level organic contamination. While the trace amounts of volatile organics identified at HM-33 may be related to former site activities, their extent and thus the potential for adverse environmental effects are considered minimal. These findings are generally consistent with those of the Hargis and Associates report (1985).

4.3.13 Site 7, Fire Department Training Area 4

During the late 1960s, FDTA 4 was reportedly the site of fire department training exercises which used about 250 gallons per exercise of waste fuels and oils. Figure 4.3.13-1 shows the reported location of the site.

Activities at FDTA 4 consisted of a soil-gas survey conducted to determine the location of the old fire training area. Results of the soil gas survey appear in Appendix I. After 28 soil-gas samples had been taken and no definite hydrocarbons noted, AF Plant 4 fire department personnel were requested to pinpoint the fire department training area noted in the Phase I report. The fire department personnel contacted stated that no FDTA had ever existed at this location; therefore, no further work was conducted at this site.

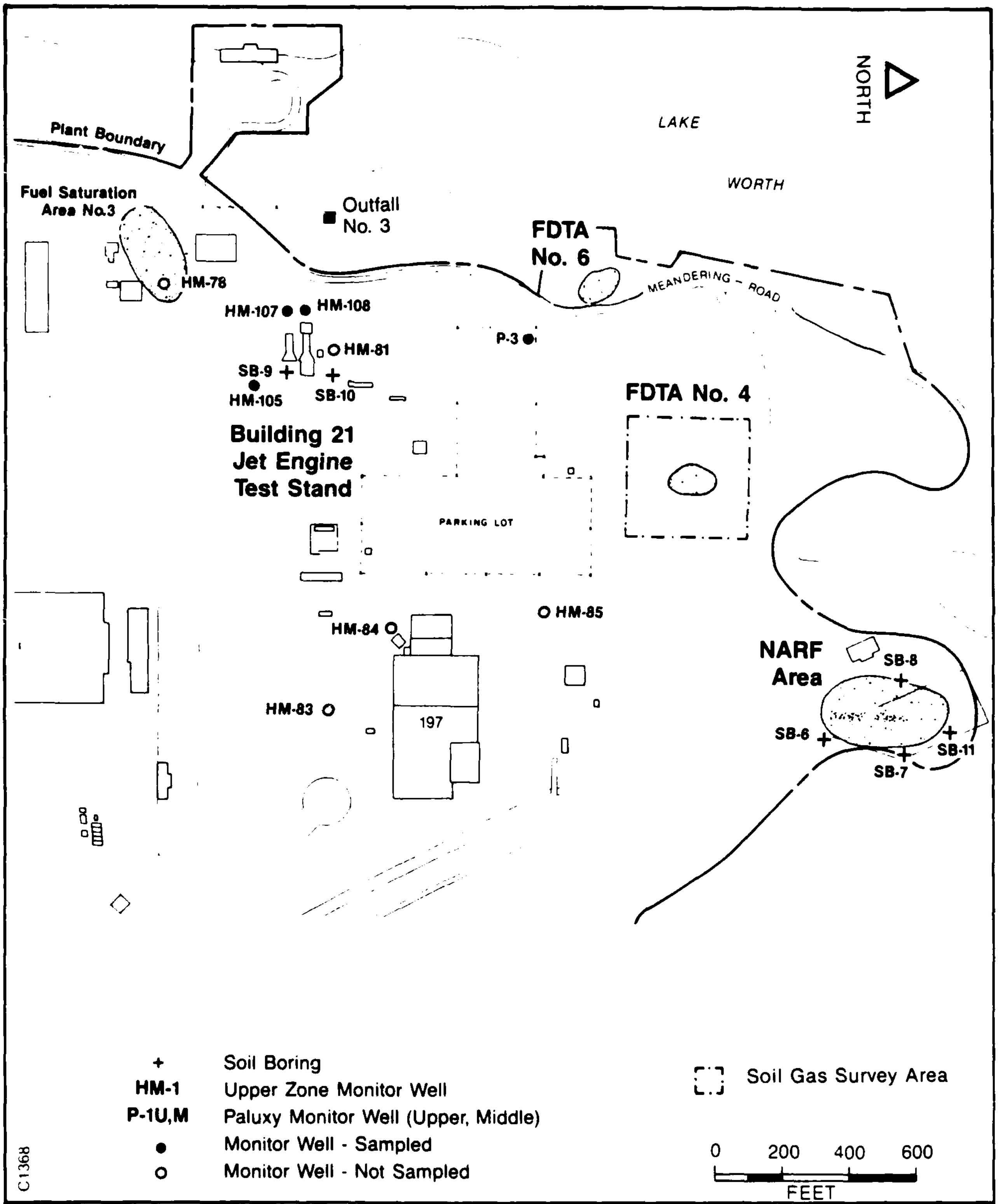

Figure 4.3.13-1. Phase II Activities at Site 7, Fire Department Training Area 4, AF Plant 4, Texas

4.3.14 Site 18, Solvent Lines

Formerly, these solvent lines reportedly carried xylene, methyl ethyl ketone, and kerosene. Leaks occurred during the 1940's before the lines were drained, capped, and abandoned in place in 1944. The actual locations of the leaks are not known (CH2M Hill, 1984).

IRP Phase II Stage 1 activities at Site 18 consisted of the installation of a downgradient monitor well in the upper zone, HM-106, collection of soil samples from that well, and collection and analysis of groundwater from HM-72, 73, 74, 75, and 106. Figure 4.3.14-1 shows the locations of these sampling points. Soil samples were analyzed for oil and grease by EPA Method 413.2 and for xylene. Groundwater samples were analyzed for oil and grease by EPA Method 413.2, for xylene by EPA Method 602, and for methyl ethyl ketone by EPA Method 8015.

4.3.14.1 Results of Investigation

A discussion of the results of IRP Phase II Stage 1 activities at Site 18 and descriptions of the topographic and geologic features of the site follow.

Topography

This site is located along the route of the former buried solvent lines from the northeast corner of Facility No. 15 to the Test Lab, Facility No. 80. The topography along this corridor has a maximum relief of about four feet in the area north of the Assembly Building, but it is nearly flat, with a surface elevation of approximately 650 MSL, along the north-south trending section (east of Building 176).

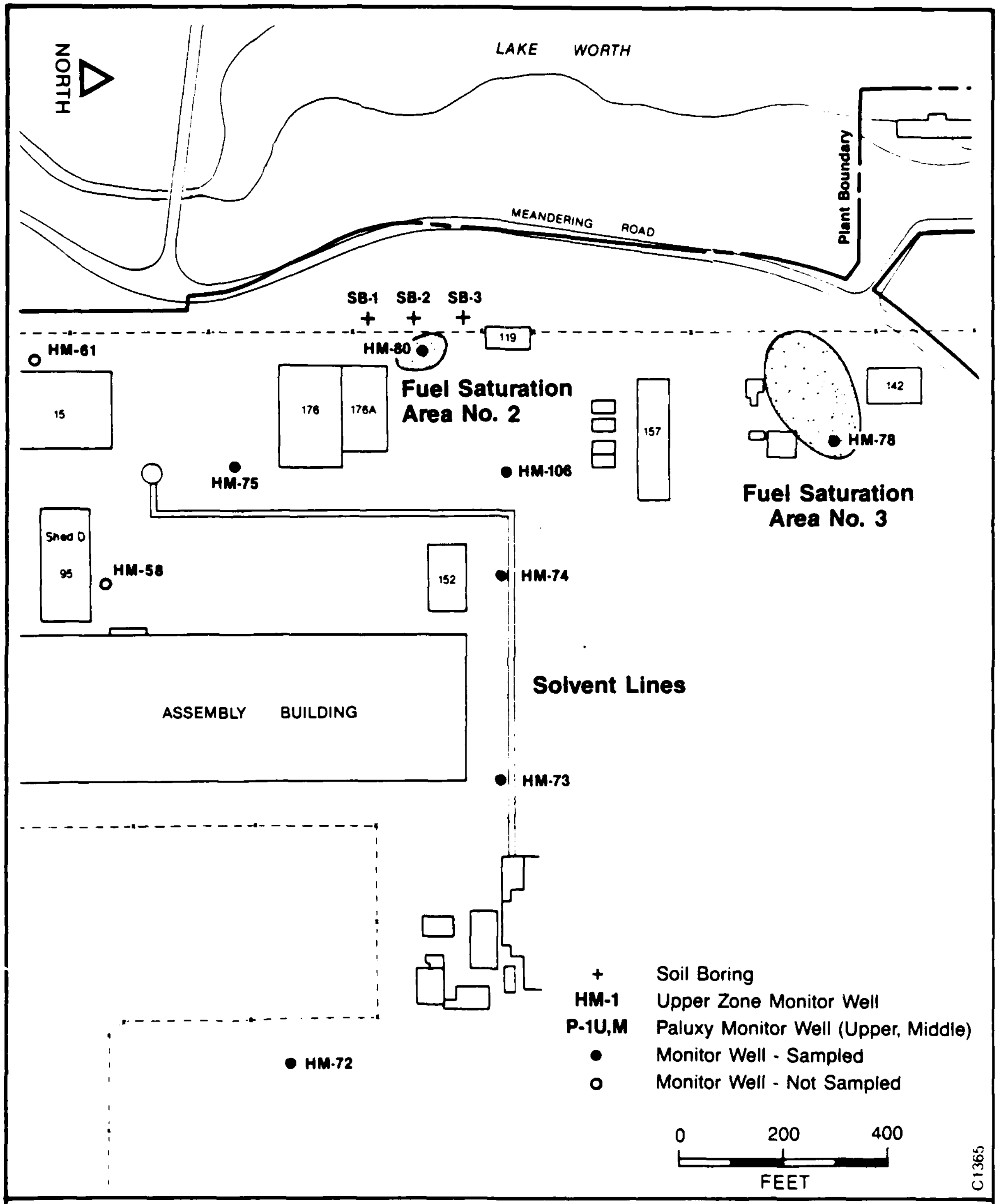

Figure 4.3.14-1. Phase II Activities at Site 18, Solvent Lines, AF Plant 4, Texas

Geologic Features

Information on shallow subsurface features derived from lithologic logs of HM-72, 73, 74, and 75 is taken from Hargis and Associates (1985). The lithologic log of well HM-106 appears in Appendix E of this report.

Upper zone monitor wells HM-72, HM-73, HM-74, HM-75, and HM-106 were drilled adjacent to the buried solvent lines. The upper zone at HM-73, 74, and 75 ranges from 4 to 32 feet in thickness and is dominated by clay. No Goodland Limestone was encountered at well HM-74, but 20 feet were encountered at well HM-73 and 18 feet were encountered at well HM-75. The upper zone at HM-106 is 29 feet thick and composed of sand, clay, and shale. A 0.5-foot layer of Goodland Limestone was found at HM-106 and the Walnut Formation was encountered at a depth of 32 feet.

Occurrence of Groundwater

Groundwater occurs in the upper zone of this site. Table 4.3.14-1 gives the results of water level measurements. The water level map of the upper zone in this area of AF Plant 4 (Figure 4.1.2-5) was discussed previously in Section 4.1.2. Water levels measured in the upper zone ranged from 640.31 MSL at HM-73 to 629.71 MSL at HM-74. HM-106 was dry when measured in April, 1986, although it contained water when installed in January. As shown in Figure 4.1.2-5, groundwater flow in the upper zone is to the northwest.

Groundwater Quality

Groundwater samples were collected from monitor wells HM-72, 73, 74, and 75 and analyzed for oil and grease, xylene and methyl ethyl ketone. Table 4.3.14-2 gives results of the groundwater analyses. Complete analytical reports for these analyses appear in Appendix A.

TABLE 4.3.14-1. GROUNDWATER ELEVATIONS AT SITE 18, SOLVENT LINES AF PLANT 4, TEXAS (FEBRUARY 1986)

Monitor Well	Elevation (feet MSL)	Date
HM-72	642.26	2-14-86
HM-73	640.31	2-26-86
HM-74	629.71	2-5-86
HM-75	639.20	2-18-86
HM-106	-	- (dry)

TABLE 4.3.14-2. RESULTS OF GROUNDWATER SAMPLE ANALYSES, SITE 18, SOLVENT LINES, AT PLANT 4, TEXAS

	Method	Monitor Well				
	Detection	HM-72	HM-73	HM-74	HM-75	HM-106
Date Sampled	Limit	2-14-86	2-26-86	2-5-86	2-18-86	4-18-86
Field Parameters						
Temperature (°C)		23.0	24.5	20.5	23.0	NS
pH		6.8	6.5	6.1	6.1	NS
Conductivity (umhos)		1500	1700-3600	5400	2300	NS
Analytical Parameters						
Oil and Grease (mg/L)	1	ND	ND	ND	ND	NS
Xylenes (ug/L)						
m-Xylene	0.2	ND	ND	ND	ND	NS
p-Xylene	0.2	ND	ND	ND	ND	NS
o-Xylene	0.2	ND	ND	ND	ND	NS
Methyl Ethyl Ketone (ug/L)	1000	ND	ND	ND	ND	NS

ND = Not detected.
NS = Not sampled. Well was dry.

4.3.14.2 Significance of Findings

This section discusses of the significance of the findings of this investigation, emphasizing the groundwater and soil chemistry at the site. Hargis & Associates (1985) previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates those findings and trends identified by the Hargis report.

Significance of Organic Compounds in Soils

Soil samples collected at 9-9.5 feet and at 24-24.5 feet during the installation of HM-106 were analyzed for oil and grease, xylene, and methyl ethyl ketone (MEK). Table 4.3.14-3 shows the results of soil sample analyses. Xylene, oil and grease and MEK were not detected in either sample.

Significance of Organic Compounds in Groundwater

IRP Phase II Stage 1 sampling and analysis of the monitor wells at this site detected no organic compounds in concentrations in excess of federal MCL criteria. Methyl ethyl ketone, oil and grease, and xylene were undetected in all four of the samples analyzed. Hargis & Associates (1985) did not analyze for these parameters; therefore, no comparison can be made.

4.3.15 Site 10, Chrome Pit 1

Chrome Pit 1 was used during the early 1940s. It is suspected that miscellaneous liquid and solid chemical wastes, in addition to chrome wastes, were disposed of at this site. Although the location of this site is believed to be somewhere beneath the Process Building, its exact location could not be determined from interviews or aerial photographs.

TABLE 4.3.14-3. RESULTS OF SOIL SAMPLE ANALYSES, SITE 18, SOLVENT LINES, AF PLANT 4, TEXAS

		Soil Boring (depth - feet)	
Date Sampled	Method Detection Limit	HM-106-A (9-9.8) 1-26-86	HM-106-C (24-24.5) 1-26-86
Analytical Parameters			
Oil and Grease (mg/kg)	4-6	ND	ND
Xylenes (mg/kg)			
p-Xylene	0.11	ND	ND
m-Xylene	0.16	ND	ND
o-Xylene	0.12	ND	ND
Methyl Ethyl Ketone (mg/kg)	1	ND	ND

ND = Not detected.

Activities at Chrome Pit 1 consisted of installing upper zone monitor well HM-103 east of the chrome pit, collecting and analyzing soil samples, and collecting and analyzing groundwater samples from wells HM-48 and HM-103. Figure 4.3.15-1 shows the locations of these sampling points. The location of monitor well HM-103 was selected because of the need for further information on groundwater flow in the upper zone in this area and to note contamination, if any, present in this area. Soil samples were analyzed for halogenated and aromatic hydrocarbons by EPA Methods 8010 and 8020, and for chromium by ICPES. Groundwater samples were also analyzed for halogenated and aromatic hydrocarbons (EPA Methods 601 and 602) and for chromium by ICPES.

4.3.15.1 Results of Investigation

The IRP Phase II Stage 1 investigation focused on the installation of upper zone monitor well HM-103 and on the collection, analysis and interpretation of soil and groundwater samples. A discussion of the results of these activities and descriptions of the topographic and geologic features of the site follow.

Topography

This site is located beneath Facility No. 181, in the south part of the AF Plant 4 complex. The surface elevation under the building in the vicinity of the site is between 554 feet and 556 feet MSL.

Geologic Features

Upper zone monitor well HM-48 is located approximately 500 feet northwest of Chrome Pit 1. Monitor wells HM-60 and HM-77 are located slightly further away to the southwest of the site. Information on shallow subsurface features is derived from the lithologic logs of these wells (Hargis and Associates, 1985).

The upper zone in this area ranges in thickness from 17 feet at HM-48 to 30 feet at HM-60. The Goodland Limestone was fully penetrated by

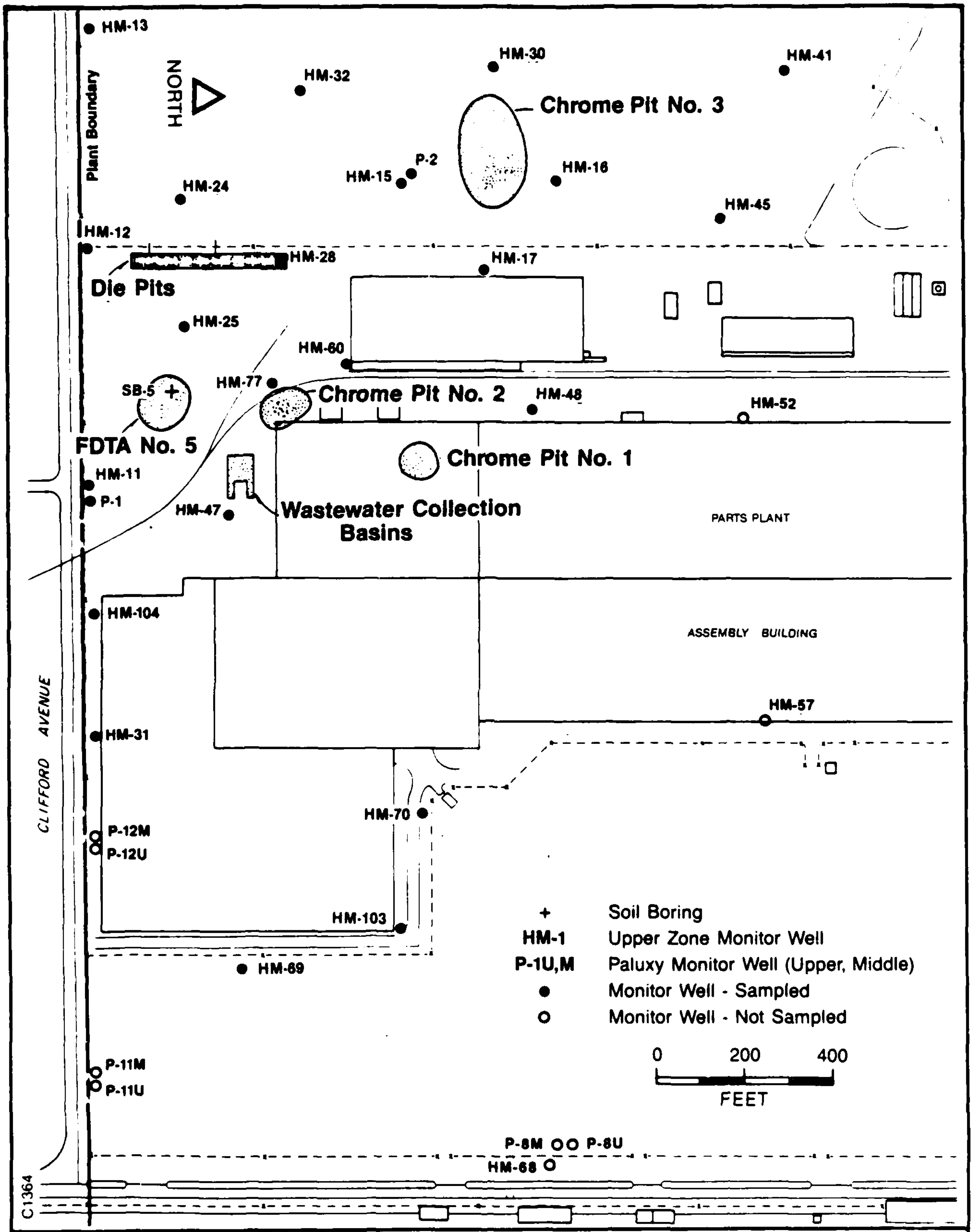

Figure 4.3.15-1. Phase II Activities at Site 10, Chrome Pit 1, AF Plant 4, Texas

HM-48, where it is only two feet thick. The Goodland Limestone was not encountered at HM-77, where 30 feet of silty clay and gravel overlie limestone of the Walnut Formation.

Upper zone well HM-103 is located approximately 800 feet east of Chrome Pit 3. The upper zone at this well is about 36 feet thick and consists primarily of clayey silt. Approximately three feet of Goodland Limestone were encountered.

This descripton of geologic features at Chrome Pit 1 is generally consistent with that in the Hargis and Associates report (1985).

Occurrence of Groundwater

Groundwater occurs in the upper zone of this site. Table 4.3.15-1 gives results of water level measurements. Water levels in the upper zone range from 642.42 feet MSL at HM-48 to 623.57 feet MSL at HM-103. The water level map for the upper zone in this area of AF Plant 4 (Figure 4.1.2-7) was discussed previously in Section 4.1.2. As shown on that map, groundwater flow in this area is to the south-southwest.

Groundwater Quality

Groundwater samples were collected from monitor wells HM-48 and HM-103 and analyzed for volatile organic compounds by EPA Methods 601 and 602, and for chromium by ICPES. Table 4.3.15-2 gives results of the groundwater analyses. Complete analytical reports for these analyses appear in Appendix A.

To evaluate the degree of groundwater contamination, analytical results from IRP Phase II Stage 1 sampling events were compared to federal standards and guidelines. Table 4.3.15-3 summarizes this comparison.

TABLE 4.3.15-1. GROUNDWATER ELEVATIONS AT SITE 10, CHROME PIT 1, AF PLANT 4, TEXAS (FEBRUARY THROUGH APRIL 1986)

Monitor Well	Elevation (feet MSL)	Date
HM-48	642.42	2-14-86
HM-103	623.57	4-10-86

TABLE 4.3.15-2. RESULTS OF GROUNDWATER SAMPLE ANALYSES, SITE 10, CHROME PIT 1, PLANT 4, TEXAS

	Method Detection Limit	Monitor Well	
		HM-48	HM-103
Date Sampled		2-14-86	4-10-86
Field Parameters			
Temperature (°C)		18.0	22.0
pH		7.6	6.3
Conductivity (umhos)		300	620
Analytical Parameters[a]			
Metals (mg/L)			
Chromium	0.005	ND	0.01*
Volatile Organics (ug/L)			
Method 601 (Halogenated Hydrocarbons)			
Concentration Factor		5	500
Chloroform	0.05	3.0	ND
Trichloroethylene	0.12	20	5500
Chlorobenzene	0.25	ND	ND
Method 602 (Aromatic Compounds)			
Concentration Factor		1	1
Toluene	0.2	0.83	ND
Chlorobenzene	0.2	ND	18

ND = Not detected.
* = Value less than five times detection limit. Errors may range up to 100 percent.
a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.

TABLE 4.3.15-3. COMPARISON OF WATER QUALITY AT SITE 10, CHROME PIT 1, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location	
		HM-48	HM-103
ORGANIC COMPOUNDS (ug/L)			
Trichloroethylene	5	20	5500

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

4.3.15.2 Significance of Findings

This section discusses the significance of the findings of this investigation, emphasizing the groundwater and soil chemistry at the site. Hargis & Associates (1985) previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates those findings and trends identified by the Hargis report.

Significance of Organic Compounds and Metals in Soils

Soil samples were collected at depths of 29-30 feet BGL and 34-35 feet BGL during the installation of HM-103 and analyzed for halogenated and aromatic volatiles by EPA Methods 8010 and 8020 and for chromium by EPA Method 6010. Table 4.3.15-4 gives results of these analyses. Two compounds, trans-1,2-dichloroethylene and trichloroethylene, were detected in both samples. Concentrations of trans-1,2-dichloroethylene ranged from 0.039 mg/kg at 29-30 feet to 0.096 mg/kg at 34-35 feet. Levels of trichloroethylene also increased with depth. TCE was present at 0.065 mg/kg in soil from 29-30 feet and 0.17 mg/kg in soil from 34-35 feet.

Chromium was also detected in both soil samples. However, concentrations detected were below the normal range of chromium concentrations found in soils (Table 4.2.1-3).

Significance of Metals in Groundwater

Groundwater samples from HM-48 and HM-103 were analyzed for chromium. Concentrations were less than instrument detection limits in both cases. These findings agree with the data presented by Hargis & Associates (1985).

Significance of Organic Compounds in Groundwater

Of the volatile organic compounds analyzed for, trichloroethylene was the only compound detected at levels in excess of federal MCL criteria.

TABLE 4.3.15-4. RESULTS OF SOIL SAMPLE ANALYSES, SITE 10, CHROME PIT 1, AF PLANT 4, TEXAS

Date Sampled	Method Detection Limit	HM-103-A (29-30) 1-21-86	HM-103-B (34-35) 1-21-86
Analytical Parameters[a]			
Chromium (mg/kg)	0.5	7.4	7.1
Volatile Organics (mg/kg)			
Method 8010 (Halogenated Hydrocarbons)			
Concentration Factor		12.5	12.5
trans-1,2-Dichloroethylene	0.00010	0.039	0.096
Trichloroethylene	0.00013	0.065	0.17
Method 8020 (Aromatic Compounds)[b]			
Concentration Factor		125	125

a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.

b = No compounds were detected by this analysis.

TCE ranged from 20 ug/L at HM-48 to 5500 ug/L at HM-103. The Hargis & Associates (1985) report also noted the presence of TCE in monitor well HM-48, but at lower levels. TCE was reported in this study at concentrations ranging from 55 to 93 ug/L.

4.3.16 Site 5, Fire Department Training Area 2

FDTA 2 was used for approximately two years during 1955-1956. This site consisted of a 50-foot diameter earthen ring located just north of Landfill 1. Exercises were held twice a year. However, disposal of waste oils and fuels, as well as uncontrolled burns, may have occurred more frequently.

Activities at FDTA 2 included a geophysical survey and collection of groundwater samples from seven existing upper zone monitor wells. The geophysical survey was conducted to determine the extent of any hydrocarbon plume. Upper zone wells sampled at this site included HM-19, 49, 50, 51, 65, 66, and 76. Figure 4.3.16-1 shows the locations of these wells. Groundwater samples were analyzed for volatile organic compounds by EPA Methods 601 and 602, for hydrocarbon fuels by EPA Method 418.1, and for oil and grease by EPA Method 413.2.

4.3.16.1 Results of Investigation

A discussion of the results of IRP Phase II Stage 1 activities at FDTA 2 and descriptions of the topographic and geologic features of the site follow.

Topography

This site is located under the pavement in the west employee parking lot. The land surface across the site slopes gently to the northwest, toward Meandering Road Creek from elevations of about 640 feet to 636 feet MSL.

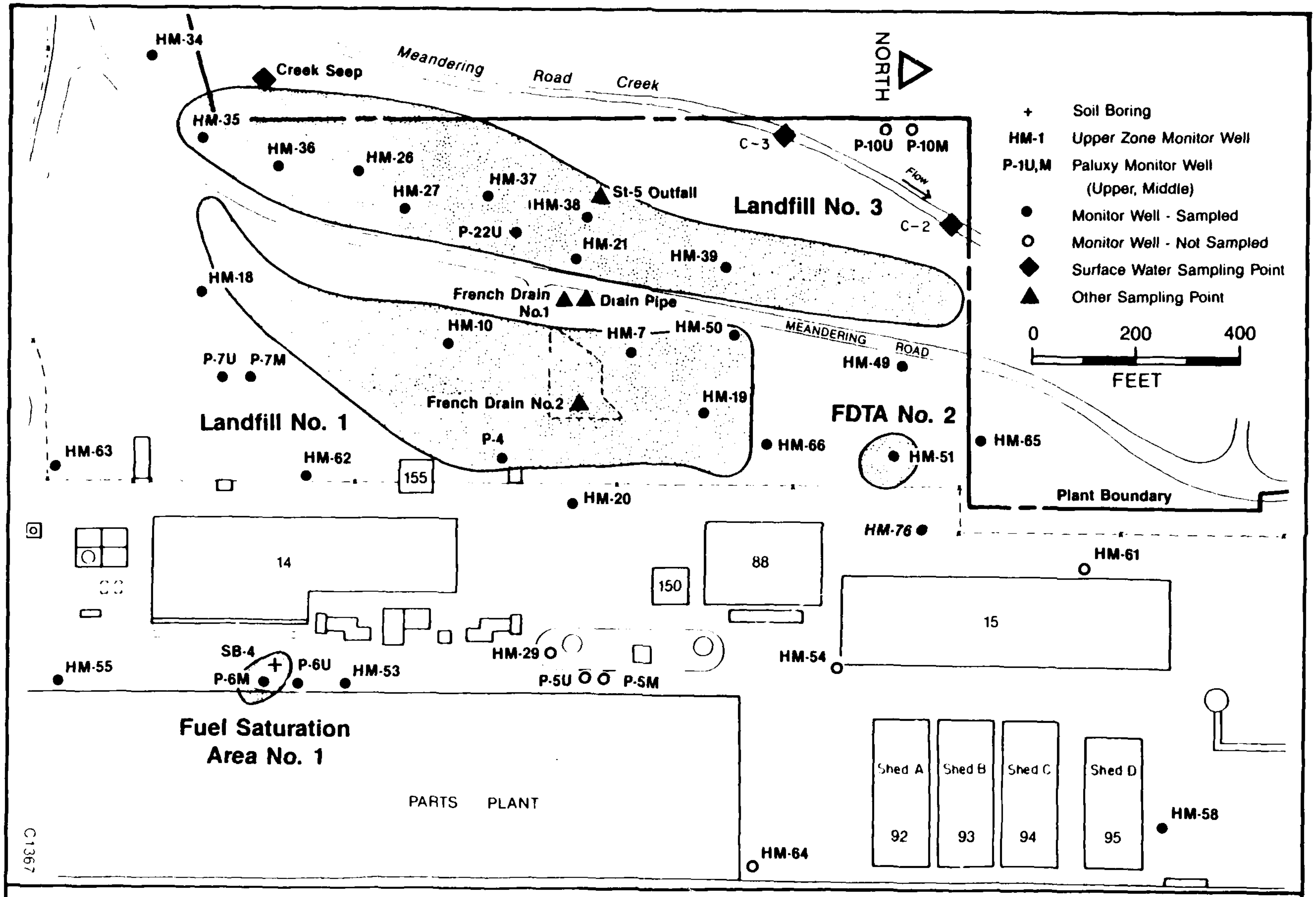

Figure 4.3.16-1. Phase II Activities at Site 5, Fire Department Training Area 2, AF Plant 4, Texas

Geologic Features

Information on the shallow subsurface features was provided by the lithologic logs of monitor wells HM-49, HM-51, HM-65, HM-66, and HM-76 (Hargis and Associates, 1985). The thickness of the upper zone at this site ranges from four feet at HM-66 to 16 feet at HM-76. The Goodland Limestone, encountered at HM-65, HM-66, and HM-76, consists of shale and clay and ranges in thickness from four feet at HM-65 to 13 feet at HM-66. The Goodland Limestone is absent at HM-49 and HM-51.

The thickness of the Walnut Formation is unknown in the immediate vicinity of FDTA 2; however, on the basis of lithologic data obtained from Paluxy monitor wells P-10U, P-10M, and P-4, it is believed to be at least 25 feet thick.

Occurrence of Groundwater

Elevations of water levels of groundwater occurring in the upper zone at this site range from 641.34 feet MSL to 622.09 feet MSL. Table 4.3.16-1 presents results of water level measurements. The water level map for the upper zone in this area of AF Plant 4 (Figure 4.1.2-6) was discussed previously in Section 4.1.2. As shown on that map, groundwater flow in this area is to the west-northwest, toward Meandering Road Creek.

Geophysical Survey

A terrain conductivity survey consisting of electromagnetic profiling was performed in November 1985. A grid was established as described in Section 3.1.1.

Figure 4.3.16-2 illustrates the location of the survey. Complete results appear in Appendix I. The conductivity values recorded indicate two large anomalous zones and one small anomalous zone. The anomalous zone in the center of the site is interpreted to be shallow soil contamination and/or a chemical reaction between contamination and subsurface materials. The second

TABLE 4.3.16-1. GROUNDWATER ELEVATIONS AT SITE 5, FIRE DEPARTMENT TRAINING AREA 2, AF PLANT 4, TEXAS (FEBRUARY THROUGH MARCH 1986)

Monitor Well	Elevation (feet MSL)	Date
HM-19	622.09	3-1-86
HM-49	627.19	2-12-86
HM-50	629.95	2-12-86
HM-51	630.79	2-11-86
HM-65	627.19	2-12-86
HM-66	-	(not measured)
HM-76	641.34	2-13-86

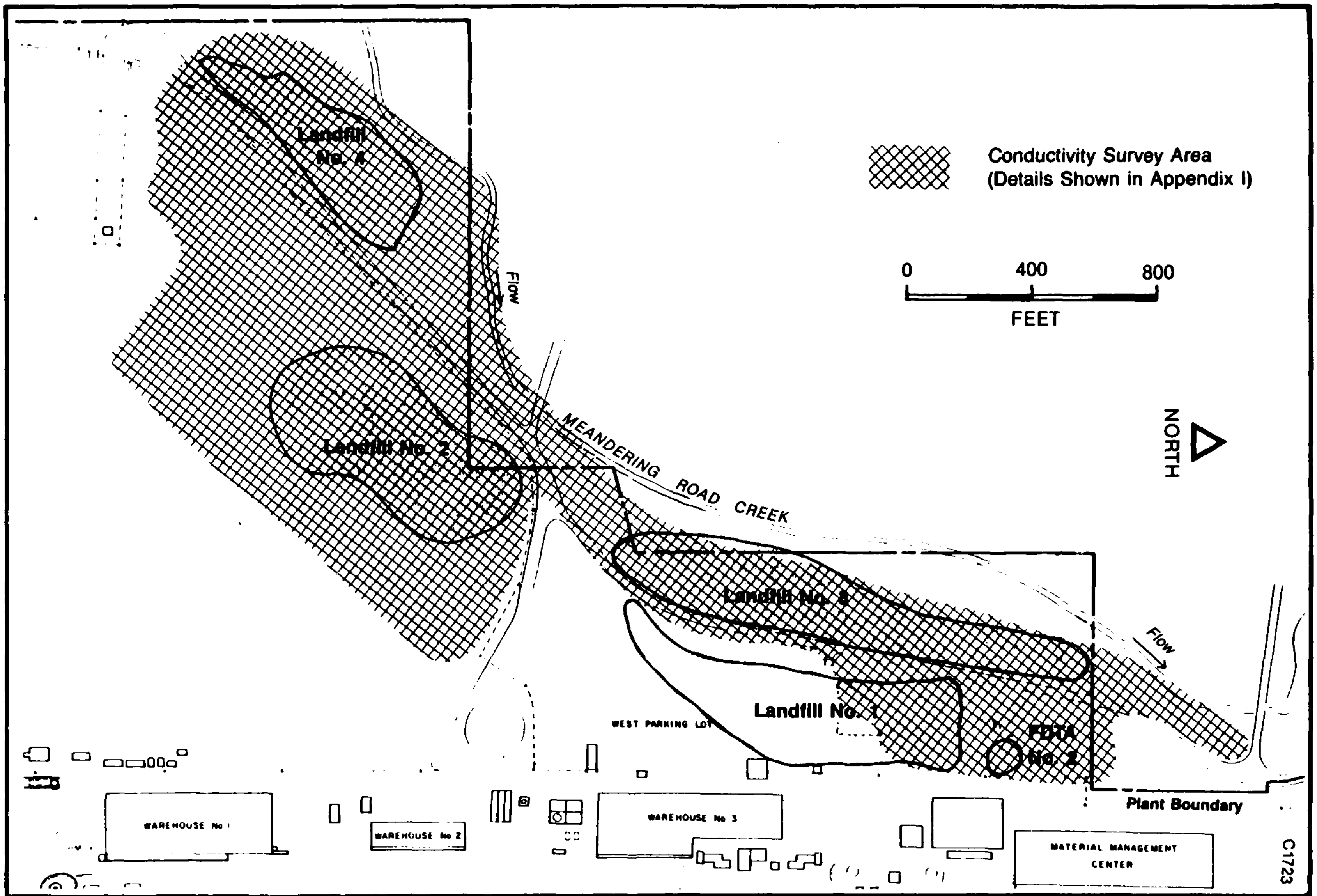

Figure 4.3.16-2. Location of the Geophysical Survey, Site 5, Fire Department Training Area 2, AF Plant 4, Texas

zone, may indicate moderate amounts of fill. The third zone located in the southwestern corner of the area, is interpreted to be large amounts of metal.

Groundwater Quality

Groundwater samples were collected from wells HM-19, 49, 50, 51, 65, 66, and 76 and analyzed for volatile organic compounds by EPA Methods 601 and 602, for hydrocarbon fuels (EPA Method 418.1) and for oil and grease (EPA Method 413.2). Table 4.3.16-2 presents results of the groundwater analyses. Complete analytical reports for these analyses appear in Appendix A.

To evaluate the degree of groundwater contamination, analytical results from IRP Phase II Stage 1 sampling were compared to federal standards and guidelines. Table 4.3.16-3 summarizes the results of this comparison.

4.3.16.2 Significance of Findings

This section discusses the significance of the findings of this investigation, emphasizing the groundwater chemistry at the site. Hargis & Associates (1985) previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates those previous findings and trends identified by the Hargis report.

Significance of Organic Compounds in Groundwater

Three volatile organic compounds, trichloroethylene, toluene, and 1,2-dichloroethane, were detected in upper zone groundwater in concentrations exceeding the federal MCL criteria. An unknown compound with the same retention time as trans-1,2-dichloroethylene was detected on the first column in groundwater samples from HM-50 and HM-51. Methylene Chloride was detected in HM-51 at a concentration of 200,000 ug/L. Levels of TCE ranged from 9.0 ug/L in HM-19 to 420,000 ug/L in HM-51. Toluene was present only in groundwater sampled from HM-51, at a concentration of 96,000 ug/L. 1,2-Dichloroethane was

TABLE 4.3.16-2. RESULTS OF GROUNDWATER SAMPLE ANALYSES, SITE 5, FIRE DEPARTMENT TRAINING AREA 2, AF PLANT 4, TEXAS

	Method	Monitor Well						
	Detection	HM-19	HM-49	HM-50	HM-51	HM-65	HM-66	HM-76
Date Sampled	Limit	3-1-86	2-12-86	2-12-86	2-11-86	2-12-86	2-13-86	2-13-86
Field Parameters								
Temperature (°C)		21.0	15.5	-	19.0	17.5	19.0	19.0
pH		6.3	7.4	-	5.8	6.5	6.6	6.5
Conductivity (umhos)		340	1200	-	9700	3900	1200	2100
Analytical Parameters[a]								
Volatile Organics (ug/L)								
Method 601 (Halogenated Hydrocarbons)								
Concentration Factor		1	1	500	10000	1	1	1
Methylene Chloride	0.25	ND	ND	ND	200000	ND	ND	ND
trans-1,2-Dichloroethylene	0.10	ND**	ND**	ND**	ND**	ND	ND**	ND
1,2-Dichloroethane	0.03	ND	ND	ND	27000	ND	ND	ND
Trichloroethylene	0.12	9.0	1.9	ND	420000	ND	29	ND
Tetrachloroethylene	0.03	0.41	1.1	ND	ND	ND	ND	ND
Method 602 (Aromatic Compounds)								
Concentration Factor		5	1	100	1000	1	1	1
Toluene	0.2	ND	1.4	ND	96000	1.5	1.8	0.99
Hydrocarbon Fuels (mg/L)	1.	ND	ND	ND	11	ND	ND	ND
Oil and Grease (mg/L)	1.	ND	ND	ND	17	ND	ND	ND

ND = Not detected.
** = Compound not confirmed by second-column analysis.
- = Data not collected, insufficient volume.
a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.

TABLE 4.3.16-3. COMPARISON OF WATER QUALITY AT SITE 5, FDTA 2, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location		
		HM-19	HM-51	HM-66
ORGANIC COMPOUNDS (ug/L)				
1,2-Dichloroethane	5		27000	
Trichloroethylene	5	9	420000	29
Toluene	2000		96000	
Methyl Chloride			200000	

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

present in HM-51 at a concentration of 27,000 ug/L. Hydrocarbon fuels and oil and grease were present in levels above instrument detection limit only in groundwater from HM-51. At this well, hydrocarbon fuels were detected at 11 mg/L and oil and grease was detected at 17 mg/L.

Hargis & Associates (1985) noted a hydrocarbon fuel concentration of 63 mg/L in groundwater from HM-51 in comparison to the 11 mg/L detected during the present study. Otherwise, Hargis & Associates' observations generally agree with present observations of hydrocarbon fuel levels and oil and grease levels in upper zone groundwater. Hargis & Associates (1985) also report levels of volatile organic compounds generally consistent with those reported here. However, they noted high levels of 1,2-trans-dichloroethylene in groundwater from HM-50 and HM-51.

The highest concentrations of contaminants are found in groundwater samples taken from HM-51, directly in the center of FDTA 2. Downgradient from this well (HM-49 and HM-65), concentrations of all organic compounds drop off to much lower levels, indicating that the contamination is localized.

4.3.17 Site 14, Fuel Saturation Area 1

Fuel Saturation Area 1 (FSA 1) is located just north of a fuel tank truck unloading and pumping station. From the 1970s until the early 1980s (CH2M Hill, 1984), the ground at this site reportedly became saturated by fuels from leaking buried fuel lines.

Activities at FSA 1 included drilling one borehole, collecting groundwater samples from the borehole, two upper zone monitor wells and two Paluxy wells, and observing the monitor wells for the existence of any fuel lens on the water table. Monitor wells sampled at this site included HM-53, 55, P-6M and P-6U. Groundwater samples were analyzed for hydrocarbon fuels (EPA Method 418.1) and for oil and grease (EPA Method 413.2). Soil samples collected during the drilling of soil boring SB-4 were also analyzed for hydrocarbon fuels. Figure 4.3.17-1 shows the locations of all sampling points.

4.3.17.1 Results of Investigation

A discussion of the results of IRP Phase II Stage 1 activities at FSA 1 and descriptions of the topographic and geologic features of the site follow.

Topography

This area is located west of, and adjacent to, Facility No. 5 (Parts Plant) across from Building 14. The surface elevation in this area is about 654 feet MSL.

Geologic Features

Paluxy monitor wells P-6M and P-6U are located in the immediate vicinity of Fuel Saturation Area 1. The lithologic logs of these wells (Hargis and Associates, 1985) show an upper zone thickness of about 27 feet.

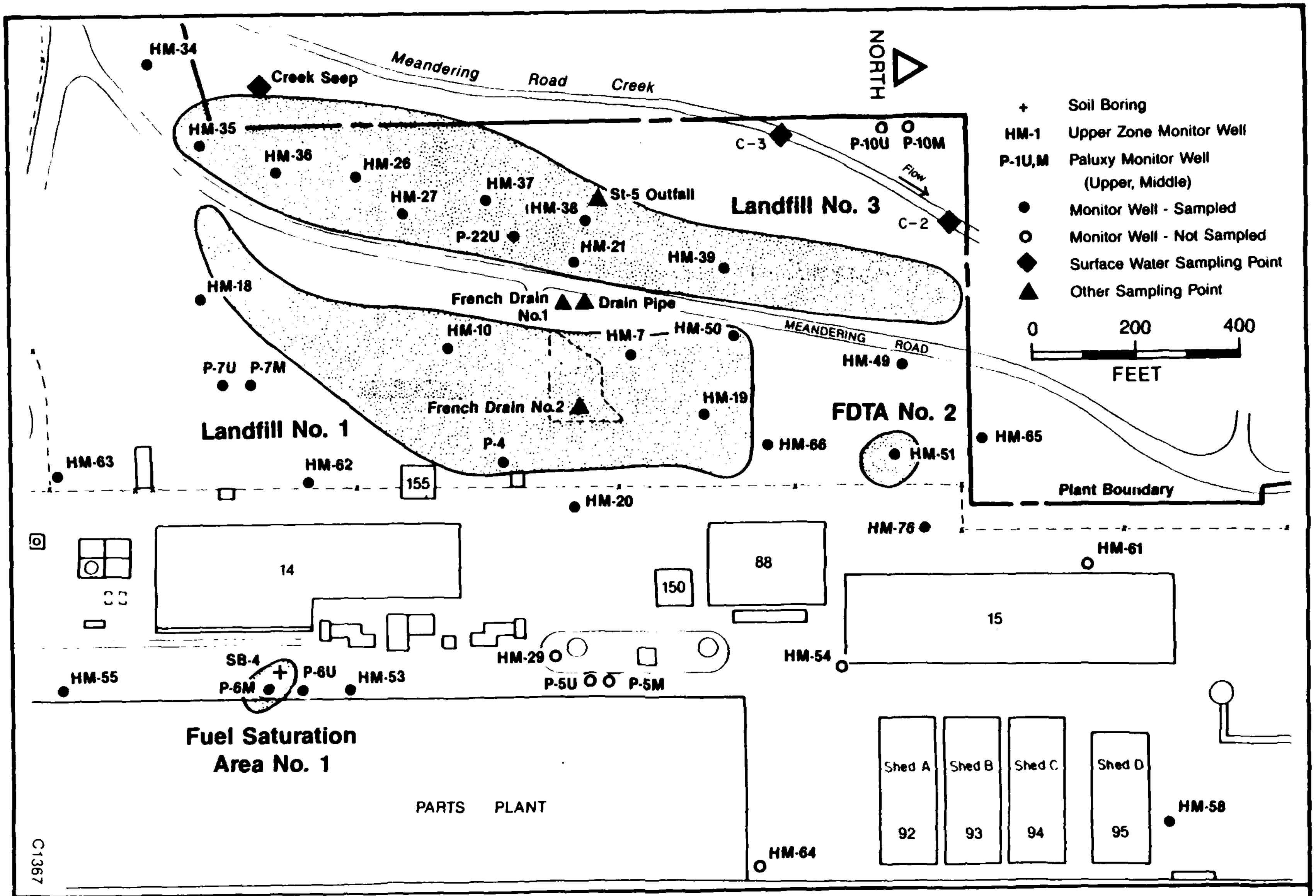

Figure 4.3.17-1. Phase II Activities at Site 14, Fuel Saturation Area 1, AF Plant 4, Texas

The Goodland Limestone is approximately four feet thick and the Walnut Formation is about 33 feet thick.

Soil boring SB-4 was drilled at this site. The lithologic log of this soil boring (Appendix E, this report) reveals an upper zone thickness of at least 28 feet. The upper zone is composed of sand and sand and gravel overlain by 3.5 feet of fill.

Occurrence of Groundwater

Groundwater occurs in both the upper zone and in the Paluxy Formation. Table 4.3.17-1 provides results of water level measurements. Water levels in the upper zone ranged from 638.91 feet MSL at HM-55 to 629.50 feet MSL at HM-53. The water level map for the upper zone in this area of AF Plant 4 (Figure 4.1.2-6) was discussed previously in Section 4.1.2. Upper zone groundwater flow in this area is to the north. Groundwater elevations in the Paluxy Formation ranged from 571.69 feet MSL in the upper Paluxy Formation to 566.69 feet MSL in the middle Paluxy Formation, indicating that the direction of hydraulic gradient is from the upper to the middle member. Figures 4.1.2-2 and 4.1.2-3 show groundwater flow in the upper and middle Paluxy.

Groundwater Quality

Groundwater samples were collected from monitor wells HM-53, 55, P-6M, and P-6U and analyzed for hydrocarbon fuels and oil and grease. Table 4.3.17-2 gives the results of the groundwater analyses. Complete analytical reports for these analyses appear in Appendix A.

4.3.17.2 Significance of Findings

This section discusses the significance of the findings of this investigation, emphasizing the soil and groundwater chemistry at the site.

TABLE 4.3.17-1. GROUNDWATER ELEVATIONS AT SITE 14, FUEL SATURATION AREA 1, AF PLANT 4, TEXAS (FEBRUARY 1986)

Monitor Well	Elevation (feet MSL)	Date
HM-53	629.50	2-10-86
HM-55	638.91	2-4-86
P-6M	566.69	2-4-86
P-6U	571.69	2-5-86

TABLE 4.3.17-2. RESULTS OF GROUNDWATER SAMPLE ANALYSES, SITE 14, FUEL SATURATION AREA 1, AF PLANT 4, TEXAS

	Method Detection Limit	Monitor Well				
		HM-53	HM-55	P-6M	P-6U	SB-4-D Water Grab
Date Sampled		2-10-86	2-4-86	2-4-86	2-5-86	1-27-86
Field Parameters						
Temperature (°C)		20.5	21	20	17	NA
pH		6.8	7.0	7.2	11.2	NA
Conductivity (umhos)		950	730	760	1300	NA
Analytical Parameters						
Hydrocarbon Fuels (mg/L)	1	1.0	ND	ND	ND	97%
Oil and Grease (mg/L)	1	NA	ND	ND	ND	NA

ND = Not detected.
NA = Not analyzed.

Hargis and Associates (1985) previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates those findings and trends identified by the Hargis report.

Significance of Organic Compounds in Soil

Soil samples were collected during the drilling of Soil Boring 4 (SB-4) at two depths: 9 to 10 feet BGL, and 25 to 25.5 feet BGL. Samples were analyzed for hydrocarbon fuels. Table 4.3.17-3 gives the results of these analyses. Soil from the 9- to 10-foot depth contained the lowest concentrations of hydrocarbon fuels, lower than the instrument detection limit. At greater depths, levels of hydrocarbon fuels increased to 59,000 mg/kg at 25 to 25.5 feet.

Significance of Organic Compounds in Groundwater

Hydrocarbon fuels and oil and grease were not detected except in groundwater from well HM-53, where hydrocarbon fuels were detected at a concentration of 1.0 mg/L. These observations generally agree with those of the Hargis and Associates (1985) report with one exception. In the Hargis report, oil and grease was detected in water from HM-53 at 240 mg/L, and hydrocarbon fuel concentrations ranged from 12 to 18 mg/L. This suggests a decrease in contaminant levels over time.

The borehole for SB-4 was allowed to stand open over night and a grab sample of accumulated liquid was collected the next day. Analysis of this sample revealed 97% hydrocarbon fuels.

TABLE 4.3.17-3. RESULTS OF SOIL SAMPLE ANALYSES, SITE 14, FUEL SATURATION AREA 1, AF PLANT 4, TEXAS

Date Sampled	Method Detection Limit	SB-4-A (9-10) 1-26-86	SB-4-B (25-25.5) 1-26-86
Analytical Parameters			
Hydrocarbon Fuels (mg/kg)	4-6	ND	59000

ND = Not detected.

4.3.18 Site 19, NARF Area

The Nuclear Aerospace Research Facility (NARF) formerly located at this site reportedly housed several experimental atomic reactors between 1953 and 1974. Large quantities of nuclear activation material were produced at this site as an undesirable side effect of neutron bombardment. Those activation products were reportedly contained on site, and the entire facility was decommissioned and disposed of by contractor in 1974. A total of over two million pounds of miscellaneous parts and 15 million pounds of concrete rubble were hauled off site to Barnwell, South Carolina. Post-closure inspection of this site reportedly revealed no remaining contamination (CH2M Hill, 1984).

Investigation activities at this site included drilling four boreholes, collecting and analyzing soil samples, collecting groundwater samples from three upper zone monitor wells (HM-83, 84 and 85), researching past analytical data from wells at AF Plant 4 and the City of White Settlement for radionuclide results during the NARF operations period, and determining the exact locations of past operations.

According to a representative of the City of White Settlement, no information on radionuclides is available for White Settlement municipal wells. In addition, AF Plant 4 personnel stated that the information from wells at Plant 4 during NARF operations was archived and that separate action would be required to retrieve this information.

Soil samples were collected during the drilling of four soil borings, SB-6, SB-7, SB-8, and SB-11. These samples were analyzed for alpha, beta, and gamma radiation. Figure 4.3.18-1 shows the locations of soil boring locations.

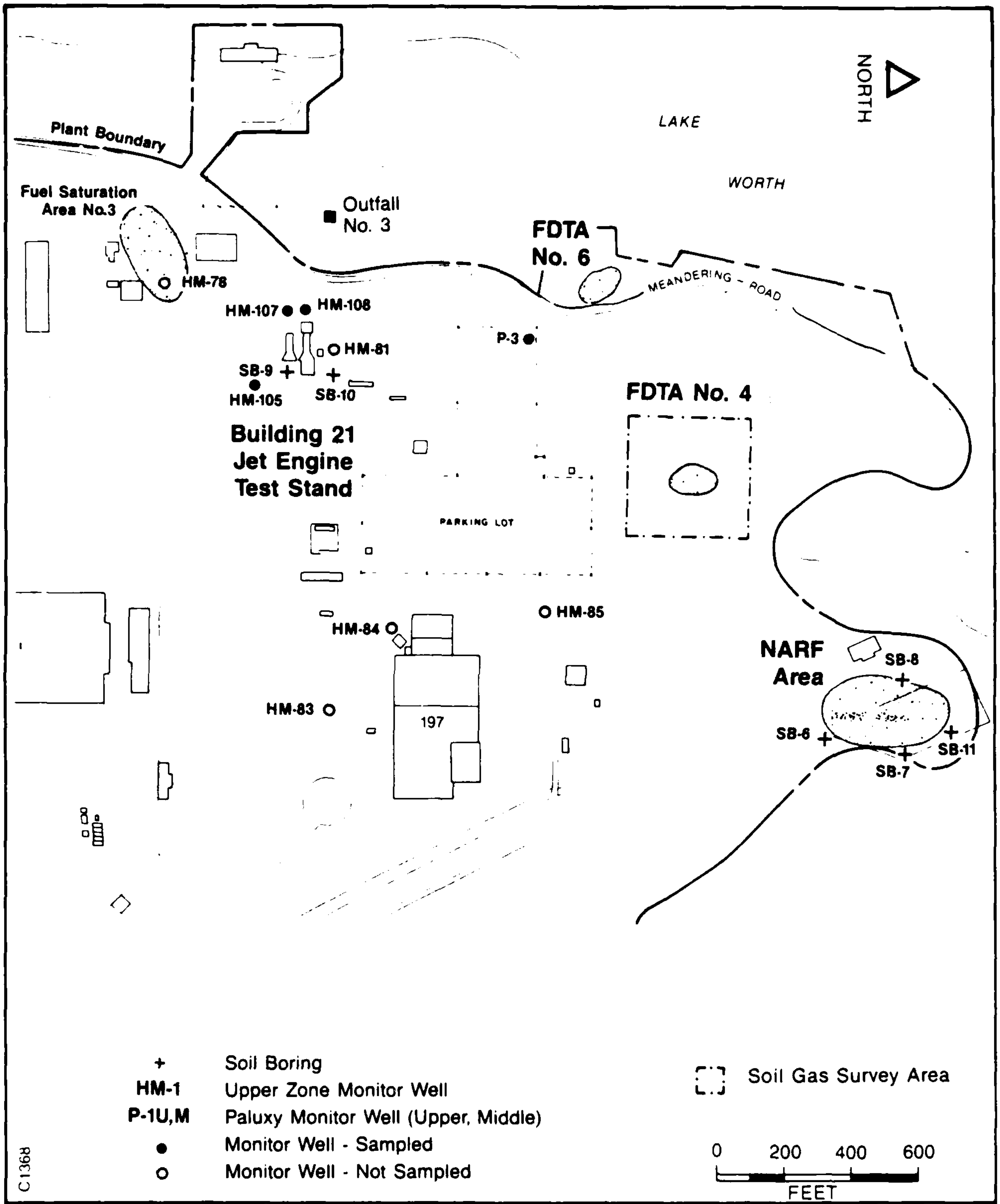

Figure 4.3.18-1. Phase II Activities at Site 19, NARF Area, AF Plant 4, Texas

4.3.18.1 Results of Investigation

The investigation focused on the collection and analysis of soil samples. A discussion of the results of these activities and descriptions of the topographic and geologic features of the site follow. Wells HM-83, -84 and -85 are relatively far removed from the NARF. Because of this, monitoring results for these wells are reported in the discussion of ambient monitoring in Section 4.3.20.

Topography

The former NARF area is located at the north end of AF Plant 4, just south of Lake Worth. The topography of the site is relatively flat. The surface elevation is about 622 feet MSL, but the slope steepens northward towards the shoreline of Lake Worth.

Geologic Features

Although two monitor wells installed in the early 1960s are located near this area, lithologic logs are not available. Therefore, the thickness and nature of the upper zone at these locations are unknown.

Occurrence of Groundwater

Water level data from upper zone wells HM-83, HM-84, and HM-85 suggest a groundwater elevation between 628 and 630 feet MSL and a westerly flow direction. The water level map of the upper zone in this are of AF Plant 4 (Figure 4.1.2-4) was discussed previously in Section 4.1.2.

4.3.18.2 Significance of Findings

This section discusses the significance of the findings of this investigation, emphasizing the soil chemistry at the site. No previous soil chemistry data exist for this site; therefore, no comparisons can be made.

Significance of Radioactive Materials in Soil

Soil samples were collected during the drilling of Soil Boring 6, 7, 8, and 11. Table 4.3.18-1 shows the depths of sample collection at each borehole. Samples were analyzed for alpha, beta, and gamma radiation. Table 4.3.18-1 shows the results of these analyses. Complete analytical reports for these analyses appear in Appendix A.

Levels of alpha radiation ranged from 6.7 pCi/g at SB-6-A to 12.4 pCi/g at SB-6-C. Beta radiation was detected at levels ranging from 16.1 pCi/g at SB-11-A to 23.1 pCi/g at SB-8-A. Instead of directly measuring gamma radiation, which is a fission by-product, analyses were conducted for the detection of Cesium 137, which is also a fission by-product. If Cesium 137 was detected at high levels, then an actual test of gamma radiation levels could have been run. However, levels of Cesium 137 were below instrument detection limit; therefore it was not necessary to analyze directly for gamma radiation.

While no background radiological data are available, as discussed above, all other data suggest that there is no residual radiation above acceptable levels at this site.

TABLE 4.3.18-1. RESULTS OF SOIL SAMPLE ANALYSES, SITE 19, NARF AREA, AF PLANT 4, TEXAS

		Soil Boring (depth - feet)								
Date Sampled	Method Detection Limit	SB-6-A (2-3) 7-21-86	SB-6-B (4-5) 7-21-86	SB-6-C (6-7) 7-21-86	SB-6-D (8-9) 7-21-86	SB-7-A (2-3) 7-21-86	SB-8-A (2-3) 7-21-86	SB-11-A (2-3) 7-24-86	SB-11-B (2-3) 7-24-86	SB-11-C (4-4.5) 7-24-86
Analytical Parameters										
Alpha radiation (pCi/g)	0.5	6.7(±6.6)	11.3(±6.8)	7.1(±6.5)	12.4(±6.9)	9.2(±5.9)	9.7(±6.5)	7.1(±6.5)	8.7(±6.4)	7.6(±5.8)
Beta radiation (pCi/g)	0.8	19.6(±4.2)	15.2(±4.2)	15.8(±4.2)	19.5(±4.2)	22.9(±4.4)	23.1(±4.4)	16.1(±4.2)	18.3(±4.2)	10.0(±3.9)
Gamma radiation (pCi/g) (Cesium 137)	40-60	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected.

4.3.19 Jet Engine Test Stand, Building 21

The purpose of the investigation in the vicinity of Building 21 was to determine if soil and groundwater have been affected by activities at the site. Reportedly, jet fuel and gasoline had collected downslope of the facility in a sump.

Activities at the Jet Engine Test Stand included installation of three upper zone monitor wells, HM-105, 107, and 108, drilling of soil borings SB-9 and SB-10, collection of soil samples during drilling operations, collection of groundwater samples from the three upper zone monitor wells, and collection of surface water samples from two outfalls, Outfall 1, and Outfall 5. Soil samples were analyzed for hydrocarbon fuels by EPA Method 418.1 and for oil and grease. Samples of groundwater, surface water, and Outfall 1 were analyzed for volatile organic compounds by EPA Methods 601 and 602, for hydrocarbon fuels by EPA Method 418.1, and for oil and grease by EPA Method 413.2. Outfall 5 surface water samples were analyzed for hydrocarbon fuels and oil and grease. Figure 4.3.19-1 shows the locations of the monitor wells. Figure 4.3.19-2 shows the two outfalls.

4.3.19.1 Results of Investigation

A discussion of the results of collecting and analyzing soil, surface water, and groundwater samples at the Jet Engine Test Stand follows. Other aspects of the site, such as topography and geology are also discussed.

Topography

The Jet Engine Test Stand is located in the northwestern corner of AF Plant 4, just northeast of Fuel Saturation Area 3. The topography of the site is relatively flat. The surface elevation is about 640 feet MSL.

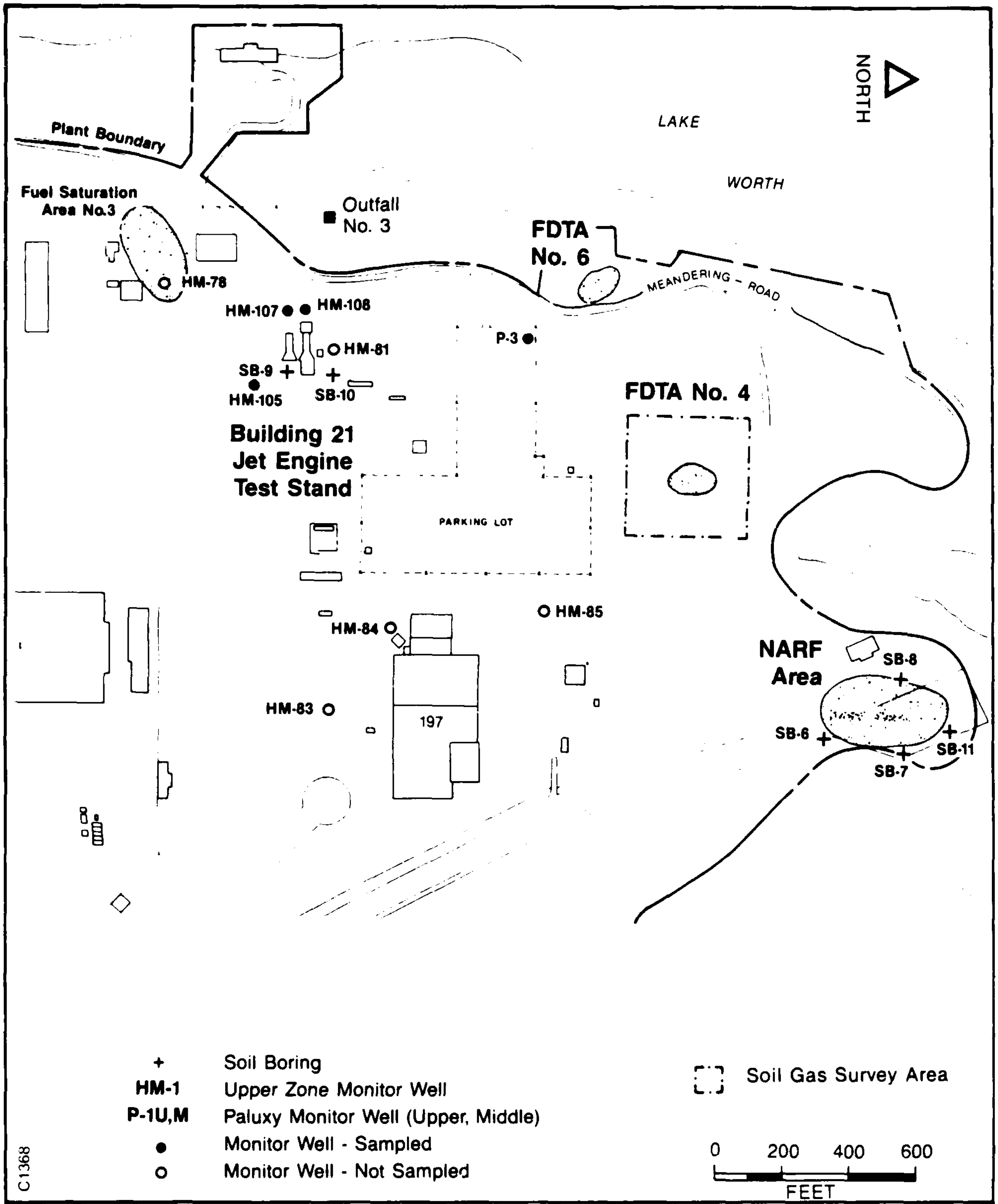

Figure 4.3.19-1. Phase II Activities at Jet Engine Test Stand, Building 21, AF Plant 4, Texas

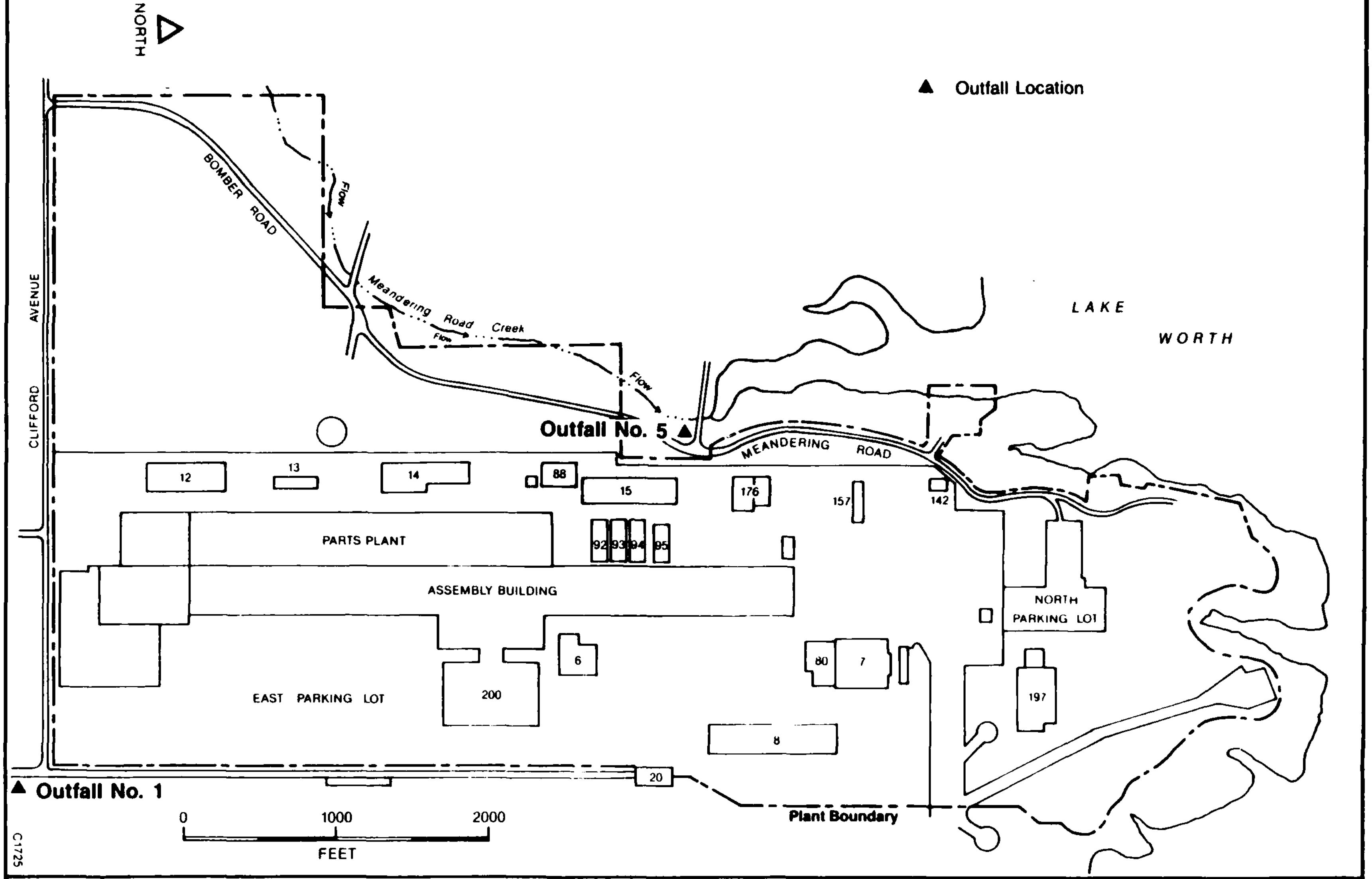

Figure 4.3.19-2. Location of Outfalls 1 and 5, AF Plant 4, Texas

Geologic Features

Upper zone monitor wells HM-105, HM-107, and HM-108 are located in the vicinity of the Jet Engine Test Stand. Soil borings SB-9 and SB-10 were also drilled in the vicinity of this site. The upper zone is 15 to 19 feet thick at these wells and consists of clay, sand, and silt gravel. About 2 feet of Walnut Formation were encountered at HM-105 and HM-108; about 8 feet of Walnut Formation were encountered at HM-107.

Occurrence of Groundwater

Table 4.3.19-1 shows groundwater elevations in the upper zone at this site. Groundwater elevations range from 626.74 feet MSL at HM-105 to 624.45 feet MSL at HM-108. The map of water levels in the upper zone in this area of AF Plant 4 (Figure 4.1.2-4) was discussed previously in Section 4.1.2. As shown on Figure 4.1.2-4, groundwater flow at this site is to the southwest.

Groundwater and Surface Water Quality

Groundwater samples were collected from monitor wells HM-105, 107, and 108 and surface water samples were collected from Outfall 1. All samples were analyzed for volatile organic compounds by EPA Methods 601 and 602, for hydrocarbon fuels, and for oil and grease. Surface water samples collected from Outfall 5 were analyzed for hydrocarbon fuels and oil and grease. Tables 4.3.19-2 (Outfall 1) and 4.3.19-3 (Outfall 5) present the results of surface water analyses. Although Outfall 3 (not 5) is associated with the Jet Engine Test Stand facility, Outfall 5 was sampled as stated in the statement of work. Table 4.3.19-4 gives results of the groundwater analyses. Complete analytical reports for these analyses appear in Appendix A.

TABLE 4.3.19-1. GROUNDWATER ELEVATIONS AT JET ENGINE TEST STAND, BUILDING 21, AF PLANT 4, TEXAS (AUGUST 1986)

Monitor Well	Elevation (feet MSL)		Date
HM-105	641.92	626.74	8-19-86
HM-107	642.33	625.26	8-19-86
HM-108	639.76	624.45	8-20-86

TABLE 4.3.19-2. RESULTS OF SURFACE WATER SAMPLE ANALYSES, OUTFALL 1, JET ENGINE TEST STAND, BUILDING 21, AF PLANT 4, TEXAS

	Method Detection Limit	Sample Site									
		OF1-1030	OF1-1130	OF1-1230	OF1-1330	OF1-1430	OF1-1530	OF1-1630	OF1-1730	OF1-1730D	OF1-COMPOSITE
Date Sampled		8-20-86	8-20-86	8-20-86	8-20-86	8-20-86	8-20-86	8-20-86	8-20-86	8-20-86	8-20-86
Field Parameters											
Temperature (°C)		33.0	-	33.0	33.0	34.0	33.0	31.0	32.0	32.0	NA
pH		6.9	-	7.4	7.4	8.0	8.1	8.1	8.1	8.1	NA
Conductivity (umhos)		690	-	450	410	410	410	410	400	400	NA
Analytical Parameters[a]											
Volatile Organics (ug/L)											
Method 601 (Halogenated Hydrocarbons)											
Concentration Factor		1	1	1	1		1	1	1	1	1
Methylene Chloride	0.25	ND	ND	ND	ND	NA	ND	ND	ND	43	ND
Trichlorofluoromethane	0.4	ND	ND	ND	ND	NA	ND	ND	ND	2.3	ND
Chloroform	0.05	3.0	4.3	2.7	2.6	NA	2.4	2.2	2.8	2.6	2.9
1,2-Dichloroethane	0.03	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	0.03	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.12	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND
Bromodichloromethane	0.1	4.0	4.8	4.1	3.9	NA	3.7	3.5	4.7	3.7	4.8
Trichloroethylene	0.12	ND	0.13	ND	0.19	NA	0.29	0.23	0.25	ND	ND
Dibromochloromethane	0.09	4.4	4.8	4.3	4.4	NA	4.6	4.2	5.6	4.5	5.2
Bromoform	0.2	1.7	2.0	1.8	1.9	NA	1.8	1.8	2.0	1.8	1.9
Method 602 (Aromatic Compounds)											
Concentration Factor		1	1	1	1		1	1	1	1	1
Toluene	0.2	ND	ND	ND	ND	NA	ND	ND	ND	1.5	ND
Oil and Grease (mg/L)	1	ND	ND	ND	ND	NA	ND	ND	ND	1*	ND
Hydrocarbon Fuels (mg/L)	1	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND

a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.
ND = Not detected.
NA = Not analyzed.
OF = Outfall.
* = Value less than five times detection limit. Errors may range up to 100 percent.
- = Data not collected, instrument not available.

TABLE 4.3.19-3. RESULTS OF SURFACE WATER ANALYSES, OUTFALL 5, JET ENGINE TEST STAND, BUILDING 21, AF PLANT 4, TEXAS

		Sample Site								
Date Sampled	Method Detection Limit	OF5-930 8-20-86	OF5-1130 8-20-86	OF5-1230 8-20-86	OF5-1330 8-20-86	OF5-1430 8-20-86	OF5-1530 8-20-86	OF5-1630 8-20-86	OF5-1730 8-20-86	OF5-Comp. 8-20-86
Field Parameters										
Temperature (°C)		-	-	34.5	33.0	33.0	33.0	33.5	32.0	NA
pH		-	-	7.3	7.6	7.8	7.9	7.2	7.5	NA
Conductivity (umhos)		-	-	590	370	510	390	520	610	NA
Analytical Parameters										
Volatile Organics (ug/L)		NA	NA	NA	NA	NA	NA	NA	NA	NA
Oil and Grease (mg/L)	1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hydrocarbon Fuels (mg/L)	1	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected.
NA = Not analyzed.
- = Data not collected, instrument not available.

TABLE 4.3.19-4. RESULTS OF GROUNDWATER ANALYSES, JET ENGINE TEST STAND, BUILDING 21, AF PLANT 4, TEXAS

	Method Detection Limit	Monitor Well		
		HM-105	HM-107	HM-108
Date Sampled		8/19/86	8/19/86	8/20/86
Field Parameters				
Temperature (°C)		26.6	24.0	27.5
pH		7.2	6.8	7.1
Conductivity (umhos)		670	620	870
Analytical Parameters				
Volatile Organics (ug/L)		NA	NA	NA
Oil and Grease (mg/L)	1	2*	2*	ND
Hydrocarbon Fuels (mg/L)	1	ND	ND	ND

ND = Not detected.
* = Value less than five times detection limit. Errors may range up to 100 percent.

4.3.19.2 Significance of Findings

This section discusses the significance of the findings of this investigation, emphasizing the soil and groundwater chemistry at the site.

Significance of Organic Compounds in Soil

Soil samples were collected during the drilling of HM-105, 107, and 108. Samples were analyzed for hydrocarbon fuels and oil and grease. Table 4.3.19-5 gives the results of these analyses. The highest concentration of hydrocarbon fuels was 1700 mg/kg found in soil from HM-107 at a depth of 14 to 15 feet. At SB-9, 1300 mg/kg of hydrocarbon fuels were found in soil at a depth of 9 to 10 feet. At HM-105 and HM-108, hydrocarbon fuels were less than the instrument detection limit. The highest concentration of oil and grease was also found at HM-107, at 2000 mg/kg. At SB-9, 1800 mg/kg of oil and grease was found at 9 to 10 feet. The concentrations of oil and grease at HM-105 and HM-108 were 170 mg/kg and 310 mg/kg, respectively.

Significance of Organic Compounds in Groundwater

Concentrations of hydrocarbon fuels and oil and grease were less than the instrument detection limit in samples from all three monitor wells at the Jet Engine Test Stand.

Significance of Organic Compounds in Surface Water

Concentrations of organic compounds in water sampled from Outfalls 1 and 5 were all below federal MCL criteria. Outfall 1 was sampled every hour for eight consecutive hours. One eight-hour hand-composited sample was also collected. Samples were analyzed for volatile organic compounds, hydrocarbon fuels, and oil and grease. For one time period, the volatile organics samples were not analyzed; however, no trends in contaminant concentration were observed. Eight samples plus one eight-hour composited sample were also collected from Outfall 5 and analyzed for hydrocarbons and oil and grease. These

TABLE 4.3.19-5. RESULTS OF SOIL SAMPLE ANALYSES, JET ENGINE TEST STAND, BUILDING 21, AF PLANT 4, TEXAS

	Method Detection Limit	Soil Sample (depth - feet)					
		HM-105 (18.5)	HM-107 (14-15)	HM-108 (9-10)	SB-9-A (9-10)	SB-9-C (19-20)	SB-10-A (9-10)
Analytical Parameters							
Hydrocarbon Fuels (mg/kg)	4-6	ND	1700	ND	1300	ND	ND
Oil and Grease (mg/kg)	4-6	170	2000	310	1800	ND	ND

ND = Not detected.

samples were collected at the times shown in Table 4.3.19-3. All concentrations were below the instrument detection limit and, again, no trends in contaminant concentration were observed. These outfalls were not sampled during the Hargis and Associates investigation (1985); therefore, no comparisons can be made.

4.3.20 Ambient Monitoring

Several wells installed at AF Plant 4 are not associated with a particular waste disposal site or suspected spill area. Groundwater from these and other wells was sampled and analyzed to gain a complete view of groundwater quality at AF Plant 4.

IRP Phase II Stage 1 ambient monitoring activiteis entailed the collection of groundwater samples from eleven upper zone monitor wells and eight Paluxy monitor wells. Upper zone monitor wells included in this group are the following: HM-29, 52, 54, 56, 57, 58, 59, 61, 64, 79, 81, 83, 84, and 85. Paluxy wells included are: P-5M, P-5U, P-9M, P-9U, P-10M, P-10U, P-11M, and P-11U. Figure 4.3.20-1 shows the locations of these wells. Groundwater samples were analyzed for volatile organic compounds by EPA Methods 601 and 602, for acid and base/neutral extractable compounds by EPA Method 625, for heavy metals by EPA Methods 200.7, 206.2, 239.2, 245.1, and 270.2, for hydrocarbon fuels by EPA Method 418.1, and for oil and grease by EPA Method 413.2. In addition, samples from HM-83 , HM-84, and HM-85 (sampled as part of the NARF area activities, Section 4.3.18) were analyzed for radioactive materials.

4.3.20.1 Results of Investigation

A discussion of results of the IRP Phase II Stage 1 ambient monitoring follows.

Occurrence of Groundwater

Groundwater occurs in both the materials of the upper zone and in the Paluxy Formation in the ambient monitoring wells. Table 4.3.20-1 presents results of water level measurements. Water levels in the upper zone ranged from 649.26 feet MSL at HM-57 to 623.78 feet MSL at HM-79. Groundwater elevations in the upper member of the Paluxy Formation ranged from 596.05 feet MSL at P-10U to 555.66 feet MSL at P-11U. Groundwater elevations in the

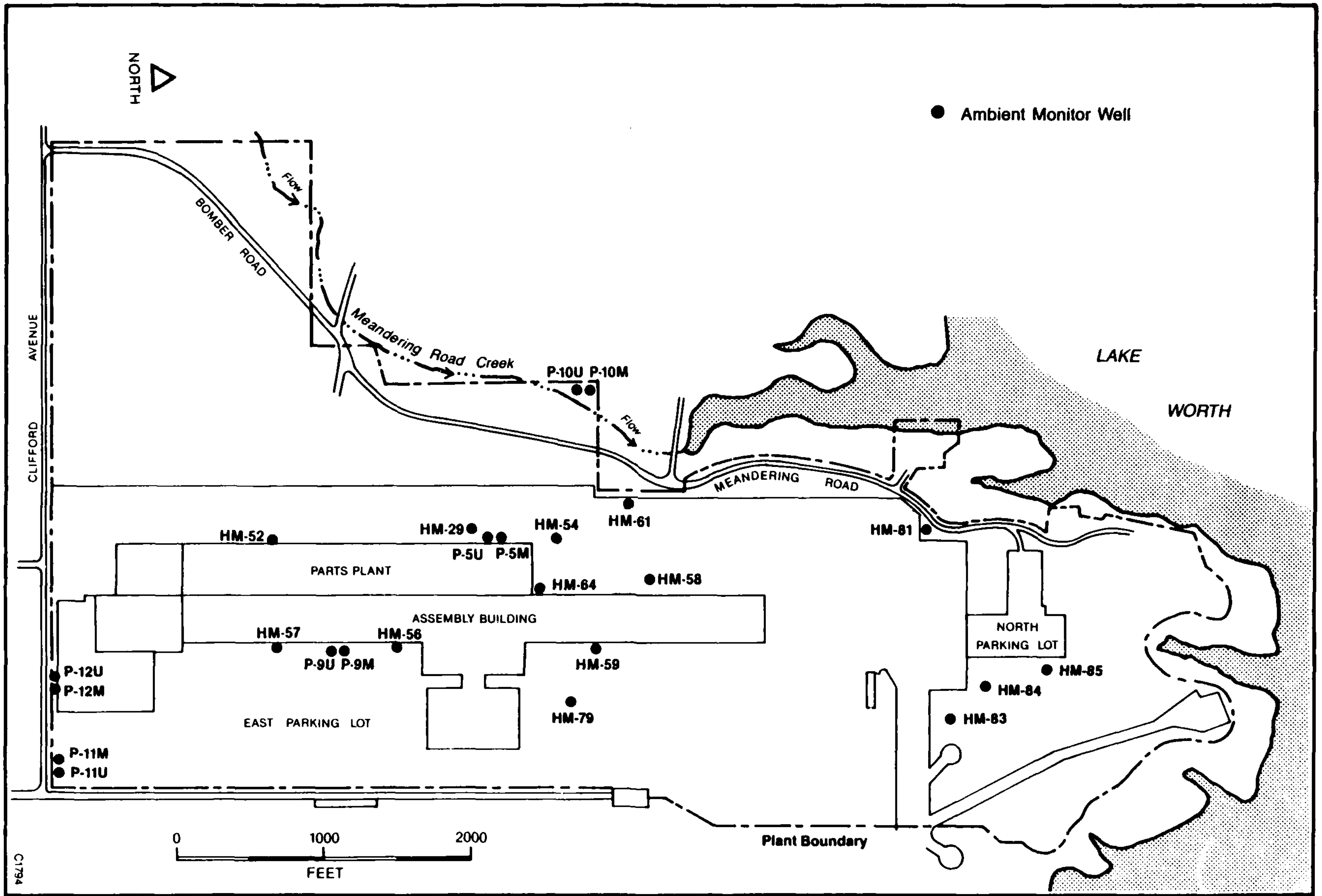

Figure 4.3.20-1. Phase II Activities at Ambient Monitoring Wells, AF Plant 4, Texas

TABLE 4.3.20-1. GROUNDWATER ELEVATIONS AT AMBIENT MONITORING LOCATIONS, AF PLANT 4, TEXAS (JANUARY THROUGH AUGUST 1986)

Monitor Well	Elevation (feet MSL)	Date
HM-29	629.04	2-21-86
HM-52	643.95	2-10-86
HM-54	638.52	2-10-86
HM-56	632.01	2-21-86
HM-57	649.26	2-26-86
HM-58	643.10	2-26-86
HM-59	639.45	2-30-86
HM-61	640.65	2-26-86
HM-64	628.89	2-26-86
HM-79	623.78	2-3-86
HM-81	634.32	2-7-86
HM-83	629.41	8-21-86
HM-84	628.22	8-21-86
HM-85	630.01	8-21-86
P-5M	570.81	1-31-86
P-5U	564.78	1-31-86
P-9M	564.25	2-5-86
P-9U	565.15	2-5-86
P-10M	575.83	2-17-86
P-10U	596.05	2-17-86
P-11M	555.46	2-28-86
P-11U	555.66	2-28-86
P-12M	557.53	2-28-86
P-12U	557.74	2-28-86

middle member of the Paluxy Formation ranged from 575.83 feet MSL at P-10M to 555.46 feet MSL at P-11M. Maps of water levels in these zones are presented and discussed in Section 4.1.2.

Groundwater Quality

Groundwater samples were collected from the following upper zone monitor wells: HM-29, 52, 54, 56, 57, 58, 59, 61, 64, 79, 81, 83, 84 and 85. The following Paluxy wells were sampled: P-5M, P-5U, P-9M, P-9U, P-10M, P-10U, P-11M and P-11U. Water levels were also measured at P-12M and P-12U. Samples were analyzed for volatile organic compounds (EPA Methods 601 and 602), for acid and base/neutrals (EPA Method 625), for heavy metals (EPA Methods, 200.7, 206.2, 239.2, 245.1, and 270.2), for hydrocarbon fuels (EPA Method 418.1), and for oil and grease (EPA Method 413.2). In addition, groundwater sampled from HM-83, HM-84, and HM-85 was analyzed for radioactive materials. Table 4.3.20-2 presents results of the groundwater analyses. Complete analytical reports for these analyses appear in Appendix A.

To evaluate the degree of groundwater contamination, analytical results from IRP Phase II Stage 1 sampling were compared to federal standards and guidelines. Table 4.3.20-3 summarizes this comparison.

4.3.20.2 Significance of Findings

This section discusses of the significance of the findings of this investigation, emphasizing the groundwater chemistry at the site. Hargis and Associates (1985) previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates those findings and trends identified by the Hargis report.

TABLE 4.3.20-2. RESULTS OF GROUNDWATER SAMPLE ANALYSES, AMBIENT MONITORING, AF PLANT 4, TEXAS

	Method Detection Limit	Monitor Well									
		MW-29	MW-52	MW-52D	MW-54	MW-54D	MW-56	MW-57	MW-58	MW-58D	MW-59
Date Sampled		2-21-86	2-10-86	2-10-86	2-10-86	2-10-86	2-21-86	2-26-86	2-26-86	2-26-86	2-3-86
Field Parameters											
Temperature (°C)		21.5	16.0	16.0	20.5	20.5	-	-	19.0	19.0	21.1
pH		7.0	7.2	7.2	7.0	7.0	-	-	6.9	6.9	6.8
Conductivity (umhos)		1000	550	550	1100	1100	-	-	1200-1500	1200-1500	1700
Analytical Parameters[a]											
Metals (mg/L)											
Arsenic	0.002-0.005	ND	0.002*	0.007*	0.005*	NA	0.01*	ND	0.046	0.047	ND
Barium	0.009	0.10	0.068	0.12	0.021	NA	0.48	0.093	0.19	0.17	0.097
Cadmium	0.002	ND	ND	0.003*	ND	NA	ND	ND	ND	ND	ND
Chromium	0.005	0.14	0.005*	0.034	0.005*	NA	0.02*	0.01*	0.075	0.070	0.029
Lead	0.001-0.002	ND	0.033	0.27	0.040	NA	0.007	ND*	0.024	0.023	0.006*
Mercury	0.0002	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND
Selenium	0.002-0.004	ND	0.003*	ND	ND	NA	ND	ND	ND	ND	ND
Silver	0.002	0.012	ND	0.004*	ND	NA	0.012	0.008*	0.010	0.011	0.011
Volatile Organics (ug/L)											
Method 601 (Halogenated Hydrocarbons)											
Concentration Factor		250	1	1	1		1	1	1	1	1
Vinyl Chloride	0.18	ND	ND	ND	ND	NA	0.80	ND	ND	ND	ND
Methylene Chloride	0.25	ND	ND	0.74	ND	NA	ND	0.42	ND	ND	ND
trans-1,2-Dichloroethylene	0.1	ND	ND	ND	ND**	NA	4.2	ND	1.9	2.0	ND
Chloroform	0.05	ND	4.3	3.8	ND	NA	ND	4.0	ND	ND	ND
1,1,1-Trichloroethane	0.03	ND	ND	ND	2.1	NA	ND	ND	ND	0.05	ND
Bromodichloromethane	0.10	ND	1.9	1.8	ND	NA	ND	1.9	ND	ND	ND
Trichloroethylene	0.12	5800	0.93	0.95	6.4	NA	0.75	0.14	0.74	0.84	6.6
Dibromochloromethane	0.09	ND	0.42	0.72	ND	NA	ND	0.45	ND	ND	ND
Tetrachloroethylene	0.03	ND	ND	ND	0.17	NA	ND	0.1	ND	ND	43
Trichlorofluoromethane	0.4	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND
Method 602 (Aromatic Compounds)											
Concentration Factor		10	1	1	1		10	1	1	1	1
Benzene	0.2	ND	ND	ND	ND	NA	110	ND	ND	ND	ND
Toluene	0.2	ND	3.0	0.90	10	NA	ND	0.92	ND	ND	5.3
Method 624											
Concentration Factor							1				
trans-1,2-Dichloroethylene	1.6	NA	NA	NA	NA	NA	4	NA	NA	NA	NA
Benzene	4.4	NA	NA	NA	NA	NA	35	NA	NA	NA	NA
Extractable Organics (ug/L)											
Method 625 Acid											
Concentration Factor		1	1		1	1	1	1	1.06	1	1
Phenol	1.5	2	2	NA	3	2	9	ND	2	2	ND
Method 625 Base/Neutral											
Concentration Factor		1	1		1	1	1	1	1.06	1	1
N-nitrosodiphenylamine	1.9	11BL	ND	NA	ND	ND	ND	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	2.5	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND
Di-n-butyl phthalate	2.5	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND
Radioactive Materials		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Alpha radiation (pCi/L)	2										
Beta radiation (pCi/L)	4-6										
Gamma radiation*** (pCi/L)	9-13										
Hydrocarbon Fuels (mg/L)	1	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND
Oil and Grease (mg/L)	1	ND	ND	ND	ND	NA	NA	ND	ND	ND	ND

(Continued)

TABLE 4.3.20-2. (Continued)

Date Sampled	Method Detection Limit	Monitor Well HM-61 2-26-86	HM-64 2-26-86	HM-79 2-3-86	HM-81 2-7-86	P-6M 1-31-86	P-5U 1-31-86	HM-83 8-21-86	HM-84 8-21-86	HM-85 8-21-86	HM-85D 8-21-86
Field Parameters											
Temperature (°C)		22.0	21.5	22.0	18.0	21.0	21.0	21.5	24.0	25.0	25.0
pH		7.1	7.1	6.8	6.4	7.1	6.8	6.7	6.7	6.5	6.5
Conductivity (umhos)		650	1500	1000	1500	910	1000	800	1300	760	760
Analytical Parameters[a]											
Metals (mg/L)											
Arsenic	0.002-0.005	0.11	ND	ND	0.007* ●	ND	ND	0.26	0.004*	0.086	0.004*
Barium	0.009	0.18	0.072	0.082	0.077	0.095	0.05	0.16	0.081	0.12	0.13
Cadmium	0.002	0.003*	ND	ND	ND	0.003*	0.003*	0.006*	ND	ND	0.003*
Chromium	0.005	0.17	0.006*	0.02*	0.050	0.007*	0.01*	0.009*	0.02*	0.02*	0.007*
Lead	0.001-0.002	0.08	0.007	ND	0.20	ND●	0.003*	0.050	0.009	0.022	0.006
Mercury	0.0002	ND	ND	ND	ND	ND	ND	0.0002*	ND	ND	ND
Selenium	0.002-0.004	ND	0.004●	0.003●	ND ●	ND	ND	0.005*	ND	ND	ND
Silver	0.002	0.020	0.003*	0.008*	0.019	0.011	0.008*	ND	ND	ND	ND
Volatile Organics (ug/L)											NA
Method 601 (Halogenated Hydrocarbons)											
Concentration Factor		10	10	1	1	1	1	1	1	1	
Vinyl Chloride	0.18	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Methylene Chloride	0.25	ND	ND	ND	ND	ND	ND	ND	ND	ND	
trans-1,2-Dichloroethylene	0.1	ND	ND	ND	ND	ND**	ND**	ND	0.58	ND	
Chloroform	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	
1,1,1-Trichloroethane	0.03	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Bromodichloromethane	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Trichloroethylene	0.12	ND	75	170	ND	ND	ND	7.4	0.30	ND	
Dibromochloromethane	0.09	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Tetrachloroethylene	0.03	ND	ND	13	ND	ND	ND	0.10	ND	ND	
Trichlorofluoromethane	0.4	ND	ND	ND	ND	ND	ND	1.5	1.2	1.3	
Method 602 (Aromatic Compounds)											
Concentration Factor		1	10	1	1	5	5	1	1	1	
Benzene	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Toluene	0.2	2.7	ND	1.4	3.5	ND	ND	4.4	1.2	1.4	
Method 624											
Concentration Factor											
trans-1,2-Dichloroethylene	1.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Benzene	4.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Extractable Organics (ug/L)											
Method 625 Acid											
Concentration Factor			1	1	1	1	1	1	1	1	1
Phenol	1.5	NA	ND	2	3	ND	3	ND	ND	ND	ND
Method 625 Base/Neutral											
Concentration Factor			1	1	1	1	1	1	1	1	1
N-nitrosodiphenylamine	1.9	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	2.5	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di-n-butyl phthalate	2.5	NA	ND	ND	4	ND	ND	ND	ND	ND	ND
Radioactive Materials		NA	NA	NA	NA	NA	NA				
Alpha radiation (pCi/L)	2							5.1(±4.4)	ND	3.6(±4.0)	3.3(±2.2)
Beta radiation (pCi/L)	4-6							4.7(±3.8)	ND	ND	7.2(±2.2)
Gamma radiation*** (pCi/L)	9-13							10.7	ND	ND	ND
Hydrocarbon Fuels (mg/L)	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
Oil and Grease (mg/L)	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA

(Continued)

TABLE 4.3.20-2. (Continued)

Date Sampled	Method Detection Limit	Monitor Well P-9M 2-5-88	 P-9U 2-5-88	 P-10M 2-17-88	 P-10MD 2-17-88	 P-10U 2-17-88	 P-10UD 2-17-88	 P-11M 2-28-88	 P-11MD 2-28-88	 P-11U 2-28-88
Field Parameters										
Temperature (°C)		22.0	22.0	18.5	18.5	21.0	21.0	21.0	21.0	18.0
pH		6.8	7.2	6.8	6.8	6.5	6.5	7.4	7.4	9.6
Conductivity (umhos)		720	740	625	625	800	800	700	700	460
Analytical Parameters[a]										
Metals (mg/L)										
Arsenic	0.002-0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	0.009	0.076	0.072	0.068	0.083	0.041	0.043	0.078	0.075	0.024
Cadmium	0.002	ND	ND●	ND●	ND	ND	ND	ND	ND	ND
Chromium	0.005	0.007*	ND	ND●	ND	ND	ND	0.031	ND	0.02*
Lead	0.001-0.002	0.032	ND	ND●	ND	ND●	ND●	0.002*	ND	0.038
Mercury	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	0.002-0.004	ND●	ND	ND●	ND	ND●	ND●	ND	ND	ND
Silver	0.002	0.007*	0.007*	0.008	0.002*	0.007*	0.004*	0.003*	0.002*	0.008*
Volatile Organics (ug/L)										
Method 601 (Halogenated Hydrocarbons)										
Concentration Factor		1	1	1	1	1	1	1	1	1
Vinyl Chloride	0.18	ND	ND	ND	ND	0.20	0.74	ND	ND	ND
Methylene Chloride	0.25	ND	ND	ND	ND	49	91	0.28	ND	14
trans-1,2-Dichloroethylene	0.1	ND	ND	0.30	0.25	ND**	ND**	ND	ND	ND
Chloroform	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	0.03	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	0.09	ND	ND	ND	ND	1.0	0.82	ND	ND	ND
Tetrachloroethylene	0.03	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND
Method 602 (Aromatic Compounds)										
Concentration Factor		1	1	1	1	1	1	1	1	1
Benzene	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	0.2	ND	ND	16	2.8	ND	5.9	ND	1.6	7.0
Method 624										
Concentration Factor										
trans-1,2-Dichloroethylene	1.6	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	4.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
Extractable Organics (ug/L)										
Method 625 Acid										
Concentration Factor		1	1	1	1	1	1	1	1	1
Phenol	1.5	2	ND	1	2	2	ND	ND	ND	ND
Method 625 Base/Neutral										
Concentration Factor		1	1	1	1	1	1	1	1	1
N-nitrosodiphenylamine	1.9	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	2.5	ND	ND	ND	ND	ND	ND	ND	ND	3
Di-n-butyl phthalate	2.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Radioactive Materials		NA	NA	NA	NA	NA	NA	NA	NA	NA
Alpha radiation (pCi/L)	2									
Beta radiation (pCi/L)	4-6									
Gamma radiation*** (pCi/L)	9-13									
Hydrocarbon Fuels (mg/L)	1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Oil and Grease (mg/L)	1	ND	ND	ND	ND	ND	ND	ND	ND	ND

a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.

NA = Not analyzed.

ND = Not detected.

BL = Detected in reagent blank; background subtraction not performed.

** = Compound not confirmed by second-column analysis.

* = Value less than five times detection limit. Errors may range up to 100 percent.

● = Spike recovery not within acceptable limits. Indicates interferent.

– = Data not collected, insufficient volume (MW-66), omitted in field (MW-67).

D = Duplicate sample.

*** = Cesium 137.

TABLE 4.3.20-3. COMPARISON OF WATER QUALITY, AMBIENT MONITORING, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location HM-29	HM-52	HM-54	HM-56	HM-58	HM-59
METALS (mg/L)							
Arsenic	0.05						
Chromium	0.05	0.14				0.075	
Lead	0.05		0.27				
ORGANIC COMPOUNDS (ug/L)							
Trichloroethylene	5	5600		6.4			6.6
Tetrachloroethylene	8						43
Benzene	5				110		

TABLE 4.3.20-3. (Continued)

Parameter	Criteria*	Sampling Location HM-61	HM-64	HM-79	HM-81	HM-83	HM-85	P-10U	P-11U
METALS (mg/L)									
Arsenic	0.11	0.11				0.28	0.086		
Chromium	0.17	0.17			0.05				
Lead	0.08	0.08			0.2	0.05			
ORGANIC COMPOUNDS (ug/L)									
Trichloroethylene	5		75	170		7.4			
Tetrachloroethylene	8			13					
Benzene	5								
Methylene Chloride								91	14

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

Significance of Metals in Groundwater

Four metals, arsenic, cadmium, chromium, and lead, were reported in samples from upper zone wells at concentrations that exceeded federal MCL criteria. Arsenic was detected in water sampled from HM-61 at 0.11 mg/L and in water sampled from HM-83 and HM-85 at 0.26 mg/L and 0.086 mg/L, respectively. Chromium was present in groundwater sampled from HM-29, 58, 61, and 81 at levels exceeding federal standards. The highest recorded concentration of chromium was 0.17 mg/L at HM-61. Concentrations of lead that exceeded MCLs ranged from 0.08 mg/L at HM-61 to 0.27 mg/L at HM-52. Lead was detected at HM-83 at 0.05 mg/L, which is the MCL for that metal. Concentrations of metals were below federal MCL criteria in all Paluxy wells sampled as part of ambient monitoring activities.

These observations differ slightly from the Hargis and Associates (1985) report, which reported concentrations of metals in these wells at levels below federal MCL criteria. Low concentrations of heavy metals were noted in the Paluxy wells in the Hargis study.

Significance of Organic Compounds in Groundwater

Compounds detected at levels above federal standards included trichloroethylene, tetrachloroethylene, and benzene. Groundwater samples from HM-54, 59, 64, 79 and 83 contained trichloroethylene in excess of the MCL at levels ranging from 6.4 ug/L at HM-54 to 170 ug/L at HM-79. Tetrachloroethylene was detected above the MCL of 8 ug/L at HM-59 and 79. Concentrations ranged from 13 ug/L at HM-79 to 43 ug/L at HM-59. Benzene was detected at levels exceeding federal criteria at one well, HM-56, at a reported concentration of 110 ug/L.

The Hargis and Associates (1985) report noted similar concentrations of trichloroethylene in the above-mentioned wells. However, concentrations of tetrachloroethylene and benzene were noted at different levels. Wells HM-59 and 79 reportedly contained lower levels of tetrachloroethylene, while HM-64 had a higher concentration, 400 ug/L. Furthermore, the concentration of benzene in HM-56, noted in this report at 110 ug/L, was detected at concentrations ranging from 700 to 850 ug/L in 1985.

Hydrocarbon fuels and oil and grease were not detected in groundwater samples from all ambient monitoring wells.

These observations generally agree with those of the Hargis and Associates (1985) report, with a few exceptions. In 1985, Hargis reported levels of oil and grease of 21 mg/L, 16 mg/L and 12 mg/L in HM-56, 57, and 61, respectively. Otherwise, hydrocarbon fuels and oil and grease were reported at levels below the instrument detection limit.

Significance of Radioactive Materials in Groundwater

Levels of alpha radiation present in groundwater at HM-83, HM-84, and HM-85 ranged from <2.1 pCi/L at HM-85 to 5.1 pCi/L at HM-83. Beta radiation was detected at levels ranging from <4.2 pCi/L at HM-84 to 7.2 pCi/L at HM-85. Gamma radiation was not measured directly, but a test for Cesium 137, also a fission byproduct, was conducted. Since radiation was detected at very low levels, it was not necessary to run a test for gamma radiation. Levels of Cesium 137 were below the instrument detection limit for groundwater samples from all three wells. All values are below the corresponding federal criteria.

4.3.21 East Parking Lot Wells

This site has five wells, HM-68, HM-71, HM-82, P-8M, and P-8U, located in the vicinity of the East Parking Lot.

Investigation activities at East Parking Lot Wells entailed the collection and analysis of groundwater from three upper zone monitor wells and two Paluxy monitor wells. Figure 4.3.21-1 shows the locations of these wells.

4.3.21.1 Results of Investigation

A discussion of the results of IRP Phase II Stage 1 activities at the East Parking Lot and the topographic and geologic features of the site follows.

Topography

This area is located at the southeastern border of AF Plant 4. The surface elevation in this area is about 640 to 648 feet MSL.

Geologic Features

Lithologic logs of monitor wells P-8M, P-8U, HM-68, HM-71, and HM-82 (Hargis and Associates, 1985) provide information on the subsurface at this site.

The upper zone, from 30 to over 50 feet thick in this area, consists of silty and sandy clay, clayey sand, and sand and gravel. The Walnut Formation is 26 to 28 feet thick. The Goodland Limestone is absent.

Previous investigators (Hargis and Associates, 1985) have described a buried bedrock valley, trending east-northeast across the East Parking Lot. It has been suggested that contaminants from the plant area are moving in the

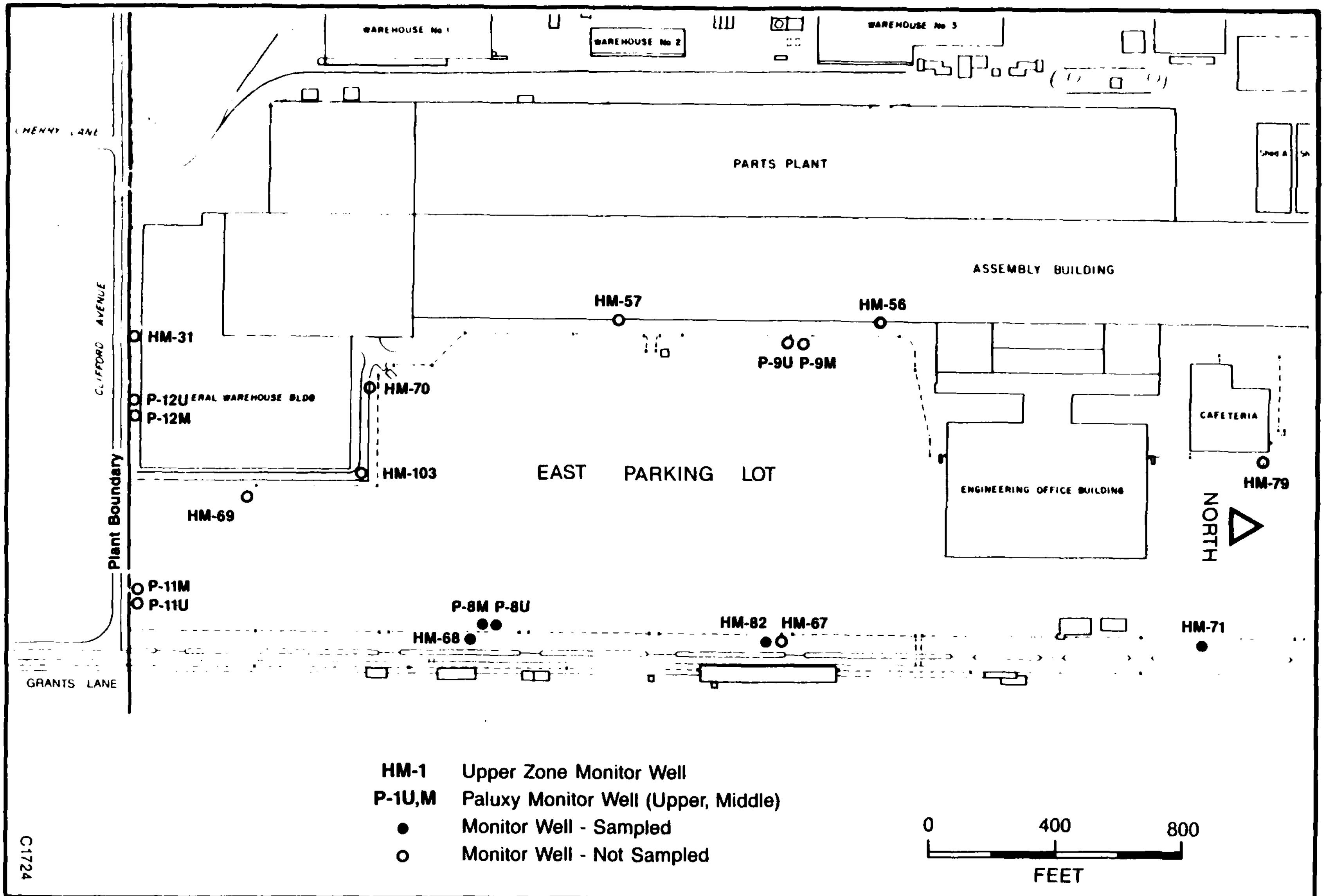

Figure 4.3.21-1. Phase II Activities at East Parking Lot Wells, AF Plant 4, Texas

upper zone down this valley along the contact between the upper zone and the Walnut. It has been further suggested that the Walnut Formation is thin or absent in the floor of this valley, providing a "window" through which contaminants could enter the Paluxy. The Corps of Engineers was actively studying this topic at the time this report was being prepared.

Occurrence of Groundwater

Groundwater occurs in both the materials of the upper zone and in the Paluxy Formation. Table 4.3.21-1 presents results of water level measurements. The water level map for the upper zone in this area of AF Plant 4 (Figure 4.1.2-9) was discussed previously in Section 4.1.2. Water levels in the upper zone in the area of the East Parking Lot ranged from 647.09 feet MSL at HM-82 to 615.38 feet MSL at HM-68. As shown in Figure 4.1.2-9, upper zone groundwater flow in this area is to the east and northeast. The effects of the buried bedrock valley are not well displayed by the contours shown. Groundwater elevations in the Paluxy Formation ranged from 573.84 feet MSL in the upper Paluxy Formation to 559.58 feet MSL in the middle Paluxy Formation. Figures 4.1.2-2 and 4.1.2-3 shows groundwater flow in the Paluxy.

Groundwater Quality

Groundwater samples were collected from monitor wells HM-68, 71, 82, P-8M, and P-8U and analyzed for volatile organic compounds by EPA Methods 601 and 602, for acid and base/neutral extractable compounds by EPA Method 625, and for heavy metals by EPA Methods 200.7, 206.2, 239.7, 245.1, and 270.2. Table 4.3.21-2 shows the results of the groundwater analyses. Complete analytical reports for these analyses appear in Appendix A.

To evaluate the degree of groundwater contamination, analytical results from IRP Phase II Stage 1 sampling were compared to federal standards and guidelines. Table 4.3.21-3 summarizes the results of this comparison.

TABLE 4.3.21-1. GROUNDWATER ELEVATIONS AT EAST PARKING LOT WELLS, AF PLANT 4, TEXAS (FEBRUARY 1986)

Monitor Well	Elevation (feet MSL)	Date
HM-68	615.38	2-28-86
HM-71	615.76	2-3-86
HM-82	647.09	2-4-86
P-8M	559.58	2-4-86
P-8U	573.84	2-7-86

TABLE 4.3.21-2. RESULTS OF GROUNDWATER SAMPLE ANALYSES, EAST PARKING LOT, AF PLANT 4, TEXAS

	Method Detection Limit	Monitor Well				
		HM-68	HM-71	HM-82	P-8M	P-8U
Date Sampled		2-28-86	2-3-86	2-4-86	2-4-86	2-7-86
Field Parameters						
Temperature (°C)		19.5	22.0	22.0	22.0	15.0
pH		6.8	6.8	6.8	7.3	6.8
Conductivity (umhos)		820	1100	940	810	600
Analytical Parameters[a]						
Metals (mg/L)						
Arsenic	0.002-0.005	ND	ND	ND	ND	ND
Barium	0.009	0.11	0.091	0.13	0.082	0.099
Cadmium	0.002	ND	ND	ND	ND	ND
Chromium	0.005	ND	0.14	0.33	0.006*	0.02*
Lead	0.001-0.002	0.021	ND	0.004*	ND@	0.025
Mercury	0.0002	ND	ND	ND@	ND	ND
Selenium	0.002-0.004	ND	ND	ND@	0.003*	ND
Silver	0.002	0.004*	0.012	0.012	0.007*	0.006*
Volatile Organics (ug/L)						
Method 601 (Halogenated Hydrocarbons)						
Concentration Factor		1	100	1000	1	250
Methylene Chloride	0.25	0.37	ND	ND	ND	ND
trans-1,2-Dichloroethylene	0.10	ND**	ND**	ND**	ND	ND**
1,1,1-Trichloroethane	0.03	0.07	ND	ND	ND	ND
Trichloroethylene	0.12	32	1300	19000	ND	7200
Tetrachloroethylene	0.03	0.17	23	ND	ND	ND
1,2-Dichlorobenzene	0.15	5.0	ND	ND	ND	ND
Method 602 (Aromatic Compounds)						
Concentration Factor		1	1	500	1	25
Toluene	0.2	11	7.6	ND	0.64	ND
1,2-Dichlorobenzene	0.4	4.0	ND	ND	ND	ND

(Continued)

TABLE 4.3.21-2. (Continued)

	Method Detection Limit	Monitor Well				
		HM-68	HM-71	HM-82	P-8M	P-8U
Date Sampled		2-28-86	2-3-86	2-4-86	2-4-86	2-7-86
Extractable Organics (ug/L)						
Method 625 Acid Concentration Factor		1	1	1	1	1
Phenol	1.5	ND	2	4	3	ND
Method 625 Base/Neutral Concentration Factor		1	1	1	1	1
1,2-Dichlorobenzene	1.9	2	ND	ND	ND	ND
Di-n-butyl phthalate	2.5	ND	ND	4BL	ND	ND
Hydrocarbon Fuels (mg/L)	1	ND	ND	ND	ND	ND
Oil and Grease (mg/L)	1	ND	ND	ND	ND	ND

a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables 4.2.2-2, 4.2.2-3, and 4.2.2-4.
* = Value less than five times detection limit. Errors may range up to 100 percent.
** = Compound not confirmed by second-column analysis.
@ = Spike recovery not within acceptable limits. Indicates interferent.
ND = Not detected.
BL = Detected in reagent blank; background subtraction not performed.

TABLE 4.3.21-3. COMPARISON OF WATER QUALITY, EAST PARKING LOT, AF PLANT 4, TEXAS WITH APPLICABLE WATER QUALITY CRITERIA

Parameter	Criteria*	Sampling Location HM-68	HM-71	HM-82	P-8U
METALS (mg/L)					
Chromium	0.05		0.14	0.33	
ORGANIC COMPOUNDS (ug/L)					
Trichloroethylene	5	32	1300	19000	7200
Tetrachloroethylene	8		23		

* See Tables 4.2.1-1 and 4.2.1-2 for source of criteria.

4.3.21.2 Significance of Findings

This section discusses the significance of the findings of this investigation, emphasizing the groundwater chemistry at the site. Hargis and Associates (1985) previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates those findings and trends identified by the Hargis report.

Significance of Metals in Groundwater

Groundwater in the upper zone and in the Paluxy Formation at the East Parking Lot contained concentrations of heavy metals generally below federal MCLs. The one exception is chromium, which was detected at levels exceeding the MCL of 0.05 mg/L in HM-71 and HM-82. The detected value at HM-71 was 0.14 mg/L. At HM-82 the detected level of chromium was 0.33 mg/L. The results of previous efforts by Hargis and Associates (1985) agree with present observations.

Significance of Organic Compounds in Groundwater

Trichloroethylene and tetrachloroethylene were detected in upper zone water at this site in levels in excess of federal MCL criteria. An unknown compound, with a retention time near that of trans-1,2-dichloroethane, was also present in high concentrations in upper zone groundwater. The highest concentration of TCE observed was 19,000 ug/L in HM-82.

Groundwater samples collected from two Paluxy aquifer wells revealed the presence of organic compounds at levels exceeding federal MCL criteria only in the upper zone of the Paluxy. The middle member had no organic compounds in excess of federal criteria. Trichloroethylene was detected at 7200 ug/L in P-8U. An unknown compound with a retention time near that of trans-1,2-dichloroethane was also detected in P-8U.

These observations differ somewhat from those of the Hargis and Associates (1985) report. In the previous report, TCE was detected at HM-68 at lower levels and other purgeable halocarbons and aromatics were reported as not detected. Similarly, at HM-71 only TCE was reported at a detectable level (1200 ug/L and 2500 ug/L for separate sampling episodes in 1985). In addition, in the 1985 report, levels of TCE in groundwater from HM-82 were noted at much lower levels than in this report. The reported value in 1985 was 9500 ug/L, while this study shows the concentration of TCE at HM-82 to be 19,000 ug/L.

The results of this study and those of previous work support the suggestion that contaminants are entering the upper Paluxy through a window in the Walnut. The detailed investigation being conducted by the Corps of Engineers will establish the flow relationships with more certainty.

4.3.22 Fuel Storage Tank

This site has been the location of a 100,000-gallon above-ground JP-4 storage tank since 1962.

Investigation activities for the Fuel Storage Tank site entailed the collection of a groundwater sample from the one upper zone well in the area, HM-23. The sample was analyzed for hydrocarbon fuels by EPA Method 418.1 and oil and grease by EPA Method 413.2. Figure 4.3.22-1 shows the location of HM-23.

4.3.22.1 Results of Investigation

A discussion of the results of IRP Phase II Stage 1 activities at the Fuel Storage Tank and the topographic and geologic features of the site follows.

Topography

The Fuel Storage Tank is located just north of Clifford Avenue in the southwest corner of the Plant 4 facility. The ground surface is relatively flat and has an elevation of approximately 680 feet MSL.

Geologic Features

The lithologic log of monitor well HM-23 (Hargis and Associates, 1985) gives shallow subsurface information for the Fuel Storage Tank site.

The upper zone is about 42 feet thick and consists of silty to sandy clay grading down into sand and gravel and clayey sandy gravel. About 8 feet of Walnut Formation were encountered. The Goodland Limestone is absent at this location.

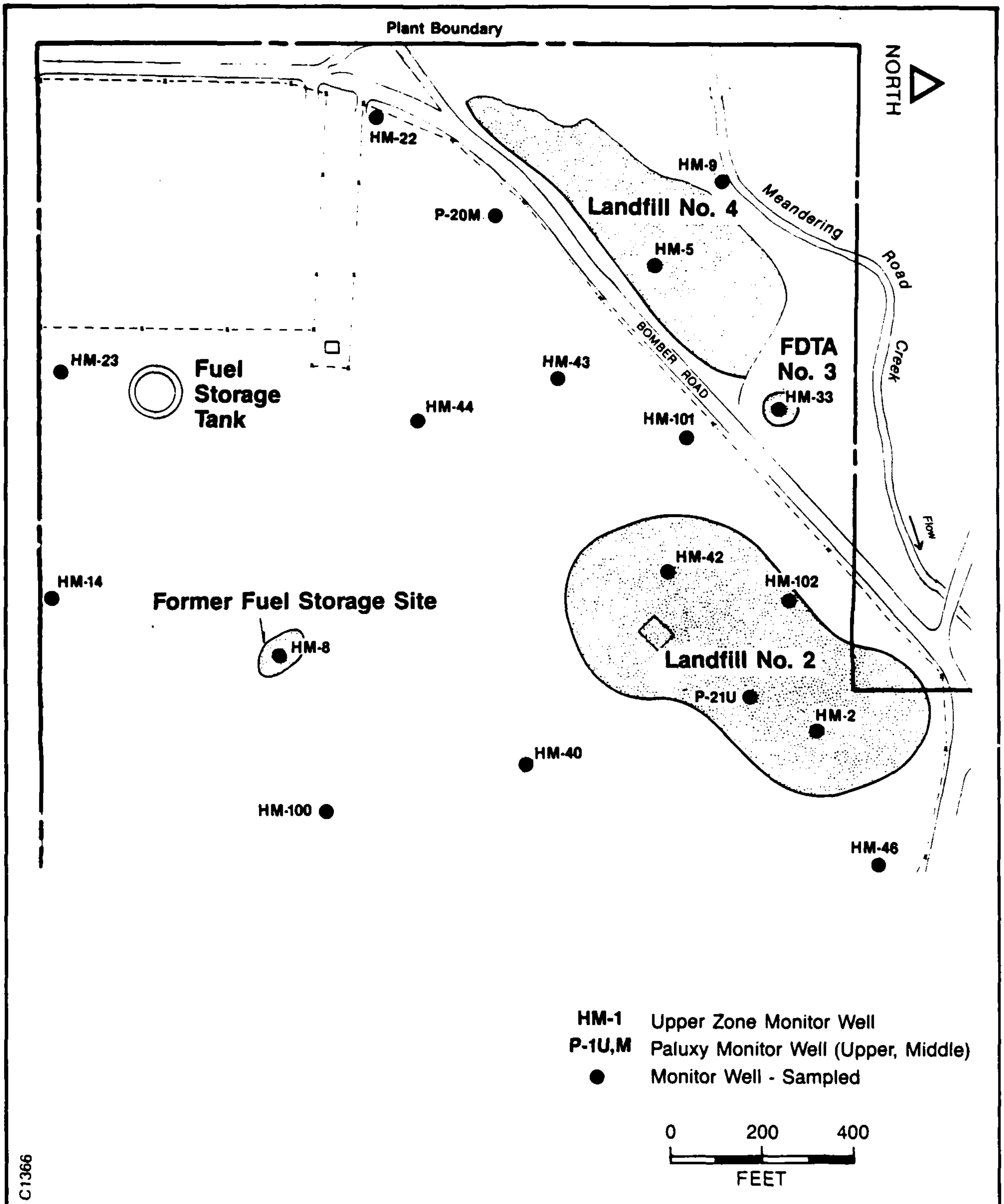

Figure 4.3.22-1. Phase II Activities at Fuel Storage Tank, AF Plant 4, Texas

Occurrence of Groundwater

The water level elevation at HM-23 was 638.19 during February, 1986. The water level map of the upper zone in this area of AF Plant 4 (Figure 4.1.2-8) was discussed previously in Section 4.1.2. As shown on this map, upper zone groundwater flow in this area is to the north.

Groundwater Quality

Groundwater sampled from HM-23 was analyzed for hydrocarbon fuels and oil and grease. Table 4.3.22-1 presents results of the groundwater analyses. Complete analytical reports for these analyses appear in Appendix A.

4.3.22.2 Significance of Findings

This section discusses the significance of the findings of this investigation, emphasizing the groundwater chemistry at the site. Hargis and Associates (1985) previously discussed the significance of groundwater quality data collected in 1985 and earlier. Where appropriate, this report recognizes and incorporates those findings and trends identified by the Hargis report.

Significance of Organic Compounds in Groundwater

Hydrocarbon fuels and oil and grease were not detected in the upper zone groundwater at this site.

The Hargis and Associates (1985) report also notes low levels of these compounds; however, in 1984, hydrocarbons were detected at 5.7 mg/L and oil and grease was detected at 7.1 mg/L.

TABLE 4.3.22-1. RESULTS OF GROUNDWATER SAMPLE ANALYSES, FUEL STORAGE TANK, AF PLANT 4, TEXAS

Date Sampled	Method Detection Limit	Monitor Well HM-23 2-17-86
Field Parameters		
Temperature (°C)		22.0
pH		6.6
Conductivity (umhos)		590
Analytical Parameters		
Hydrocarbon Fuels (mg/L)	1	ND
Oil and Grease (mg/L)	1	ND

ND = Not detected.

4.3.23 Lake Worth Monitor Well

This site comprises one monitor well installed along the northern area of AF Plant 4 that borders Lake Worth. A monitor well was installed at this location to determine the occurrence and character of groundwater in the vicinity of Lake Worth.

Investigation activities at this site included the installation of a Paluxy monitor well completed in the upper member of the formation, and the collection of two sets of water samples, approximately four months apart. Figure 4.3.23-1 shows the location of this Paluxy well, P-23U. Groundwater samples were analyzed for volatile organic compounds by EPA Methods 601 and 602, for acid and base/neutral extractable compounds by EPA Method 625, and for heavy metals by EPA Methods 200.7, 206.2, 239.2, 245.1, and 270.2.

4.3.23.1 Results of Investigation

A discussion of the results of the IRP Phase II Stage 1 activities for the Lake Worth monitor well and descriptions of the topographic and geologic features of the site follow.

Topography

The Lake Worth well is located in the northwest corner of the AF Plant 4 facility. The land surface near well P-23U slopes down rather steeply toward Lake Worth. Elevations range from 620 feet MSL at P-23U to 590 feet MSL at Lake Worth.

Geologic Features

The upper zone is absent at this site. The Walnut Formation was encountered at the surface when drilling and is about 25 feet thick. It is

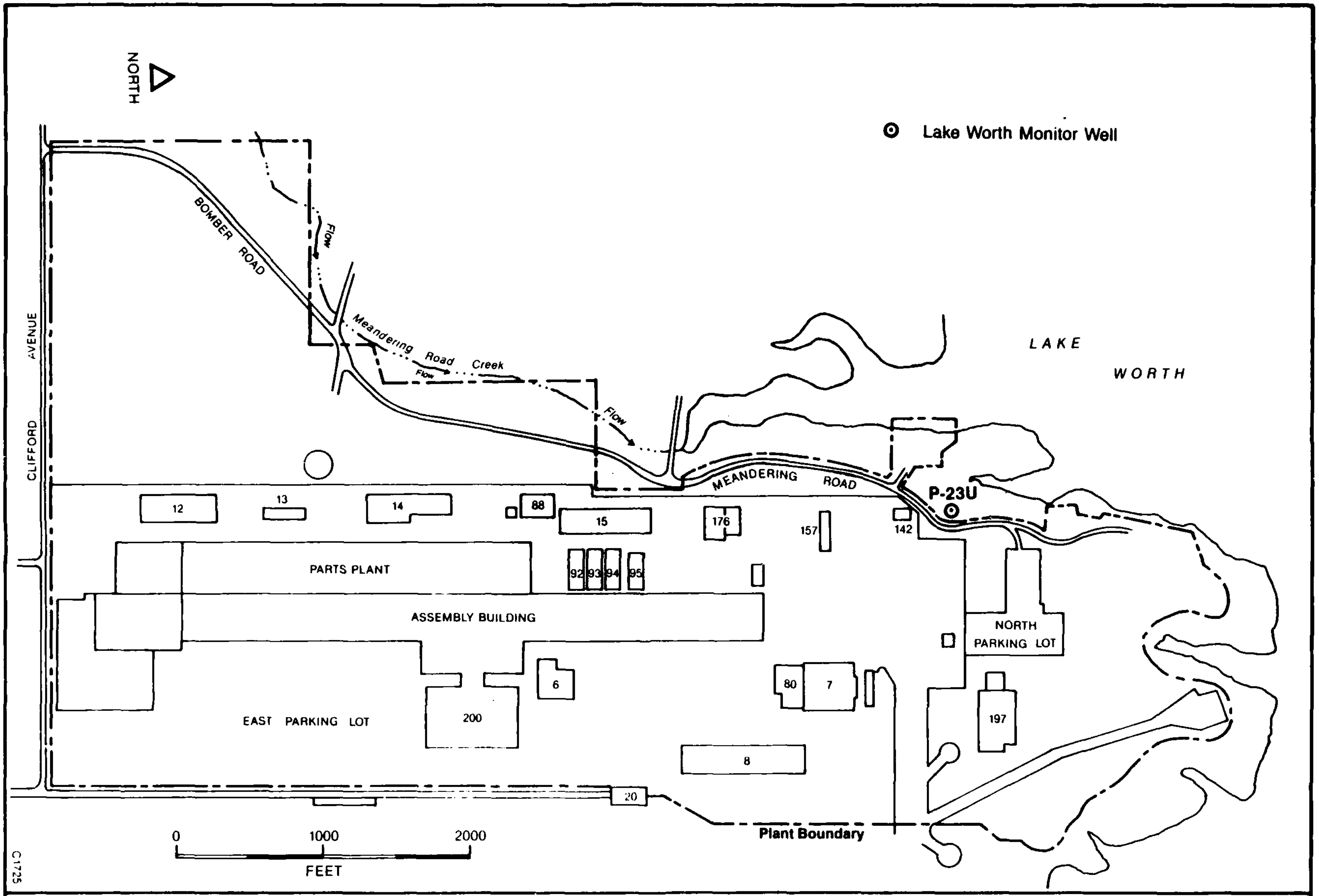

Figure 4.3.23-1. Location of Lake Worth Monitor Well (P-23U), AF Plant 4, Texas

composed of layers of fossiliferous limestone and calcareous shale. Monitor Well P-23U penetrates approximately 20 feet of sand in the Upper Paluxy Formation.

Occurrence of Groundwater

Groundwater at this site occurs in the upper member of the Paluxy Formation. The water level elevation at P-23U was 587.71 feet MSL in April 1986 and 588.35 feet MSL in August, 1986. Groundwater in the upper member of the Paluxy Formation flows to the east-southeast in this area.

Groundwater Quality

Groundwater samples were collected and analyzed from monitor well P-23U at two separate sampling periods; April, 1986, and August, 1986. Samples were analyzed for volatile organic compounds (EPA Methods 601 and 602), for acid and base/neutral extractable compounds (EPA Method 625), for heavy metals (EPA Methods 200.7, 206.2, 239.2, 245.1, and 270.2), for hydrocarbon fuels (EPA Method 418.1), and for oil and grease (EPA Method 413.2). Table 4.3.23-1 presents results of the groundwater analyses. Complete analytical reports for these analyses appear in Appendix A.

4.3.23.2 Significance of Findings

This section discusses the significance of the findings [illegible] investigation, emphasizing the groundwater chemistry at the site.

Significance of Metals in Groundwater

All metals detected in groundwater at P-23U were [illegible] trations below federal MCL criteria.

Significance of Organic Compounds [illegible]

Analysis for organic compounds [illegible] number of compounds, all at concentrations [illegible]

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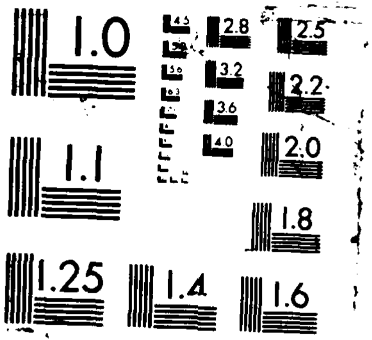
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TABLE 4.3.23-1. RESULTS OF GROUNDWATER SAMPLE ANALYSES, LAKE WORTH WELL (P-23), AF PLANT 4, TEXAS

	Method Detection Limit	Monitor Well	
Date Sampled		P-23U 4-18-86	P-23U 8-21-86
Field Parameters			
Temperature (°C)		-	-
pH		6.3	-
Conductivity		1000	-
Analytical Parameters[a]			
Metals (mg/L)			
Arsenic	0.002-0.005	0.015	0.017
Barium	0.009	0.06	0.036
Cadmium	0.002	ND	0.002*
Chromium	0.005	0.02*	0.006*
Lead	0.001-0.002	0.023	0.007
Mercury	0.0002	ND	0.0004*
Selenium	0.002-0.004	ND(0.03)	ND
Silver	0.002	0.01*	ND
Volatile Organics (ug/L)			
Method 601 (Halogenated Hydrocarbons)			
Concentration Factor		1	1
Trichlorofluoromethane	0.40	ND	1.9
Method 602 (Aromatic Compounds)			
Concentration Factor		1	1
Toluene	0.2	7.0	3.6
Ethyl Benzene	0.2	1.2	ND
Extractable Organics (ug/L)			
Method 625 Acid[b]			
Concentration Factor		1	1
Method 625 Base/Neutral			
Concentration Factor		1	1
Bis(2-ethylhexyl)phthalate	2.5	3	4
Di-n-butyl phthalate	2.5	3BL	ND

ND = Not detected, values in parentheses are actual sample detection limits.
BL = Detected in reagent blank; background subtraction not performed.
- = Data not collected, omitted in field.
a = Compounds not listed were not detected. Sample detection limits are the method detection limit times the concentration factor. Method detection limits are found in Tables X-1, X-2, and X-3.
b = No compounds were detected by this analysis.
* = Value less than five times detection limit. Errors may range up to 100 percent.

4.3.24 White Settlement Groundwater Pumping Effects

An investigation of of the pumpage effects of White Settlement's municipal wells was performed on the groundwater to determine the zone of influence, long-term drawdowns (if any) and the influence on the direction of groundwater flow in the Paluxy aquifer beneath the Plant 4 area. Groundwater flows and drawdowns were determined by reviewing existing geologic and hydrologic information and current pumpage records for the City of White Settlement. These data were supported by comparing actual water level data to simulated results from a simple finite-difference steady-state groundwater model (Koch, 1984). Background data used in executing the simulated pump test of the Paluxy aquifer were gathered from a variety of sources, including the City of White Settlement Engineers Office, historical records of the AF Plant 4 Paluxy wells, previous groundwater investigations conducted by General Dynamics, Phase II results, and existing published literature.

Model Application

The application of a groundwater model to the Paluxy aquifer involves data collection, data input for the model, historical matching and predictive simulation.

As a first step, initial estimates of Paluxy aquifer parameters were compared to known regional aquifer parameters by running the model and matching the results with existing conditions in the AF Plant 4 area. By trial and error, the estimated values for aquifer properties were calibrated and refined. A predictive simulation using the estimated hydraulic conductivity, aquifer thickness, specific yield and discharge was then run to compute drawdown in the AF Plant 4 area.

Results of the predictive simulation were compared with observed drawdown. It was not necessary to modify the input data to fine tune the results of the simulated pump test.

The nearest municipal wells to AF Plant 4 are wells WS-6 (re-designated as WS-2 in 1982) and WS-12. Well WS-2 is located about 850 feet west of the plant, and well WS-12 is located about 1500 feet south of the plant (Hargis and Montgomery, 1983). Well records of the Paluxy and Twin Mountain wells are presented in Table 4.3.24-1 below.

The total daily consumption of groundwater from these wells is approximately 750,000 gallons per day. The average yield per well is about 83,000 gallons per day. Currently, the City of White Settlement withdraws approximately 552 acre-feet of water from the Paluxy and about 27 acre-feet from the Twin Mountains aquifers (Otrosky, 1986).

Because of the projected increase in the demand for groundwater by the community and by Fort Worth to the east, the city is planning to install an additional three (3) wells in the next five years. All three wells will be screened in the Twin Mountain aquifer: two wells at existing Paluxy well sites (WS-2 and WS-H3), and the other in Rockwall County.

Previous Pump Test Data

Results of pumping tests conducted on three Paluxy wells within two miles of AF Plant 4 indicate that the transmissivity of the Paluxy ranges between 3100 and 7500 gallons per day per foot (Nordstrom, 1982). Specific yield was estimated to be on the order of 0.15 to 0.20 for the Paluxy. The average rate of water movement in the Paluxy was calculated to be less than 2 feet per year in a south-easterly direction. The present hydraulic gradient is east-southeast, approximately 27 feet per mile (Nordstrom, 1982).

Historical water level records show that groundwater levels have not declined appreciably in outcrop areas of the Paluxy. The aquifer is under water-table conditions in the outcrop area, and observation wells show only minor fluctuations from year to year (Hargis and Montgomery, 1983). This is not unusual since Lake Worth provides a source of constant recharge to the

TABLE 4.3.24-1. CITY OF WHITE SETTLEMENT WELL DATA

Well Number	Date Drilled	Total depth (ft)	Aquifer	Discharge (gpd)
WS-1	1945	254	Paluxy	96,000
WS-3	1950	201	Paluxy	70,000
WS-5	1951	720	Twin Mtn.	123,000
WS-5A	1966	305	Paluxy	65,000
WS-6*	1947	170	Paluxy	70,000
WS-8	1966	286	Paluxy	100,000
WS-10	1952	950	Twin Mtn.	120,000
WS-12	1965	195	Paluxy	55,000
WS-H3	1943	282	Paluxy	51,000

Source: City Engineer's Office, White Settlement
*Designation changed to WS-2 (1982)

Paluxy Sand. However, further downgradient in the area of the municipal well field (south of AF Plant 4) groundwater declines of up to 2 feet per year have been observed (Nordstrom, 1982). Because of the growing demand for groundwater by White Settlement and Fort Worth, additional drawdowns of the Paluxy can be expected.

Past Groundwater Flow Investigations

Several investigations have documented the influence of groundwater withdrawals on flow conditions in the Paluxy aquifer. The average rate of water movement in the Paluxy is less than 2 feet per year in an east-southeast direction, except in areas of heavy pumpage (Leggat, 1957). Pump test results indicate that the normal flow patterns within the Paluxy are affected by the withdrawal of groundwater by White Settlement, causing the flow to move toward the pumped wells (Nordstrom, 1982). In the immediate area of AF Plant 4, recent investigations have noted that the City of White Settlement's nine municipal wells create a cone of depression, which in turn induces groundwater to flow in a southerly direction toward the well field and from the plant area (Hargis and Montgomery, 1983).

Aquifer Characteristics

Investigations of the Paluxy aquifer indicate that the average hydraulic conductivity of the Paluxy aquifer is about 44 gallons per day/foot^2 (Nordstrom, 1982). The specific yield in the outcrop area is about 15 percent. Using this information, combined with geological data on the Paluxy Sand and daily discharge estimates provided by the City of White Settlement (Otrosky, 1986), a simulated pump test was run on six Paluxy wells in the White Settlement-AF Plant 4 area.

4.3.24.1 Background Information

The following sections present the background information used to determine groundwater flow and drawdown in the White Settlement-AF Plant 4 areas.

Geologic Data

The Paluxy Sand (Cretaceous) is part of the Trinity Group, which includes the Travis Peak Formation, Glen Rose Limestone and Paluxy Sand. The Paluxy Sand ranges in thickness from 140-190 feet, with an average thickness of 160 feet in Tarrant County. The Paluxy consists of fine-grained, well-sorted unconsolidated sand with minor amounts of pyrite, lignite and sandy clay and shale. Previous studies have divided the Paluxy into three sand members (upper, middle, and lower) in the local area (Hargis and Montgomery, 1983). Most wells in the White Settlement area obtain groundwater from the middle and lower sand members; however, for the purpose of modeling the drawdown and flow near these wells, the Paluxy Sand was assumed to be a homogeneous aquifer 160 feet thick.

The Paluxy Sand outcrops north of White Settlement in west-central and northwest Tarrant County. The Paluxy dips uniformly at 7 degrees to the southeast at a rate of approximately 35 to 40 feet per mile (Leggat, 1957). Locally, the Paluxy Sand outcrops at the shoreline of Lake Worth west of AF Plant 4 and along the Live Creek drainage basin. No faults are known to exist (based on drill hole information) in the Paluxy underlying AF Plant 4 (Hargis and Associates, 1985).

Groundwater

The Paluxy aquifer, an important source of groundwater for the City of White Settlement, supplies much of the domestic and industrial water required by the city. Groundwater within the Paluxy aquifer exists in both water table and artesian conditions. Along outcrop and shallow subcrop areas (near White Settlement), the Paluxy aquifer exists as a water table. Downgradient from these outcrop areas, increased hydrostatic pressures caused by overlying and less permeable strata, including the Walnut and Goodland Formations, create artesian conditions within the Paluxy aquifer. Pump test records from the City of White Settlement indicate that the Paluxy aquifer underlying the city exists as a water table.

Groundwater Recharge The major source of recharge to the Paluxy is precipitation and the subsequent infiltration of surface waters along the outcrop areas. Other sources of recharge are stream and reservoir leakage into the Paluxy. The Paluxy forms the lake bottom for Lake Worth, which, it is estimated, contributes about 600,000 gallons/day to the Paluxy aquifer (Leggat, 1957).

Groundwater Discharge Groundwater discharge from the Paluxy occurs near outcrop areas through evapotranspiration and uptake by vegetation. Other natural sources of discharge occur in valleys or road cuts in the form of springs and seeps in outcrop areas. Withdrawal by municipal and private wells in the White Settlement area effects artificial discharge of groundwater from the Paluxy aquifer.

Municipal Water Use

The City of White Settlement obtains groundwater from the Paluxy aquifer and deeper Twin Mountains aquifer (Trinity Group). Currently, the City of White Settlement owns seven municipal wells in the Paluxy aquifer and two deeper wells in the Twin Mountains aquifer. Water from the Paluxy and Twin Mountains aquifers is suitable for domestic, public, stock and some industrial supplies (CH2M Hill, 1984).

4.3.24.2 Simulated Pump Test

After reviewing the information available for estimating groundwater flow and drawdown within the aquifer, it was decided that modeling techniques would be most useful in solving the problem of simultaneously pumping wells near a constant head lake (Lake Worth). The purpose of the simulated pump test was to model the withdrawal of groundwater by White Settlement and assess the direction of groundwater flow and drawdown in the Paluxy aquifer beneath AF Plant 4.

Model Selection

The model selected for this study is based on the steady-state solution of the problem of discharging finite length line sinks (wells) in a homogeneous aquifer of infinite extent. The model, developed by Koch and Associates (Koch, 1984), solves simple drawdown problems involving both constant head (Lake Worth) and constant flow (municipal wells). The resultant drawdowns at selected observation points are also determined. For this study, 30 observation points were selected in the White Settlement-AF Plant 4 area to assess the areal extent of drawdown over time.

Model Operation

The model may be used to predict drawdowns around continuously pumped wells. The well dimensions are represented by a finite line sink one foot in diameter. Given the current (1986) well discharges of the six Paluxy wells, drawdown can be predicted at any point in time. The algorithm is more accurate as time progresses because of the steady state approximation inherent in the program.

Model Assumptions and Limitations

Following are the assumptions and limitations inherent in the hydrologic model selected for the simulated pump test of the Paluxy aquifer:

- The finite line sinks (wells)/sources (Lake Worth) fully penetrate the aquifer
- The potentiometric surface is assumed to have a steady state curvature.
- The aquifer is isotropic and homogeneous. The aquifer is unconfined and the Darcy assumptions are assumed to be valid.
- Lake Worth is assumed to be a constant head, zero drawdown line source.
- The three sand units within the Paluxy are treated as one aquifer 160 feet thick.

Raw Input Data

Geologic and hydrologic data selected for the model were derived mainly from the existing sources of information discussed earlier, which were carefully checked for accuracy and correctness before incorporation into the model.

To systematize the model, a grid coordinate system was developed whereby White Settlement well, WS-H3 was arbitrarily chosen as the origin. Using existing plant maps, observation points, AF Plant 4 boundary lines, and Lake Worth were located by X-Y coordinates in feet from the origin. Table 4.3.24-2 summarizes of the input parameters used in the finite difference

TABLE 4.3.24-2. MODEL INPUT PARAMETERS

Sink No.	Well No.	X/Y location (feet from origin)	Flow (gpd)[a]
1	WS-H3	1,1	51,000
2	WS-12	2050,570	55,000
3	WS-8	950,3050	100,000
4	WS-3	900,4100	70,000
5	WS-1[b]	2600,5100	96,000
6	WS-6	6900,3900	70,000
7	Lake Worth	8200,1-10,000	------

Aquifer Characteristics

1. Water table
2. Hydraulic conductivity, 44 gpd/ft^2
3. Specific yield, 15 percent
4. Paluxy aquifer thickness, 160 feet

Observation Points: 30

---

[a] Source: City Engineer's Office, White Settlement.

[b] Designation changed to WS-2 (1982).

model. The following discussions are based on the simulated pump test results.

Model Results

The pumping test was conducted by observing simulated drawdowns from five Paluxy wells in the AF Plant 4 area. Since one well, WS-8 (old WS-16), is now abandoned and is not expected to return to operating conditions in the future, it was deleted from the pump test. The well is located approximately 2750 feet south of Plant 4. During operation, it supplied about 100,000 gallons a day to the City of White Settlement.

Another Paluxy well, WS-8 (Park), located approximately 6700 feet southwest of AF Plant 4, was deleted from the study because its radius of influence would not sufficiently alter the groundwater flow gradient or drawdowns in the AF Plant 4 area. This well produces about 100,000 gallons a day.

To predict the drawdown over time within the Paluxy aquifer, all wells were assumed to begin pumping at the same time and to be simultaneously pumping at the current capacity for a period of 20 years. Drawdowns were predicted after years 1, 3, 5, 10, 15 and 20 and plotted on maps using CPS-1®, a Radian plotting system (Figures 4.3.24-1 through 6). Results of these predictions are described in the following paragraphs.

Year 1 (Figure 4.3.24-1) During the first year of the pump test drawdowns are seen in the vicinity of the pumping wells south of AF Plant 4, but little effect is seen within Plant 4. As expected, the largest drawdowns occur near the pumping wells. Little or no drawdown occurs near the Lake Worth shoreline. In the raw output of the drawdown data, the model at some points predicts negative numbers (in the recharge area near Lake Worth). This reflects a net gain of groundwater, indicating that recharge is occurring from Lake Worth at a rate greater than the loss created by the pumping wells.

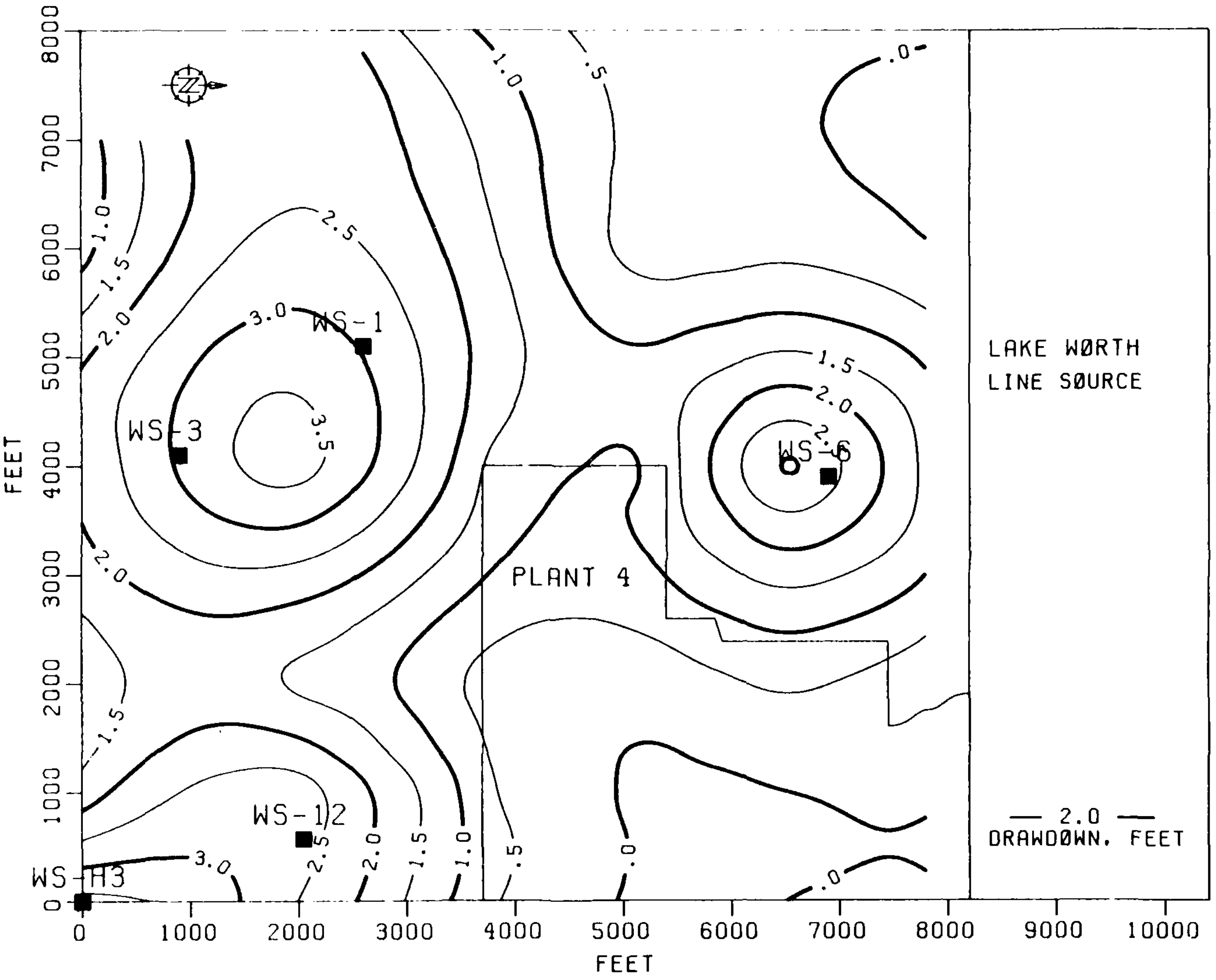

Figure 4.3.24-1. Simulated Drawdowns in the Paluxy Aquifer from White Settlement Municipal Wells - Year 1

Year 3 (Figure 4.3.24-2) After three years, drawdowns of almost 5 and 6 feet are seen in the vicinity of wells WS-12 and WS-3. Drawdowns ranging from 1.9 to 4.7 feet occur along the southern boundary of AF Plant 4.

The shoreline area of Lake Worth again shows no drawdown effects from well pumpage except in the area adjacent to well WS-6, where withdrawal of water by the well exceeds recharge from Lake Worth to the north.

Year 5 (Figure 4.3.24-3) Trends similar to those observed in Year 3 are also seen in Year 5. The most significant drawdowns occur near wells WS-H3, WS-3 and WS-1. Within AF Plant 4, the drawdown after 5 years ranged from less than 1 to 6 feet, in the northeast and southwestern areas of the plant, respectively.

Year 10 (Figure 4.3.24-4) After 10 years, the drawdown near well WS-3 is approximately 10 feet. Drawdowns along the southeastern boundary of AF Plant 4 range from 5.5 feet in the southeastern corner to 8 feet in the southwestern corner, indicating flow is being directed to the southwest in the southern portion of AF Plant 4. In the central AF Plant 4 area, drawdown ranges from about 2.5 feet to 4.5 feet, increasing to the west in the direction of well WS-6.

Year 15 (Figure 4.3.24-5) After 15 years, drawdowns are still most pronounced near wells WS-H3, WS-3, and WS-1. Along the southern AF Plant 4 boundary, drawdowns are between 6 feet in the southeast corner and 8.5 feet in the southwest corner of the property. Consistent with previous years, the groundwater flows to the south toward wells WS-3 and WS-12 and toward well WS-6 west of the plant area.

Year 20 (Figure 4.3.24-6) After 20 years the drawdowns begin to achieve steady state conditions. The predicted drawdowns near wells WS-H3, WS-3, and WS-1 show very little change from year 15. Drawdown along the southern perimeter of Plant 4 ranges between about 6.5 feet in the

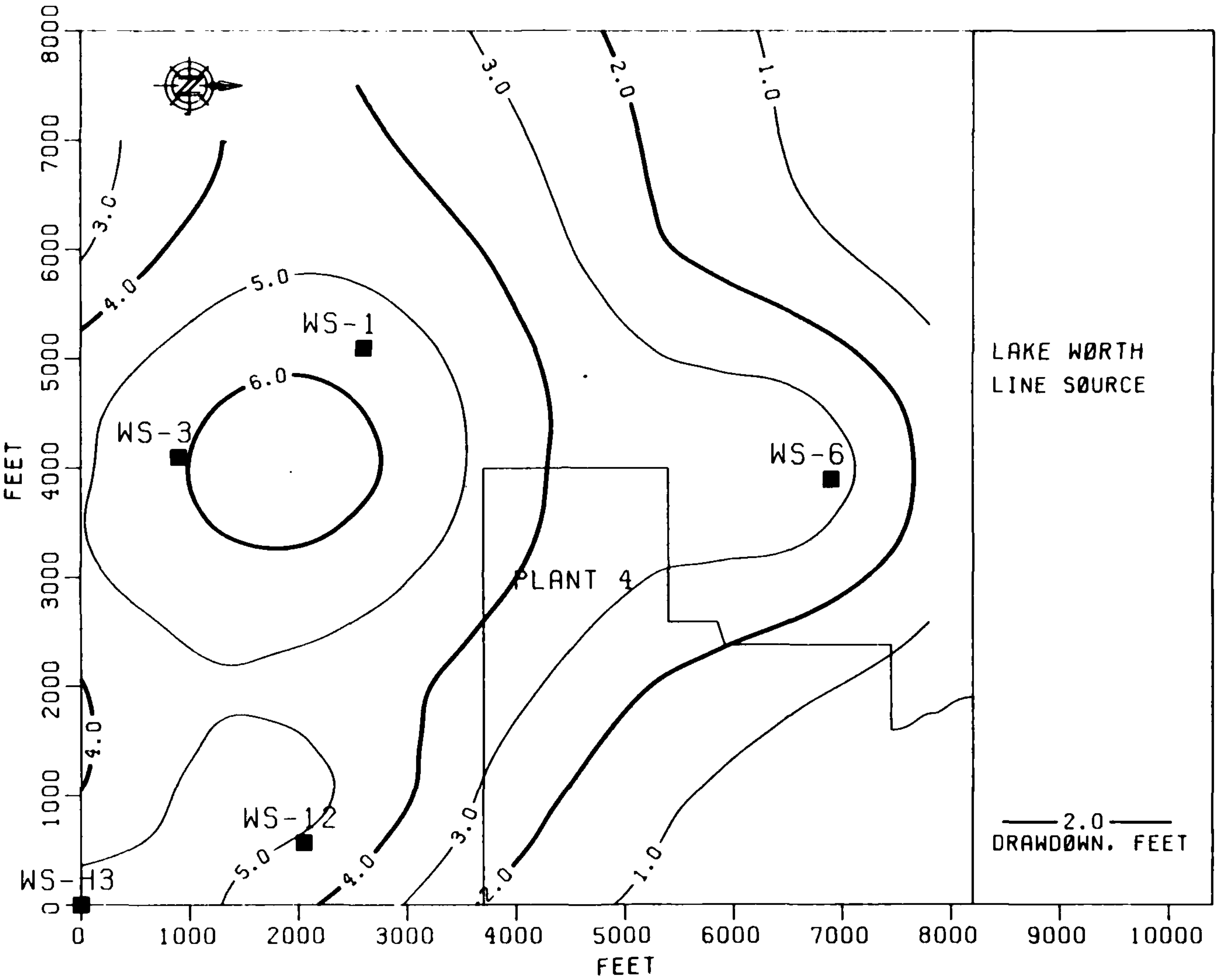

Figure 4.3.24-2. Simulated Drawdowns in the Paluxy Aquifer from White Settlement Municipal Wells - Year 3

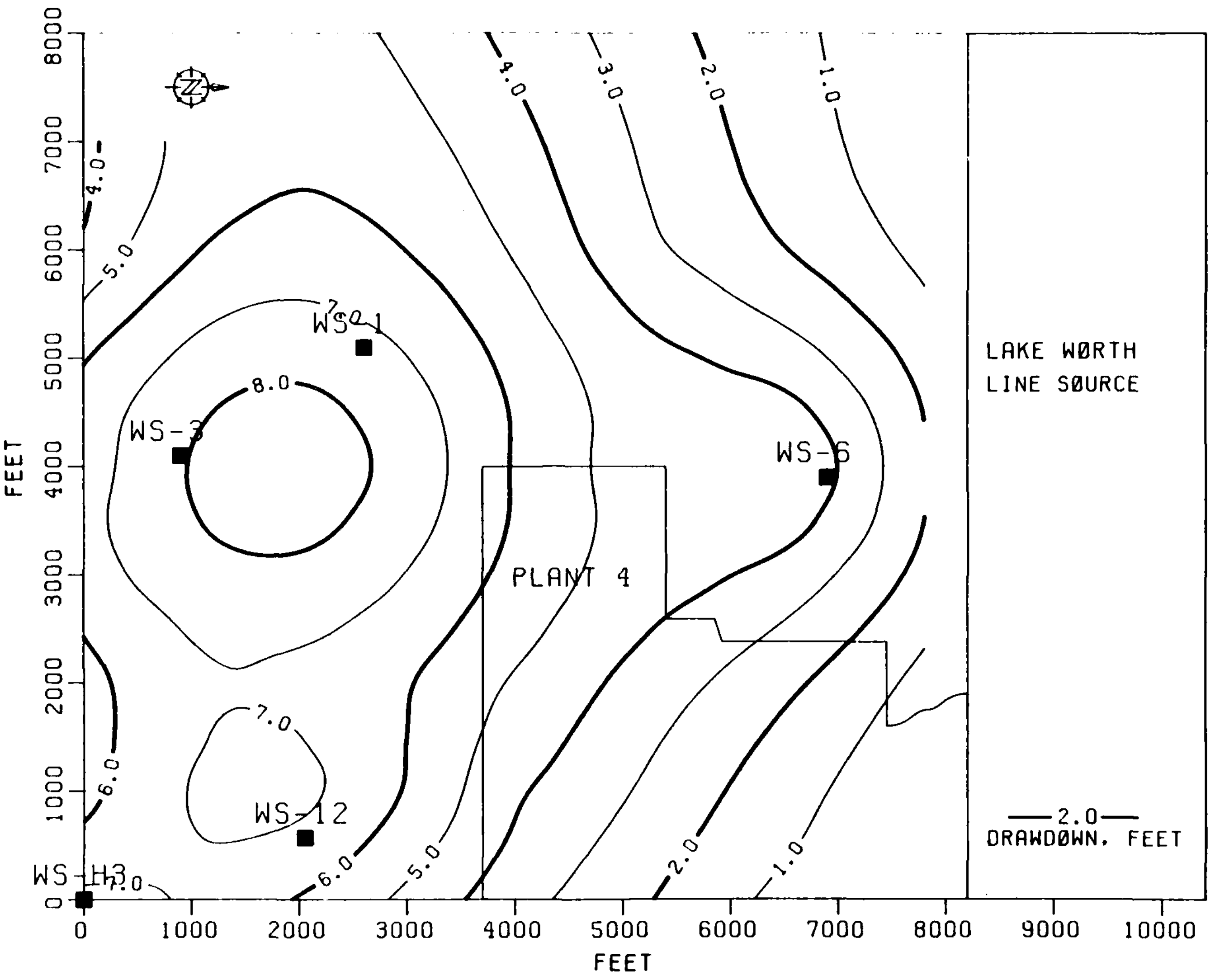

Figure 4.3.24-3. Simulated Drawdowns in the Paluxy Aquifer from White Settlement Municipal Wells - Year 5

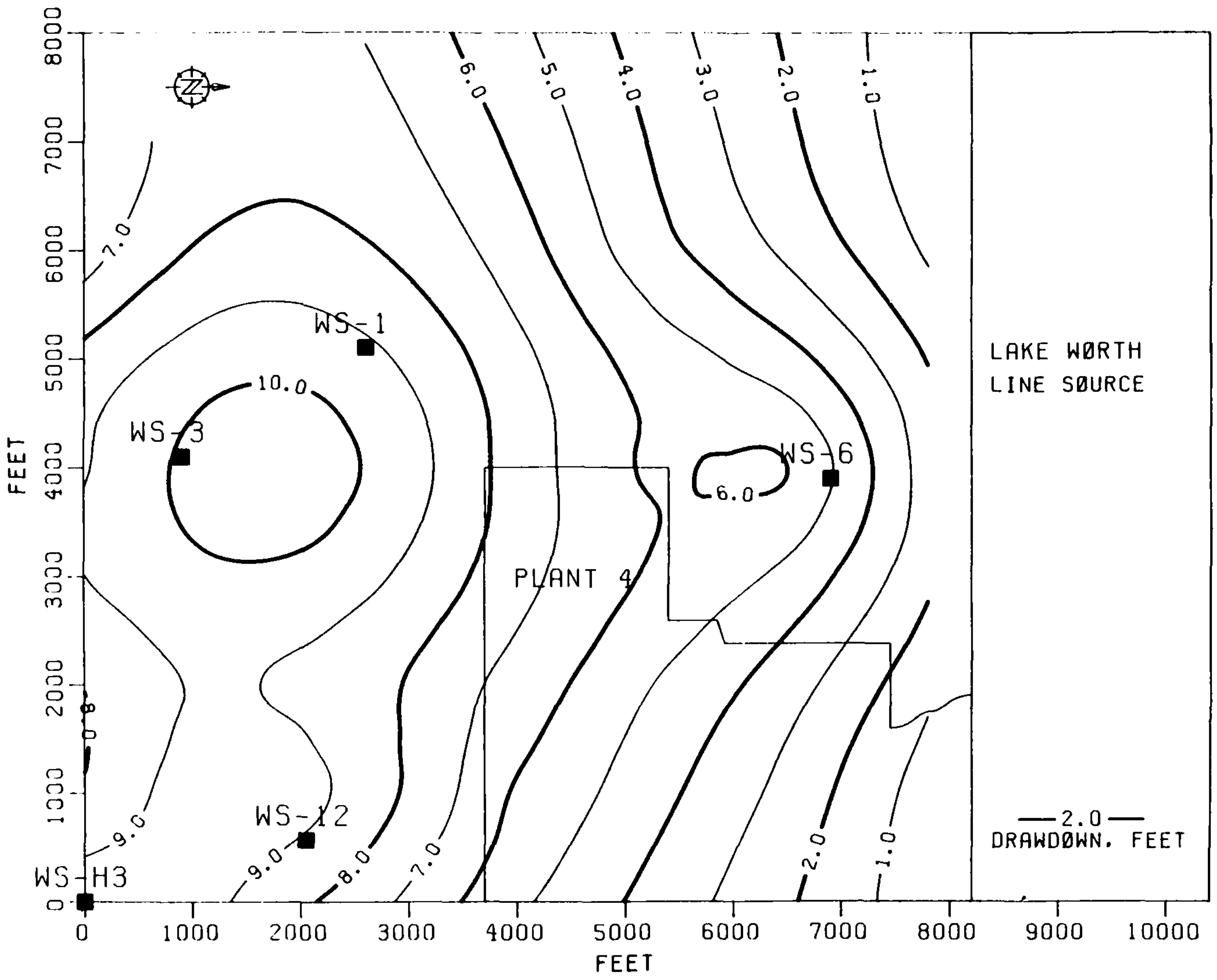

Figure 4.3.24-4. Simulated Drawdowns in the Paluxy Aquifer from White Settlement Municipal Wells - Year 10

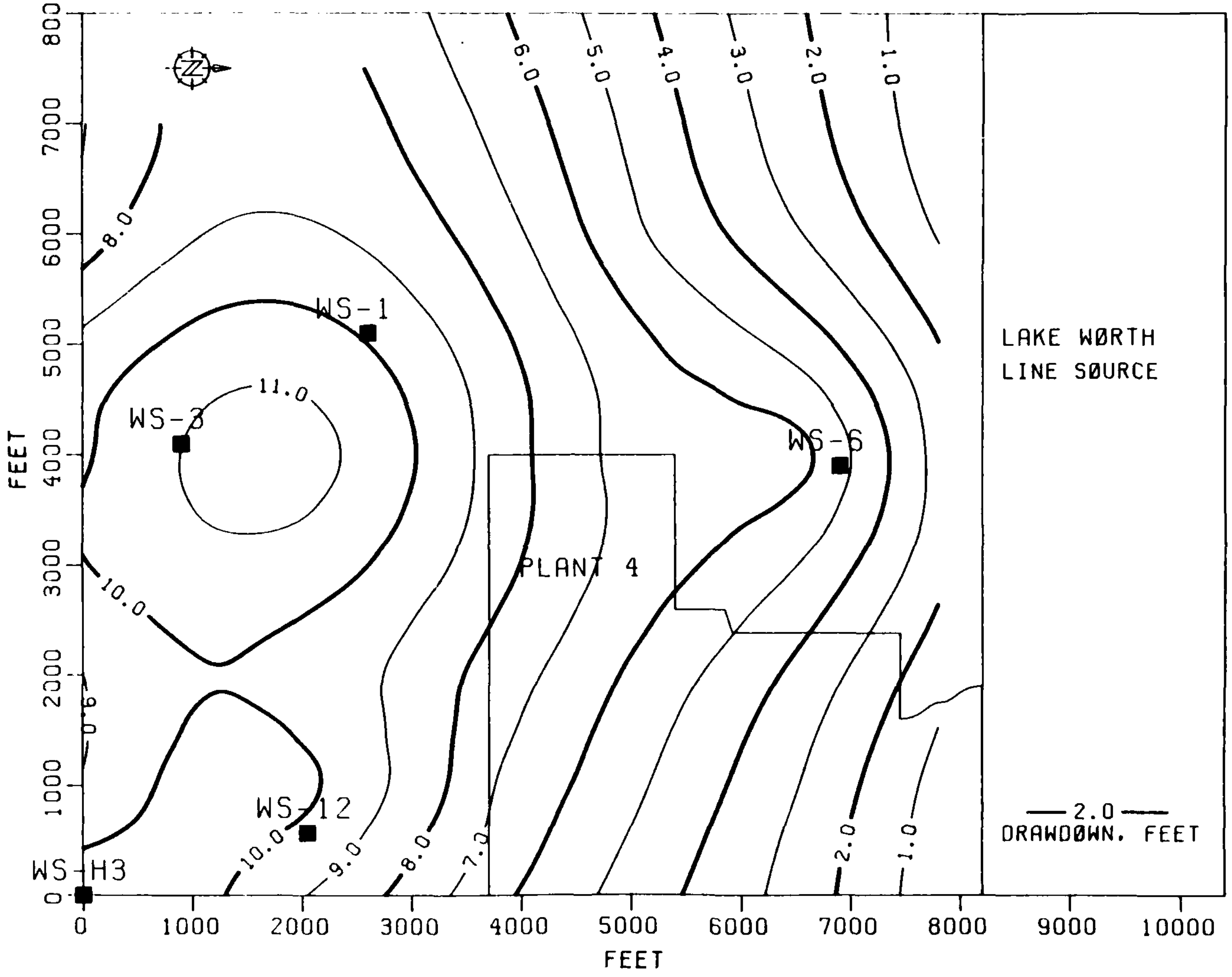

Figure 4.3.24-5. Simulated Drawdowns in the Paluxy Aquifer from White Settlement Municipal Wells - Year 15

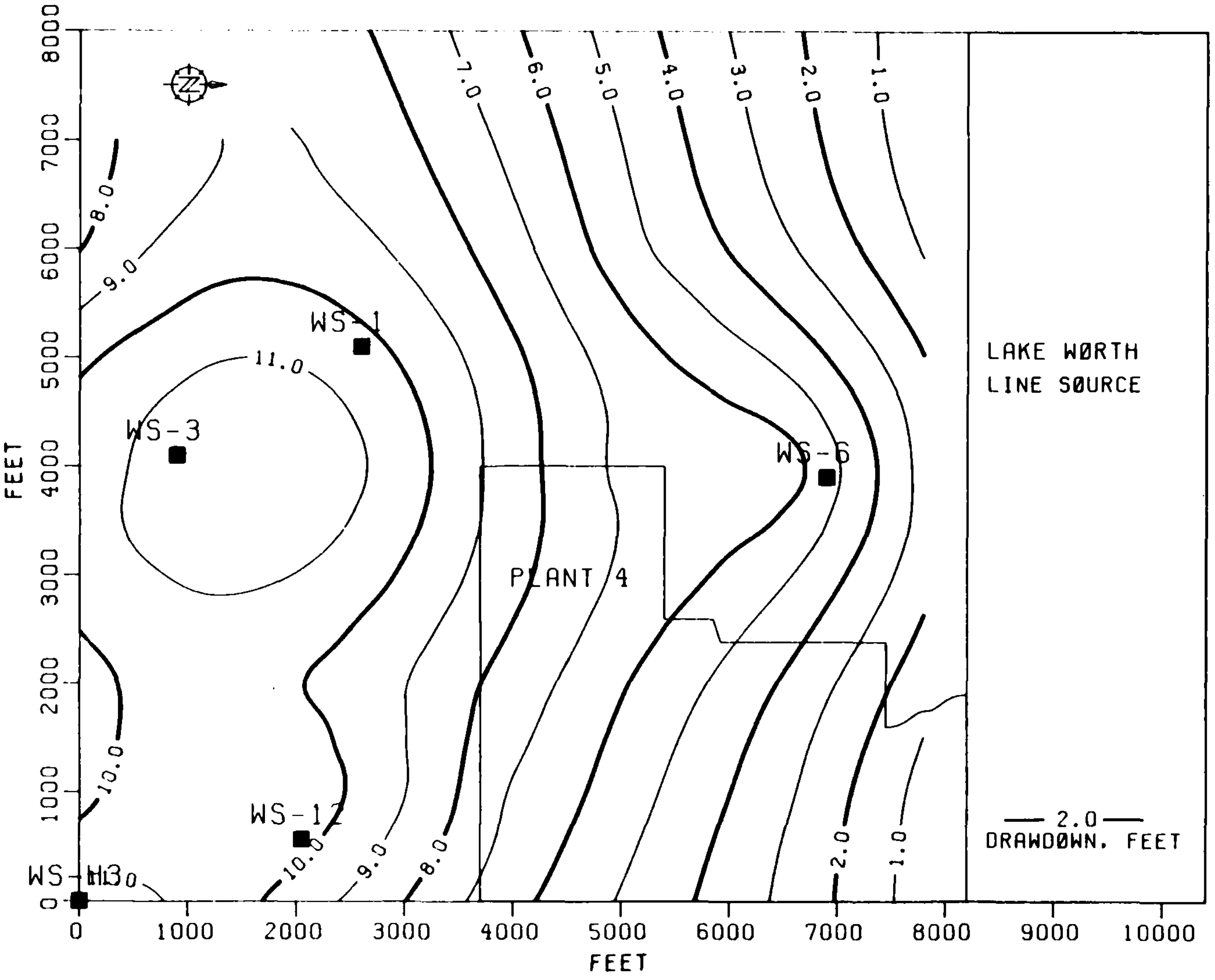

Figure 4.3.24-6. Simulated Drawdowns in the Paluxy Aquifer from White Settlement Municipal Wells - Year 20

southeastern corner to 9 feet in the southwestern corner of the plant. Drawdown remains fairly steady in the area adjacent to well WS-6; however, Lake Worth continues to recharge this area at a rate approximately equal to the rate of discharge from the well.

4.3.24.4 Conclusions

Preliminary results of the simulated pump test, as well as existing information related to groundwater flow in the Paluxy aquifer, indicate that groundwater in the Middle Paluxy aquifer beneath the Plant 4 area is influenced to some degree by the withdrawal of water by nearby municipal wells.

Figures 4.3.24-1 through 4.3.24-6 show that fairly significant drawdowns can be expected near pumping wells, which in turn could direct groundwater to flow from Lake Worth and AF Plant 4 toward these wells. Considering water quality, there appears to be a logical concern about the potential for contaminants originating at AF Plant 4 to migrate toward these wells.

Since the pump test assumes constant flow rates on a year-to-year basis, we conclude that the model indicates the worst case (i.e., maximum likely water flow rate without regard for contamination content, if any) rather that actual conditions. For instance, some wells expected to shut down for repairs may be completely abandoned. According to the City 4 Engineer's office at White Settlement, no additional Paluxy wells will be drilled by the city and no increase in pumping rate is expected. Therefore the model depicts the maximum expected municipal usage of the Paluxy aquifer in the area of AF Plant 4.

4.3.25 Well Abandonment

The Statement of Work requested that available well abandonment techniques be evaluated and a candidate method recommended. The basic concept governing the proper sealing of abandoned wells is to restorate, as far as feasible, the hydrogeologic conditions existing before the well was drilled. Any well to be permanently abandoned should be completely filled in such a way that vertical movement of water within the well bore, including vertical movement of water within the annular space surrounding the well casing, is effectively and permanently prevented and the water is permanently confined to the specific zone in which it originated.

The first step in such a process is to comply with applicable regulations. The relevant portion of the Texas Administrative Code is quoted in Table 4.3.25-1. Given the nature of Plant 4 groundwater conditions, Radian strongly recommends filling the well with concrete.

Grouting should placed from the bottom of the well upward, using a tremie pipe or dump bailer, not by pouring from the land surface. A volume of material sufficient to fill the casing and the voids in the sand pack should be calculated and that volume placed in the well. For upper zone wells, emplacement followed by topping off (if required) should be sufficient.

For the Paluxy wells, the sealing material should be placed within the casing and then forced out into the sand pack under pressure, which should be maintained long enough for the cementing mixture to set. This step is particularly important for those Paluxy wells penetrating more than one zone of the aquifer. Some pre-grouting testing will probably be required to determine the proper water-cement mixture that would ensure effective permeation of the sand pack.

Surface features (guard pipes, well pads, etc.) should be removed and a cap of concrete poured at the site.

TABLE 4.3.25-1. EXCERPT FROM TEXAS WATER WELL DRILLERS ACT RELATED RULES, TEXAS ADMINISTRATIVE CODE SECTIONS 319.49 AND 50

319.49. Standards For Plugging Wells That Penetrate Undesirable Water zones.

(a) If the use of a water well that penetrates undesirable water is to be permanently discontinued, all of the removable casing shall be removed from the well and the entire well filled with cement to the land surface.

(b) In lieu of the procedure in subsection (a) of this section, either the zone(s) contributing undesirable water, or the fresh water zone(s), shall be isolated with cement plugs and the remainder of the wellbore filled with sand, clay, or heavy mud to form a base for a cement plug extending from land surface to a depth of not less than ten (10) feet.

319.50. Standards for Plugging Existing Wells.

(a) If the use of a well that does not contain any undesirable-water zones is permanently discontinued, all of the removable casing shall be removed from the well and the entire well filled with cement to the land surface.

(b) In lieu of the procedure in subsection (a) of this section, the well may be filled with fine sand, clay, or heavy mud followed by a cement plug extending from land surface to a depth of not less than ten (10) feet.

4.3.26 Well Inventory

The Statement of Work required that an inventory of monitor wells be made on a site-by-site basis, associating monitor wells with each site, as appropriate. The complete inventory, shown in Table 4.3.26-1, was accomplished by inspecting the most recent well location map supplied by General Dynamics. Table 4.3.26-2 lists the monitor wells by site.

TABLE 4.3.26-1. COMPLETE WELL INVENTORY, AF PLANT 4

Well	Well	Well	Well	Well	Well
P-1	HM-1	HM-25	HM-51	HM-77	F-208
P-2	HM-2	HM-26	HM-52	HM-78	F-209
P-3	HM-3A	HM-27	HM-53	HM-79	F-210
P-4	HM-3B	HM-28	HM-54	HM-80	F-211
P-5U	HM-4A	HM-29	HM-55	HM-81	
P-5M	HM-4B	HM-30	HM-56	HM-82	
P-6U	HM-5	HM-31	HM-57	HM-83	
P-6M	HM-6	HM-32	HM-58	HM-84	
P-7U	HM-7	HM-33	HM-59	HM-85	
P-7M	HM-8	HM-34	HM-60	HM-100	
P-8U	HM-9	HM-35	HM-61	HM-101	
P-8M	HM-10	HM-36	HM-62	HM-102	
P-9U	HM-11	HM-37	HM-63	HM-103	
P-9M	HM-12	HM-38	HM-64	HM-104	
P-10U	HM-13	HM-39	HM-65	HM-105	
P-10M	HM-14	HM-40	HM-66	HM-106	
P-11U	HM-15	HM-41	HM-67	HM-107	
P-11M	HM-16	HM-42	HM-68	HM-108	
P-12U	HM-17	HM-43	HM-69	F-200	
P-12M	HM-18	HM-44	HM-70	F-201	
P-13U	HM-19	HM-45	HM-71	F-202	
P-13M	HM-20	HM-46	HM-72	F-203	
P-20M	HM-21	HM-47	HM-73	F-204	
P-21U	HM-22	HM-48	HM-74	F-205	
P-22U	HM-23	HM-49	HM-75	F-206	
P-23U	HM-24	HM-50	HM-76	F-207	

TABLE 4.3.26-2. WELL INVENTORY OF AF PLANT 4, ARRANGED BY SITE

Well	Status	Aquifer	Date Installed
Site 1, Landfill 1			
HM-6	Destroyed	Upper Zone	-
HM-7	Active	Upper Zone	12-4-82
HM-10	Active	Upper Zone	12-6-82
HM-18	Active	Upper Zone	3-31-83
HM-20	Active	Upper Zone	4-1-83
HM-62	Active	Upper Zone	4-18-84
HM-63	Active	Upper Zone	4-18-84
P-4	To be abandoned	Paluxy	6-15-83
P-7U	Active	Upper Paluxy	1-6-85
P-7M	Active	Middle Paluxy	2-13-85
Site 3, Landfill 3			
HM-21	Active	Upper Zone	4-1-83
HM-26	Active	Upper Zone	5-25-83
HM-27	Active	Upper Zone	5-25-83
HM-34	Active	Upper Zone	4-11-84
HM-35	Active	Upper Zone	4-11-84
HM-36	Active	Upper Zone	4-11-84
HM-37	Active	Upper Zone	4-11-84
HM-38	Active	Upper Zone	4-11-84
HM-39	Active	Upper Zone	4-11-84
P-22U	Active	Upper Paluxy	3-20-86
Site 12, Chrome Waste Pit 3			
HM-1	Destroyed	Upper Zone	12-1-82
HM-13	Active	Upper Zone	3-29-83
HM-15	Active	Upper Zone	4-1-83
HM-16	Active	Upper Zone	4-1-83
HM-17	Active	Upper Zone	3-31-83
HM-30	Active	Upper Zone	5-26-83
HM-32	Active	Upper Zone	4-13-84
HM-41	Active	Upper Zone	4-12-84
HM-45	Active	Upper Zone	4-13-84
P-2	To be abandoned	Paluxy	6-17-83

(Continued)

TABLE 4.3.26-2. (Continued)

Well	Status	Aquifer	Date Installed
Site 17, Former Fuel Storage Area			
HM-8	Active	Upper Zone	12-5-82
HM-14	Active	Upper Zone	3-30-83
HM-100	Active	Upper Zone	1-20-86
Site 2, Landfill 2			
HM-2	Active	Upper Zone	12-2-82
HM-22	Active	Upper Zone	5-23-83
HM-40	Active	Upper Zone	4-12-84
HM-42	Active	Upper Zone	4-12-84
HM-43	Active	Upper Zone	4-12-84
HM-44	Active	Upper Zone	4-13-84
HM-46	Active	Upper Zone	4-14-84
P-21U	Active	Upper Paluxy	3-10-86
Site 4, Landfill 4			
HM-5	Active	Upper Zone	12-2-82
HM-9	Active	Upper Zone	12-5-82
HM-101	Active	Upper Zone	1-21-86
P-20M	Active	Middle Paluxy	3-4-86
Zone 1: Site 13, Die Pits; Site 11, Chrome Pit 2; Site 8, FDTA 5			
HM-3A	Destroyed	Upper Zone	12-2-82
HM-3B	Destroyed	Upper Zone	12-3-82
HM-4A	Destroyed	Upper Zone	12-3-82
HM-4B	Destroyed	Upper Zone	-
HM-11	Active	Upper Zone	3-28-83
HM-12	Active	Upper Zone	3-29-83
HM-24	Active	Upper Zone	5-24-83
HM-25	Active	Upper Zone	5-25-83
HM-28	Active	Upper Zone	5-26-83
HM-60	Active	Upper Zone	4-17-84
HM-77	Active	Upper Zone	1-10-85
P-1	To be abandoned	Paluxy	3-9-83
Site 15, Fuel Saturation Area 2			
HM-80	Active	Upper Zone	1-15-85

(Continued)

TABLE 4.3.26-2. (Continued)

Well	Status	Aquifer	Date installed
Site 20, Wastewater Collection Basins			
HM-31	Active	Upper Zone	5-26-83
HM-47	Active	Upper Zone	4-14-84
HM-69	Active	Upper Zone	1-7-85
HM-70	Active	Upper Zone	1-8-85
HM-104	Active	Upper Zone	1-23-86
Site 16, Fuel Saturation 3			
HM-78	Active	Upper Zone	1-11-85
F-200	Active	Upper Zone	2-24-86
F-201	Active	Upper Zone	2-24-86
F-202	Active	Upper Zone	2-25-86
F-208	Active	Upper Zone	3-6-86
F-209	Active	Upper Zone	3-7-86
F-210	Active	Upper Zone	3-7-86
F-211	Active	Upper Zone	3-7-86
Site 9, FDTA 6			
P-3	Active	Paluxy	6-18-83
Site 6, FDTA 3			
HM-33	Active	Upper Zone	4-11-84
HM-102	Active	Upper Zone	1-21-86
Site 18, Solvent Lines			
HM-72	Active	Upper Zone	1-9-85
HM-73	Active	Upper Zone	1-9-85
HM-74	Active	Upper Zone	1-9-85
HM-75	Active	Upper Zone	1-9-85
HM-106	Active	Upper Zone	1-26-86

(Continued)

TABLE 4.3.26-2. (Continued)

Well	Status	Aquifer	Date Installed
<u>Site 10, Chrome Pit 1</u>			
HM-48	Active	Upper Zone	4-14-84
HM-103	Active	Upper Zone	1-21-86
<u>Site 5, FDTA 2</u>			
HM-19	Active	Upper Zone	4-1-83
HM-49	Active	Upper Zone	4-15-84
HM-50	Active	Upper Zone	4-15-84
HM-51	Active	Upper Zone	4-15-84
HM-65	Active	Upper Zone	1-4-85
HM-66	Active	Upper Zone	1-5-85
HM-76	Active	Upper Zone	1-10-85
<u>Site 14, Fuel Saturation Area 1</u>			
HM-53	Active	Upper Zone	4-16-84
HM-55	Active	Upper Zone	4-16-84
P-6U	Active	Upper Paluxy	5-20-84
P-6M	Active	Middle Paluxy	5-22-84
F-203	Active	Upper Zone	2-25-86
F-204	Active	Upper Zone	2-25-86
F-205	Active	Upper Zone	3-5-86
F-206	Active	Upper Zone	3-6-86
F-207	Active	Upper Zone	3-6-86
<u>Ambient Monitoring Sites</u>			
HM-29	Active	Upper Zone	5-26-83
HM-52	Active	Upper Zone	4-15-84
HM-54	Active	Upper Zone	4-16-84
HM-56	Active	Upper Zone	4-16-84
HM-57	Active	Upper Zone	4-17-84
HM-58	Active	Upper Zone	4-17-84
HM-59	Active	Upper Zone	4-17-84
HM-61	Active	Upper Zone	4-17-84
HM-64	Active	Upper Zone	4-18-84
HM-79	Active	Upper Zone	1-15-85
HM-81	Active	Upper Zone	1-6-85
HM-83	Active	Upper Zone	10-24-85
HM-84	Active	Upper Zone	10-24-85
HM-85	Active	Upper Zone	10-24-85

(Continued)

TABLE 4.3.26-2. (Continued)

Well	Status	Aquifer	Date Installed
Ambient Monitoring Sites (Continued)			
P-5U	Active	Upper Paluxy	6-3-84
P-5M	Active	Middle Paluxy	6-5-84
P-9U	Active	Upper Paluxy	1-15-85
P-9M	Active	Middle Paluxy	2-12-85
P-10U	Active	Upper Paluxy	1-23-85
P-10M	Active	Middle Paluxy	2-10-85
P-11U	Active	Upper Paluxy	8-13-85
P-11M	Active	Middle Paluxy	8-26-85
East Parking Lot			
HM-67	Abandoned	Upper Zone	1-5-85
HM-68	Active	Upper Zone	1-6-85
HM-71	Active	Upper Zone	1-8-85
HM-82	Active	Upper Zone	1-16-85
P-8U	Active	Upper Paluxy	1-19-85
P-8M	Active	Middle Paluxy	1-29-85
Fuel Storage Tank			
HM-23	Active	Upper Zone	5-24-83
Lake Worth			
P-23U	Active	Upper Paluxy	3-17-86
Fuel Test Area, Building 21			
HM-105	Active	Upper Zone	8-11-86
HM-107	Active	Upper Zone	8-11-86
HM-108	Active	Upper Zone	8-11-86

4.3.27 Well Network Selection for Future Monitoring Efforts

The total system of wells at AF Plant 4 has been evaluated with respect to designing an optimal well network for future monitoring efforts. The wells evaluated consisted of the 87 upper zone monitor wells installed by Hargis and Montgomery (Hargis and Associates, 1985) and the nine upper zone wells installed by Radian. The F-series monitor wells recently installed by Intellus Corporation have not been included in this evaluation, since no analytical chemistry data were available for them. This evaluation considers the plant site as a whole, rather than individual sites. Site-specific concerns are best addressed as exceptions after the basic network design has been completed.

In addition to the upper zone monitor wells, the Paluxy Formation monitor wells have been evaluated with respect to future monitoring efforts at AF Plant 4. Since there are so few of them, all of the currently active Paluxy Formation monitor wells should be incorporated into the well network.

The objective of designing an optional monitor well network is to decrease the number of samples needed to represent groundwater quality and the hydrogeologic conditions in the aquifer. Taking too many samples is excessively costly and may add little to an understanding of groundwater quality. Taking too few samples, however, results in insufficient data for observing or modeling the hydrogeologic conditions and changes in contaminant distribution within the system.

One approach to designing an optimal well network for future monitoring efforts at AF Plant 4 involved a geostatistical method, the variogram function. The minerals industry has used variograms as a tool to determine the optimum sampling distance in ore bodies (Blais and Carlier, 1968; Peters, 1978). The variogram function goes beyond classical statistics because it deals with regionalized variables that have specific directional and distance characteristics. Trichloroethylene (TCE) values from upper zone monitor wells were used in the same way as ore grade in a mining application of the variogram. TCE was selected as the modeled constituent since it is nearly ubiquitous and commonly occurs in the highest concentration among contaminants of concern. A series of experimental semi-variograms were computer-generated and visually inspected to see if a "range" value could be determined. The "range" value is the optimum sampling distance. The computer-generated variograms did not reveal a "range" value that could be used to determine an optimal sampling (or well spacing distance). Instead, almost all of the variograms exhibited random, inconsistent behavior that could have been due to the lack of a Gaussian or continuous population distribution. An initial logarithmic transformation of the attributes still resulted in a skewed population and random variogram patterns. The distribution of TCE in the upper zone is not sufficiently continuously distributed (mathematically continuous) to be amenable to statistical evaluations of this kind. At this point, the variogram function method was eliminated as a viable method for designing an optimal well network at Plant 4.

A second method used to design the monitor well network on AF Plant 4, involved generating a TCE concentration contour map using the most recent available data, data from all of the IRP Phase II Stage 1 sampling (Figure 4.3.27-1). The data set is not synoptic, since sampling occurred throughout the first eight months of 1986, but constitutes the best data set available at the time of the study. All wells containing 5000 ppb TCE or more were set equal to 5000 ppb TCE to reduce the contrast and obtain additional detail in the low concentration areas. The 5000 ppb level was selected as a threshold of convenience to avoid the numerical difficulties of contouring over many orders of magnitude. Results are not disturbed by selecting an arbitrary, high value. This map was generated using CPS-1®, Radian's Contour Plotting System), which uses an appropriate search algorithm to define contour values. Tables 4.3.27-1 and 4.3.27-2 show the initial and reduced data sets of TCE concentrations used in well network selection.

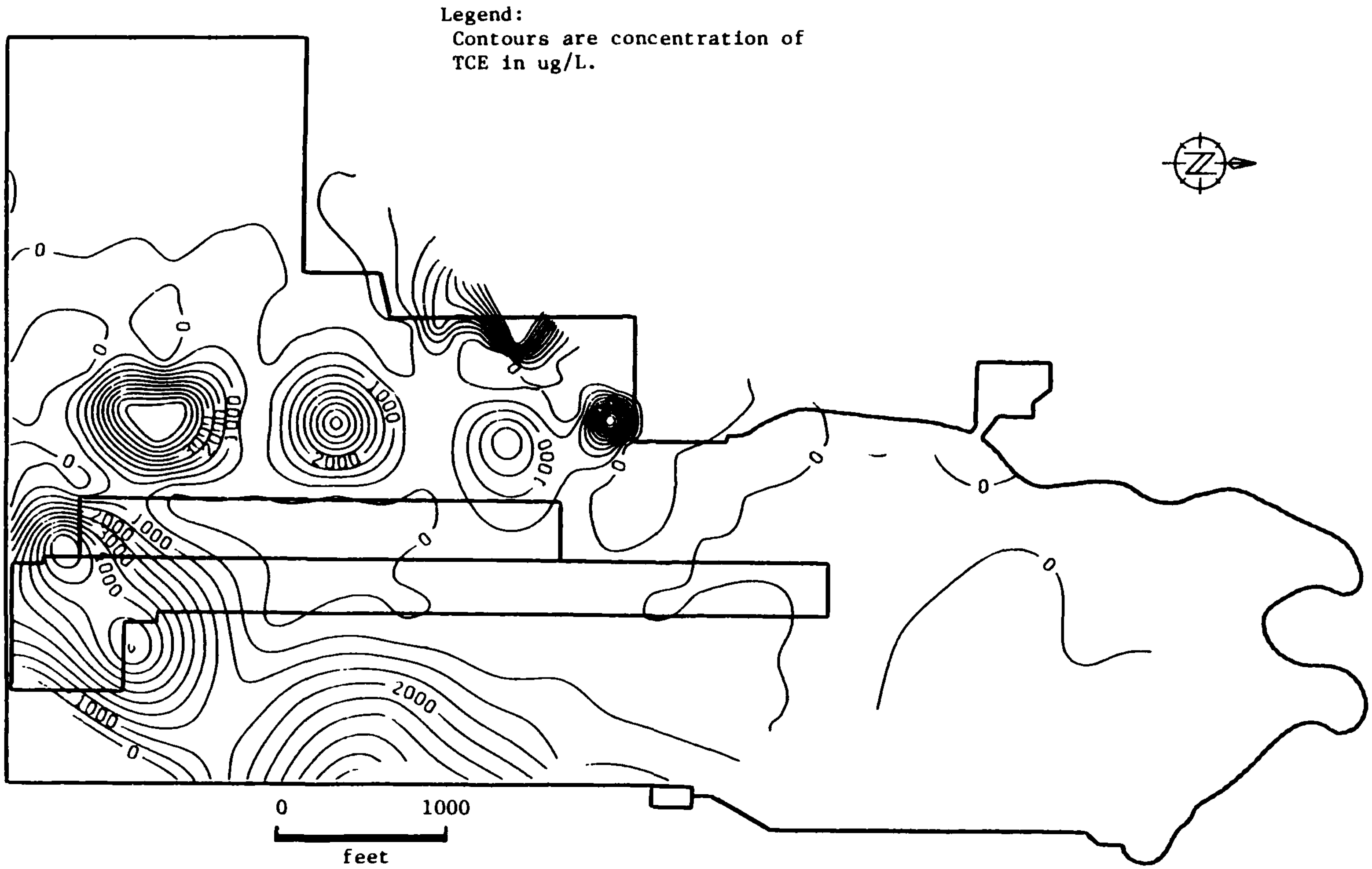

Figure 4.3.27-1. TCE Concentration Contour Map using Complete Data Set, AF Plant 4, Texas

TABLE 4.3.27-1. TCE CONCENTRATION DATA USED IN WELL NETWORK SELECTION: INITIAL DATA SET

MONITOR WELL	X-COORDINATE	Y-COORDINATE	ELEVATION	TCE CONCENTRATION (ugl)	WELL IDENTIFIER NOTE*	DATE SAMPLED
HM-23	0.017	42.721	625.000	0.0		2/17/86
HM-22	6.828	48.338	631.600	0.0		2/20/86
HM-9	14.323	47.035	630.900	0.0		2/27/86
HM-5	12.857	45.196	632.600	0.2		2/12/86
HM-44	7.751	41.762	633.700	0.0		2/25/86
HM-43	10.822	42.707	647.800	0.0		2/20/86
HM-101	13.291	41.382	621.300	--		4/18/86
HM-33	15.555	42.059	625.600	0.0		2/28/86
HM-14	-0.204	37.803	624.600	0.0		2/19/86
HM-8	4.792	36.613	623.100	0.0		2/13/86
HM-42	13.235	38.544	617.400	0.0		2/20/86
HM-2	16.399	35.040	620.100	0.0		2/20/86
HM-40	10.168	34.244	622.200	0.0		2/25/86
HM-100	5.846	33.326	621.900	--		4/11/86
HM-13	-0.097	31.310	626.200	0.0		2/19/86
HM-32	4.700	29.932	619.700	0.0		2/14/86
HM-30	9.066	30.452	615.200	177.0		2/13/86
HM-102	16.054	37.559	621.000	--		4/9/86
HM-41	15.549	30.412	619.000	2.7		2/25/86
HM-46	17.784	32.144	613.900	0.0		2/20/86
HM-45	14.140	27.026	618.300	133.0		2/25/86
HM-16	10.454	27.886	597.200	5000.0	F	2/11/86
HM-15	6.975	27.826	632.500	5000.0	F	2/25/86

(Continued)

TABLE 4.3.27-1. (Continued)

MONITOR WELL	X-COORDINATE	Y-COORDINATE	ELEVATION	TCE CONCENTRATION (ugl)	WELL IDENTIFIER NOTE*	DATE SAMPLED
HM-24	1.977	27.430	615.500	7.0		2/19/86
HM-12	-0.139	26.295	620.000	0.2		2/14/86
HM-28	4.255	26.065	615.500	602.0		2/6/86
HM-17	8.844	25.848	620.400	5000.0	F	2/11/86
HM-25	2.056	24.536	614.400	0.0		2/11/86
HM-11	-0.105	20.958	616.800	26.4		2/10/86
HM-77	4.075	23.271	619.600	3.9		2/6/86
HM-60	5.739	23.691	617.800	401.0		2/6/86
HM-47	3.076	20.268	624.700	5000.0	F	2/6/86
HM-48	9.907	22.708	626.700	19.8		2/14/86
HM-104	-0.097	18.295	611.400	--		4/10/86
HM-31	0.049	15.274	603.200	2367.0		2/14/86
HM-69	3.211	10.280	609.900	3.2		2/21/86
HM-103	7.035	10.974	609.600	--		4/10/86
HM-70	7.410	13.565	606.400	5000.0	F	2/19/86
HM-68	10.707	5.705	609.300	32.3		2/28/86
HM-82	19.789	5.640	596.300	5000.0	F	2/4/86
HM-57	15.157	15.651	616.400	0.1		2/26/86
HM-56	23.479	15.661	614.900	0.8		2/21/86
HM-52	14.691	22.586	631.200	0.9		2/10/86
HM-55	19.578	22.628	621.800	14.0		2/4/86
HM-53	25.102	22.595	619.300	15.0		2/10/86
HM-63	19.486	26.717	619.400	4485.0		2/7/86

(Continued)

TABLE 4.3.27-1. (Continued)

MONITOR WELL	X-COORDINATE	Y-COORDINATE	ELEVATION	TCE CONCENTRATION (ugl)	WELL IDENTIFIER NOTE*	DATE SAMPLED
HM-34	21.279	34.512	616.600	0.0		2/27/86
HM-35	22.288	32.951	617.800	0.0		2/27/86
HM-36	23.761	32.450	618.700	0.3		2/27/86
HM-26	25.305	32.372	615.800	2015.0		1/31/86
HM-27	26.210	31.664	617.500	390.0		1/31/86
HM-37	27.793	31.925	621.500	402.0		1/31/86
HM-38	29.720	31.521	608.700	5000.0	F	2/21/86
HM-21	29.494	30.707	618.700	0.0		2/7/86
HM-39	32.360	30.587	617.400	0.2		2/27/86
HM-49	35.785	28.750	622.300	1.9		2/12/86
HM-66	33.494	27.575	624.500	29.2		2/13/86
HM-50	32.552	29.328	622.900	0.0		2/12/86
HM-19	31.933	27.852	620.100	9.0		3/1/86
HM-7	30.583	28.923	624.700	0.0		2/13/86
HM-10	27.068	29.106	621.900	36.6		2/7/86
HM-18	22.295	30.061	620.100	0.0		2/11/86
HM-62	24.349	26.536	617.900	8.0		3/1/86
HM-20	29.480	26.072	615.100	2314.0		1/31/86
HM-51	35.604	27.020	621.500	5000.0	F	2/11/86
HM-65	37.207	27.261	618.200	0.0		2/12/86
HM-76	36.334	25.586	618.500	0.0		2/13/86
HM-61	39.288	24.975	618.400	0.1		2/26/86
HM-54	34.578	22.961	623.800	6.4		2/10/86

(Continued)

TABLE 4.3.27-1. (Continued)

MONITOR WELL	X-COORDINATE	Y-COORDINATE	ELEVATION	TCE CONCENTRATION (ugl)	WELL IDENTIFIER NOTE*	DATE SAMPLED
HM-29	29.085	23.193	614.200	1200.0		2/21/86
HM-64	33.010	19.160	622.800	75.1		2/26/86
HM-58	40.830	20.027	625.600	0.7		2/26/86
HM-59	37.006	15.657	617.200	6.6		2/3/86
HM-79	35.650	11.618	610.800	174.0		2/3/86
HM-71	33.739	5.716	604.100	1274.0		2/3/86
HM-72	45.359	9.601	611.400	0.0		2/14/86
HM-73	49.615	15.664	610.200	0.0		2/26/86
HM-74	49.474	20.224	614.000	0.0		2/5/86
HM-106	49.626	22.536	620.000	--		4/18/86
HM-75	43.525	22.565	619.700	0.0		2/18/86
HM-80	47.745	25.141	619.500	0.0		2/5/86
HM-78	56.543	23.230	614.400	1.0		2/5/86
HM-107	60.217	22.549	616.200	--		8/19/86
HM-108	60.897	22.538	621.900	--		8/20/86
HM-105	59.594	20.559	621.900	--		8/19/86
HM-81	61.747	21.343	616.600	0.0		2/7/86
HM-83	61.390	10.580	614.400	7.4		8/21/86
HM-84	63.290	12.890	613.000	0.3		8/21/86
HM-85	67.85	13.93	616.000	0.0		8/21/86

* F = Concentration fixed at 5000 ug/L.

– = Concentration data not used (not available at time of TCE concentration contour map generation).

TABLE 4.3.27-2. TCE CONCENTRATION DATA USED IN WELL NETWORK SELECTION: REDUCED DATA SET

X-COORDINATE	Y-COORDINATE	ELEVATION	TCE CONCENTRATION (ug/L)	WELL IDENTIFIER	NOTE *
0.017	42.721	625.000	0.0	HM-23	
6.828	48.338	631.600	0.0	HM-22	
14.323	47.035	630.900	0.0	HM-9	
12.857	45.196	632.600	0.2	HM-5	
7.751	41.762	633.700	0.0	HM-44	
13.291	41.382	621.300	1.0E30	HM-101	
15.555	42.059	625.600	0.0	HM-33	
13.235	38.544	617.400	0.0	HM-42	
5.846	33.326	621.900	1.0E30	HM-100	
-0.097	31.310	626.200	0.0	HM-13	
9.066	30.452	615.200	177.0	HM-30	
16.054	37.559	621.000	1.0E30	HM-102	
15.549	30.412	619.000	2.7	HM-41	
14.140	27.026	618.300	133.0	HM-45	
6.975	27.826	632.500	5000.0	HM-15	F
1.977	27.430	615.500	7.0	HM-24	
4.255	26.065	615.500	602.0	HM-28	
8.844	25.848	620.400	5000.0	HM-17	F
2.056	24.536	614.400	0.0	HM-25	
-0.105	20.958	616.800	26.4	HM-11	
5.739	23.691	617.800	401.0	HM-60	
3.076	20.268	624.700	5000.0	HM-47	F
9.907	22.708	626.700	19.8	HM-48	
-0.097	18.295	611.400	1.0E30	HM-104	
0.049	15.274	603.200	2367.0	HM-31	
7.035	10.974	609.600	1.0E30	HM-103	
7.410	13.565	606.400	5000.0	HM-70	F
10.707	5.705	609.300	32.3	HM-68	
19.789	5.640	596.300	5000.0	HM-82	F
23.479	15.661	614.900	0.8	HM-56	
19.578	22.628	621.800	14.0	HM-55	
19.486	26.717	619.400	4485.0	HM-63	
21.279	34.512	616.600	0.0	HM-34	
23.761	32.450	618.700	0.3	HM-36	
25.305	32.372	615.800	2015.0	HM-26	
27.793	31.925	621.500	402.0	HM-37	
29.720	31.521	608.700	5000.0	HM-38	F
29.494	30.707	618.700	0.0	HM-21	
32.360	30.587	617.400	0.2	HM-39	
35.785	28.750	622.300	1.9	HM-49	
31.933	27.852	620.100	9.0	HM-19	
30.583	28.923	624.700	0.0	HM-7	

(continued)

TABLE 4.3.27-2. (Continued)

X-COORDINATE	Y-COORDINATE	ELEVATION	TCE CONCENTRATION (ug/L)	WELL IDENTIFIER NOTE*
27.068	29.106	621.900	36.6 HM-10	
22.295	30.061	620.100	0.0 HM-18	
29.480	26.072	615.100	2314.0 HM-20	
35.604	27.020	621.500	5000.0 HM-51	F
37.207	27.261	618.200	0.0 HM-65	
29.085	23.193	614.200	1200.0 HM-29	
33.010	19.160	622.800	75.1 HM-64	
40.830	20.027	625.600	0.7 HM-58	
37.006	15.657	617.200	6.6 HM-59	
35.650	11.618	610.800	174.0 HM-79	
33.739	5.716	604.100	1274.0 HM-71	
49.615	15.664	610.200	0.0 HM-73	
49.626	22.536	620.000	1.0E30 HM-106	
47.745	25.141	619.500	0.0 HM-80	
56.543	23.230	614.400	1.0 HM-78	
60.217	22.549	616.200	1.0E30 HM-107	
60.897	22.538	621.900	1.0E30 HM-108	
59.594	20.559	621.900	1.0E30 HM-105	
61.747	21.343	616.600	0.0 HM-81	
61.390	10.580	614.400	7.4 HM-83	
63.290	12.890	613.000	0.3 HM-84	
67.85	13.93	616.000	0.0 HM-85	

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[*] F = Concentration fixed at 5000 ug/L.

The next step was visual inspection of the TCE concentration map to see how many of the upper zone monitor wells could be considered duplicates (spatially equivalent and displaying similar concentrations of TCE) of nearby wells. The selection was accomplished by inspection and examination of the data, utilizing best engineering judgement. Thirty-two HM-series monitor wells were identified for deletion from the total well system at AF Plant 4. Six of these had previously been destroyed (HM-1, 3A, 3B, 4A, 4B, and 6). The effect of the prior destruction of these wells was accommodated by deleting them from the data base for all computations. The 25 other HM-series wells selected were deemed to be near duplicates of nearby wells that would add no significant data in a future monitoring program. These wells were then eliminated from the data base and a new TCE concentration contour map was generated (Figure 4.3.27-2) based on the smaller data base. Visual inspection of the two contour maps shows that the elimination of the 32 monitor wells did not significantly alter the shape of the contours. This comparison validates the subjective inspection and selection process.

A difference map (contour map of the difference between the two previous contour sets) was also generated to quantify the difference between the two data sets (Figure 4.3.27-3). This map revealed a general pattern of small variations signifying that the smaller data base does not systematically differ from the larger data base. Therefore, plant-wide groundwater conditions are adequately monitored by the reduced well network. An important further step in this process is to examine the effects of well deletion on a site-by-site basis. The purpose of this examination would be to determine whether a given deletion will harm the plant contractor's ongoing monitoring program.

The wells eliminated from the total well system and the wells to be retained in the upper zone monitoring network are listed in Table 4.3.27-3. The selected well network for Plant 4 thus includes 64 upper zone monitor wells (HM-series) and all the currently active Paluxy Formation monitor wells.

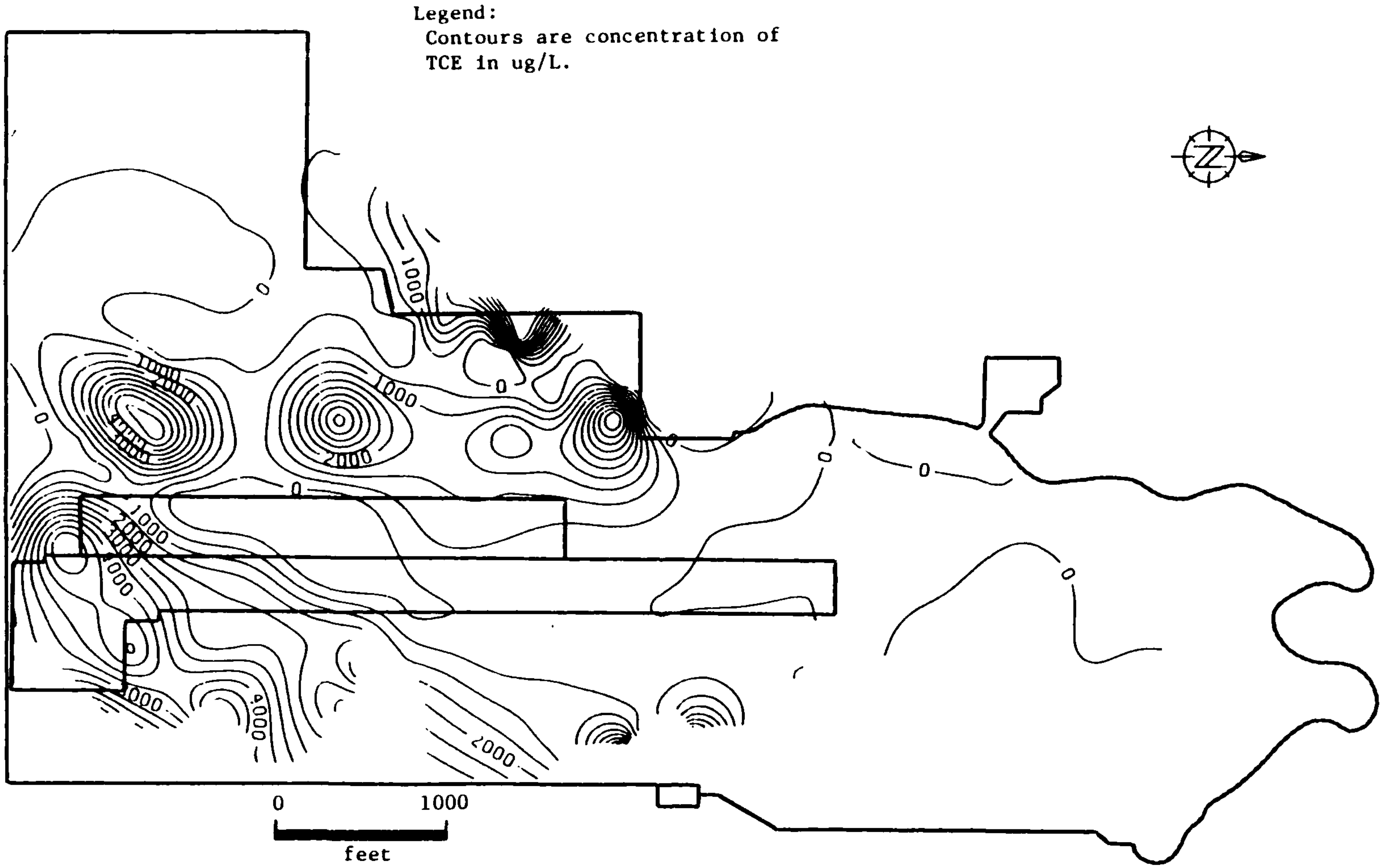
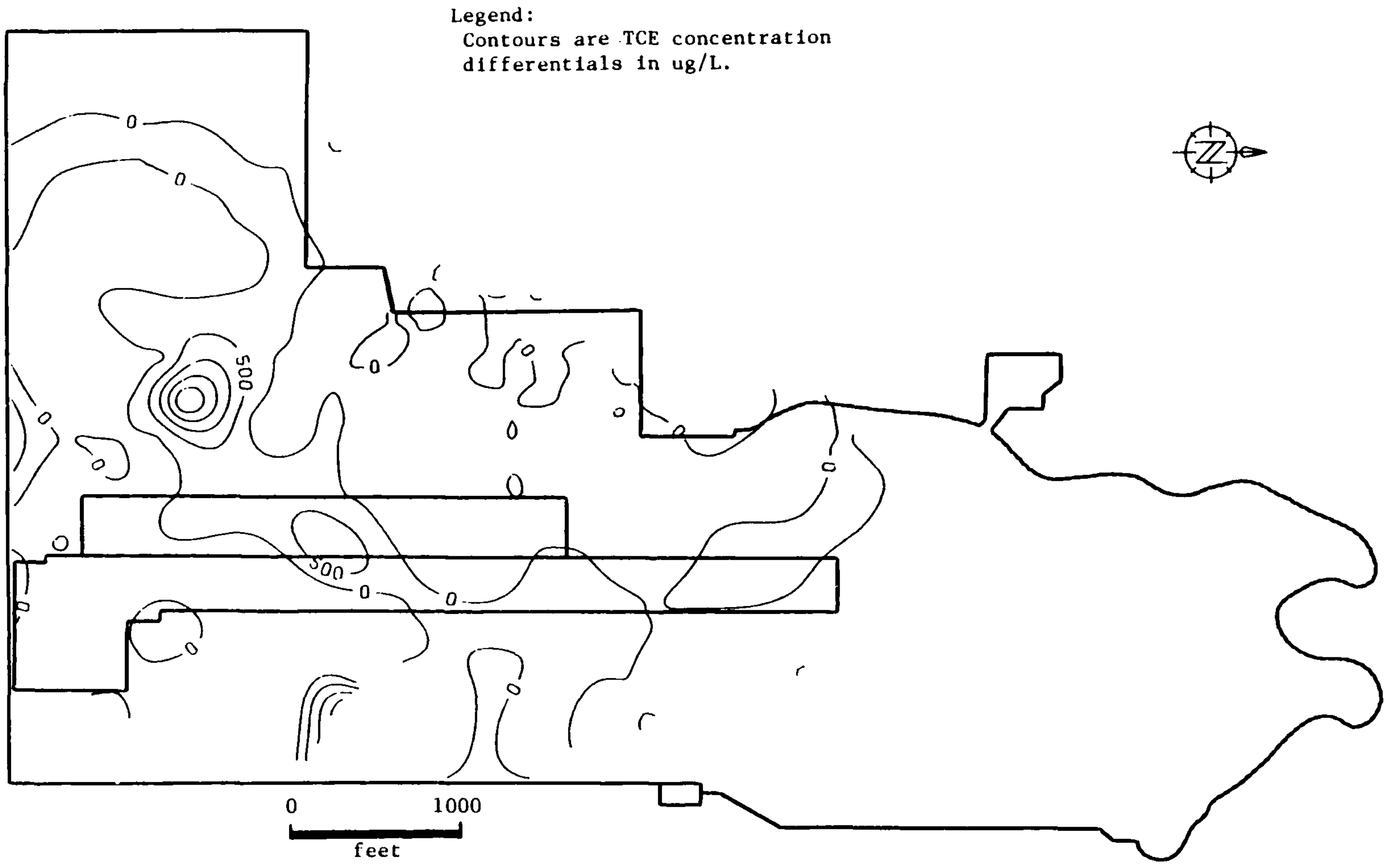


Figure 4.3.27-2. TCE Concentration Contour Map using Reduced Data Set, AF Plant 4, Texas



Legend:
Contours are TCE concentration differentials in ug/L.

Figure 4.3.27-3. Difference Contour Map for TCE Concentration, AF Plant 4, Texas

TABLE 4.3.27-3. WELL NETWORK SELECTION FOR FUTURE MONITORING AT PLANT 4

Upper Zone Monitor Wells To Be Eliminated From Well Network

HM-1
HM-2
HM-3A
HM-3B
HM-4A
HM-4B
HM-6
HM-8
HM-12
HM-14
HM-16
HM-27
HM-32
HM-35
HM-40
HM-43
HM-46
HM-50
HM-52
HM-53
HM-54
HM-57
HM-61
HM-62
HM-66
HM-67
HM-69
HM-72
HM-74
HM-75
HM-76
HM-77

Upper Zone Monitor Wells To Be Retained in Well Network

HM-5
HM-7
HM-9
HM-10
HM-11
HM-13
HM-15
HM-17
HM-18
HM-19
HM-20
HM-21
HM-22
HM-23
HM-24
HM-25
HM-26
HM-28
HM-29
HM-30
HM-31
HM-33
HM-34
HM-36
HM-37
HM-38
HM-39
HM-41
HM-42
HM-44
HM-45
HM-47
HM-48
HM-49
HM-51
HM-55
HM-56
HM-58
HM-59
HM-60
HM-63
HM-64
HM-65
HM-68
HM-70
HM-71
HM-73
HM-78
HM-79
HM-80
HM-81
HM-82
HM-83
HM-84
HM-85
HM-100
HM-101
HM-102
HM-103
HM-104
HM-105
HM-106
HM-107
HM-108

4.4 Quality Assurance and Quality Control

The objective of the quality assurance and quality control (QA/QC) efforts associated with Plant 4 activities was to ensure that data collected were of known and sufficient calibre to qualitatively and quantitatively characterize the sites of interest. Two primary aspects of the QA/QC effort are related to achieving this objective. First, the QA/QC program forms a framework for controlling data quality within preestablished limits during execution of the sampling and analytical efforts. Second, the QA/QC program estimates uncertainty in the measurement data by identifying and defining qualitative and quantitative limitations associated with these data. Section 4.4.1 briefly describes some of the key elements of the QA/QC effort and assesses QA/QC measurement data quality.

4.4.1 Summary and Approach

QA/QC data associated with the Plant 4 site investigation indicate that the measurement data are acceptable, defensible, and reliable within the expected limits of sampling and analytical error. In some cases, interferences within the sample matrix significantly affected analyte recovery. These are discussed below.

The QA/QC program for the Plant 4 study was designed to fulfill two related purposes. First, by providing an organized framework for the sampling and analytical efforts, the program was designed to control data quality within preestablished limits to ensure that the objectives of the site characterization program were achieved. This involved establishing data quality objectives for the parameters of interest. Next, protocols were defined for critical aspects of the measurement effort, including:

- Sample collection, preservation, and storage;
- Sample analysis;

- Calibration of instrumentation and apparatus;
- Data reduction, validation, and reporting;
- Documentation and sample custody; and
- Internal quality control.

The protocols were tailored to both site characterization and data quality objectives.

The second purpose of a QA/QC program is to assess data quality. Quality control data help identify and define the qualitative and quantitative limitations associated with the measurement data. Following are the key types of QA/QC procedures for quantitatively evaluating the data:

- Field and laboratory blank samples;
- Spiked samples;
- Duplicate samples;
- Duplicate analyses; and
- Quality control check samples;

Blank samples play an especially important role in remedial investigation programs. They qualitatively ensure that the analytes detected in the samples are characteristic of the media sampled and not artifacts of the sampling and/or analytical process. Results of the analysis of laboratory blanks, field blanks and trip blanks are presented in the following sections.

Laboratory (reagent) blanks address only the analytical measurement process. Typically included with each batch of samples analyzed, they provide an ongoing check of the analytical system for systematic sample contamination by contaminated reagents or preservatives. When evidence of contamination is indicated by blank values above preestablished levels, corrective action is taken to identify and eliminate the source of contamination. If possible, the affected samples may be reanalyzed.

Field blanks reflect the combined effects of sample collection, handling, transportation, storage, and analysis. Since often it is not feasible to resample when field blanks indicate possible sample contamination, field blank data are used to define the qualitative limitations of the associated measurement data. The presence of analytes of interest in either the field or laboratory blanks suggests that corresponding field samples may have been similarly contaminated and that results for these analytes should be considered suspect. If the blank data show a given analyte at widely varying concentrations, or at concentrations comparable to those for field samples, then the field sample results should be viewed as possible false positives for that analyte. If, on the other hand, blank data indicate a given analyte at concentrations much lower than typical sample concentrations, then the sample data may usually be viewed as qualitatively reliable, but as having greater than normal quantitative uncertainty.

Trip blanks are sealed VOA vials containing organic-free water which are prepared in the laboratory then shipped to the field with the empty sample containers. The trip blanks are not opened in the field but return to the laboratory with the field samples. Trip blank results are useful for determining whether volatile organic compounds are diffusing across the VOA septum into the sample during storage (e.g., refrigerants) or during the collection/transportation part of sample handling.

Two special types of spiked samples used as part of the protocol for the analysis of organic compounds by gas chromatography are matrix-spiked samples and surrogate-spiked samples. Matrix-spiked samples are field samples to which known amounts of the analytes of interest have been added. Typically, both a spiked and an unspiked aliquot of the sample are analyzed. The difference in results for the two analyses are calculated and compared to the amount of spike added. Since actual samples are used for the determination, any matrix effects are taken into consideration. Usually expressed as a percentage of the spike amount, spike recovery measures the accuracy of the analysis. For a single sample, this includes the combined effects of bias, or systematic error, and variability due to imprecision. Averaging spike recoveries for multiple samples tends to "average out" the random error caused by imprecision, thus providing an estimate of analytical bias.

Surrogate-spiked samples are similar to normal spiked samples except that an unspiked aliquot is not analyzed. Samples are spiked with a mixture of surrogate compounds chemically similar to the species of interest but not expected to be present in actual field samples. Recovery of these surrogate compounds gives an estimate of the effectiveness of the method during that single analysis.

Duplicate samples and duplicate analyses are used to indicate measurement data precision. Precision indicates the mutual agreement among individual measurements of the same constituents under prescribed similar conditions. Variability among the measurements is attributable to random error caused by imprecision. In the case of duplicate analyses, the analytical process is repeated for separate aliquots of a single sample while prescribed elements of the process are kept constant. For example, duplicate analyses are usually performed on the same day, by the same analyst, using the same instrument and the same calibration. Differences in the results for duplicate analyses, attributable to random variability in the analytical process, reflect analytical precision.

Duplicate samples are another way to measure precision. The analysis of duplicate samples involves replicating sample collection (and the associated sample handling activities) and sample analysis. Precision estimates based on duplicate sample results incorporate imprecision caused by sampling and analytical variability.

Both duplicate sample and duplicate analysis results yield data for estimating precision. Generally, however, duplicate sample data are used in a different way than are results for duplicate analyses. Since analytical precision is primarily a function of the analytical procedures employed, results for duplicate analyses may be used as an ongoing quality control check. Corrective action can be taken when results indicate that analytical precision is not within acceptable limits. Results for duplicate samples, on the other hand, are more often used to assess data quality. Because of the lag between sample collection and the availability of analytical results, it is usually not possible to initiate corrective action based on duplicate sample data. Also, variability in duplicate sample results typically includes a component attributable to inherent nonhomogeneity of the sample or sample matrix. Duplicate data of both types can indicate the degree to which chance may cause results to vary. This information is important whenever measured values are compared. Without it, it is difficult to know whether to attribute observed differences to random measurement error or to actual differences.

Quality control check samples (QCCS) are used to assess analytical performance under a given set of standard conditions. These are synthetic samples (prepared independently of calibration standards) containing some or all of the parameters of interest at known concentrations. Typically analyzed with each set of analyses, QCCS results, by comparing measured values to preestablished acceptability limits, are often used as a real-time check of analytical system performance. By comparing measured results to theoretical concentrations, quality control check sample results may also be used to estimate analytical bias and accuracy Although they do not address matrix effects, as do results for spiked samples, they allow day-to-day consideration of variability and are useful in identifying trends.

Quality control results are summarized and discussed in the following sections. Data for these summaries were obtained from the analytical data reports presented in Appendix A-4. The appendix contains tables of all the quality control information considered.

4.4.2 QA/QC Results For Water Sample Analyses

The QA/QC efforts associated with collecting and analyzing groundwater samples used in the characterization of IRP Phase II Stage I Plant 4 sites included:

- Analysis of field and laboratory blank samples;
- Analysis of spiked samples;
- Collection and analysis of duplicate samples;
- Duplicate analyses; and
- Analysis of QCCS.

Results of these QA/QC analyses are discussed in the following sections.

4.4.2.1 Blank Results

Laboratory, field, and trip blanks were analyzed as part of the QC efforts associated with Plant 4 water sample analyses. Results of the blank analyses indicate the background levels of methylene chloride, trichlorofluoromethane, trichloroethylene, toluene and phthalates that should be noted if detectable levels of these compounds are reported in actual field samples.

4.4.2.1.1 Laboratory Blanks

Laboratory reagent blanks for groundwater and surface water sample analyses were reagent water samples containing the same proportions of preservatives and reagents as used for field samples. Laboratory blank data for groundwater and surface water samples are contained in Appendix A and summarized in Tables 4.4-1 through 4.4-4. Methylene chloride, trichlorofluoromethane and trichloroethane were detected in the laboratory blanks at concentrations greater than 1.5 times the method detection limit (MDL) but less than 5 times the MDL for Method 601 analyses. These results are presented in Table 4.4-1.

TABLE 4.4-1. LABORATORY BLANK DATA REPORTED ABOVE THE METHOD DETECTION LIMIT FOR WATER SAMPLES ANALYZED FOR ORGANIC PARAMETERS

Parameter	Date Analyzed	Concentration (ug/L)	Method Detection Limit (ug/L)	QC Limit[a] (ug/L)
Method 601				
Methylene Chloride	2/12/86	0.44	0.25	0.38
Methylene Chloride	3/5/86	0.51	0.25	0.38
Trichlorofluoromethane	3/4/86	0.81	0.40	0.50
Trichloroethylene	2/6/86	0.18	0.03	0.04
Trichloroethylene	2/6/86	0.18	0.03	0.04
Trichloroethylene	2/26/86	0.20	0.03	0.04
Method 625	Work Order			
di-butyl phthalate	86-02-030	3	2.5	3.8
di-butyl phthalate	86-02-058	3	2.5	3.8
di-butyl phthalate	86-02-070	3	2.5	3.8
di-butyl phthalate	86-02-116	3	2.5	3.8
di-butyl phthalate	86-02-132	3	2.5	3.8
di-butyl phthalate	86-03-021	3	2.5	3.8
di-butyl phthalate	86-03-018	3	2.5	3.8
di-butyl phthalate	86-04-085	6	2.5	3.8
di-butyl phthalate	86-04-135	4	2.5	3.8
bis(2-ethylhexyl)phthlate	86-02-058	3	2.5	3.8
bis(2-ethylhexyl)phthlate	86-02-070	3	2.5	3.8
bis(2-ethylhexyl)phthlate	86-02-116	8	2.5	3.8
N-nitrosodiphenylamine	86-02-078	6	1.9	2.8

[a] Estimated as 1.5 times reported detection limit.

TABLE 4.4-2. LABORATORY BLANK DATA REPORTED ABOVE DETECTION LIMITS FOR METALS ANALYSES IN WATER SAMPLES

Parameter	Number of Samples[a]	Mean Concentration[b] (mg/L)	Number Above Detection Limit	Detection Limit (mg/L)
Silver	10	0.01	1	0.002
Arsenic	13	-	0	0.005
Barium	10	0.003	8	0.001
Cadmium	10	-	0	0.002
Chromium	10	0.021	3	0.005
Mercury	10	0.0003	2	0.0002
Lead	10	0.003	4	0.002
Selenium	10	-	0	0.003

[a] Total number of reagent blank analyses.

[b] Mean concentration only for values greater than detection limit.

TABLE 4.4-3. FIELD BLANK DATA REPORTED ABOVE THE METHOD DETECTION LIMIT FOR GROUNDWATER SAMPLES ANALYZED FOR ORGANIC PARAMETERS

Parameter	Sample ID	Concentration (ug/L)	Method Detection Limit (ug/L)	QC Limit[a] (ug/L)
Method 601				
Methylene Chloride	86-03-003-06	0.93	0.25	0.38
Methylene Chloride	86-04-084-06	0.38	0.25	0.38
Methylene Chloride	86-08-093-05	20.6	0.25	0.38
Trichlorofluoromethane	86-04-084-06	0.38[b]	0.40	0.60
Trichlorofluoromethane	86-08-093-05	3.07	0.40	0.60
Trichloroethylene	86-03-003-06	0.22	0.12	0.18
Method 602				
Toluene	86-02-031-07	1.73	0.20	0.30
Toluene	86-02-041-07	2.19	0.20	0.30
Toluene	86-02-075-08	17.4	0.20	0.30
Toluene	86-02-087-06	3.33	0.20	0.30
Toluene	86-04-084-06	0.99	0.20	0.30
Toluene	86-08-093-05	0.22	0.20	0.30
Toluene	86-03-003-02	3.56	0.20	0.30
Toluene	86-02-159-06	0.54	0.20	0.30
Toluene	86-02-047-06	4.06	0.20	0.30

[a] Estimated as 1.5 times reported detection limit.

[b] Instrument detection limit for this analysis allowed quantitation below method detection limit.

TABLE 4.4-4. TRIP BLANK DATA REPORTED ABOVE THE METHOD DETECTION LIMIT FOR WATER SAMPLES ANALYZED FOR ORGANIC PARAMETERS

Parameter	Sample ID	Concentration (ug/L)	Method Detection Limit (ug/L)	QC Limit[a] (ug/L)
Method 601				
Methylene Chloride	86-02-075-09	0.34	0.25	0.38
Methylene Chloride	86-02-100-07	0.47	0.25	0.38
Methylene Chloride	86-08-093-06	0.77	0.25	0.38
Trichlorofluoromethane	86-03-031-08	2.52	0.40	0.60
Trichlorofluoromethane	86-02-041-08	3.00	0.40	0.60
Trichlorofluoromethane	86-02-067-06	2.03	0.40	0.60
Trichlorofluoromethane	86-02-075-09	2.11	0.40	0.60
Trichlorofluoromethane	86-02-100-07	2.34	0.40	0.60
Trichlorofluoromethane	86-08-093-06	3.57	0.40	0.60
Trichlorofluoromethane	86-02-047-07	2.75	0.40	0.60
Trichloroethylene	86-02-067-06	0.30	0.12	0.18
Method 602				
Toluene	86-02-067-06	2.50	0.20	0.30
Toluene	86-04-084-07	0.53	0.20	0.30
Toluene	86-08-093-06	3.05	0.20	0.30

[a] As specified in the EPA CLP protocol for organic species; 1.5 times reported detection limit for inorganics and other parameters.

Di-butyl phthalate, and bis(2-ethylhexyl) phthalate were detected in several Method 625 blank samples, but at concentrations less than 1.5 times the detection limit. Phthalates are common laboratory contaminants at levels below 5 times MDL. Field samples with phthalate results at this level should be regarded with caution. N-nitrosodiphenylamine was detected in only one reagent blank, at 6 ug/L. This level is three times greater than the laboratory MDL. No major analytical contamination for Method 602 analyses (purgeable aromatics) was indicated by the analytical results for laboratory blanks. Low levels of the halogenated aliphatics reported in laboratory blanks should be considered significant only if any of those compounds were also detected in field samples analyzed by Method 601. With these two exceptions, there is no indication that the levels of organics detected in laboratory blank samples are significant in relation to the analytical results for field samples taken as part of this site characterization.

Results of laboratory blank sample analyses for metals revealed no significant contamination problems. The mean blank concentration reported for barium was 0.003 mg/L, with values for eight out of 10 blank samples greater than the reported detection limit of 0.001 mg/L. This suggests that the actual detection limit during this period might be slightly higher than estimated. Table 4.4-2 summarizes laboratory blank data reported above detection limits for metals analyses of water samples.

4.4.2.1.2 Field Blanks

Samples of organic-free water collected in the field were submitted with the actual field samples for volatile organic analyses by Methods 601 and 602. Table 4.4-3 summarizes the results for field blanks reported at concentrations greater than 1.5 times the MDL. Methylene chloride, trichlorofluoromethane, and trichloroethylene were detected at concentrations greater than 1.5 times the detection limit. Toluene was detected above 1.5 times the MDL (0.2 ug/L) in 8 field blank samples analyzed for volatile aromatic hydrocarbons by Method 602. Reported analytical values for these compounds in actual field samples should be reviewed in light of the field blank background levels. Based on the field blank results, positive values at concentrations less than 20 ug/L for methylene chloride, 3 ug/L for trichloroflouromethane and 0.2 ug/L for trichloroethane should be considered with caution. Toluene values reported at levels less than 17 ug/L should also be regarded with caution in light of possible sample contamination. The effect of samples with higher concentrations will be minimal by comparison. No field blank samples were collected for metals analyses.

4.4.2.1.3 Trip Blanks

Trip blanks were samples of organic-free water in sealed VOA vials that accompanied field samples through transportation and storage, but that were not exposed to sampling procedures. These samples were analyzed for volatile organic compounds by Methods 601 and 602. Table 4.4-4 presents these results, which support the evidence of background levels of methylene chloride and trichloromethane in Method 601 analyses of the field blank samples. Toluene was reported in three of the Method 602 analyses at concentrations greater than 1.5 times MDL. The reported concentrations of these compounds in trip blanks ranged from 0.5 to 3.6 ug/L. Positive values for methylene chloride, trichlorfluoromethane and toluene at concentrations less than 3 ug/L should be considered in the light of possible sample contamination.

4.4.2.2 Spiked Samples

Spiked samples are those to which known amounts of the analytes of interest have been added. These include both matrix spike and surrogate spike analyses. Matrix spikes are made by adding target analytes to an aliquot of the sample. The recovery of matrix spikes indicates matrix effects on sample analyses. Surrogate spikes are readily identifiable species not normally found in the sample matrix that are added to assess method control. Surrogate spikes are added to each sample before analysis for the target compounds.

Surrogate and spiked sample results for organic analyses indicated that overall bias and precision for Methods 601, 602, and 625 are within expected limits. Matrix spike results for metals analyses indicate significant matrix interferences for certain metals. These results are discussed below.

4.4.2.2.1 Spiked Sample Results for Organics Analyses

Matrix spike and surrogate spike analyses were performed for the Methods 601, 602 and 625 analyses of water samples. Surrogate spike results for purgeable halocarbons and aromatics (Methods 601 and 602) are summarized in Table 4.4-5. Table 4.4-6 summarizes surrogate spike recoveries for GC/MS BNA extractable organic analyses. Surrogate recoveries indicate small measurement bias and good analytical precision for volatile halocarbons and aromatics analyzed by GC. GC/MS Method 625 (acid and base/neutral extractable organics) surrogate recoveries varied more widely. The mean recoveries for six surrogate compounds ranged from 59 to 105 percent. Overall, Method 625 surrogate recoveries were within the expected ranges of recovery. Recovery of d_5-phenol and 2-fluorobiphenyl was outside the acceptance criteria for approximately 10 percent of the samples analyzed. This is not excessive, considering that the acceptance criteria represent a distribution of approximately 95 percent. The EPA Contract Laboratory (CLP) expected recovery for each surrogate, using method 625, is provided for comparison in Table 4.4-6.

Table 4.4-7 summarizes matrix spike results (by Methods 601 and 602) for purgeable halocarbons and aromatics. Table 4.4-8 presents a summary of matrix recovery results for Method 625 (BNA extractable organics). Matrix spike recoveries were within acceptable limits for almost every target analyte spiked into the 14 water samples analyzed for volatile organics and the 8 samples analyzed for extractable organics.

Matrix spike results from Method 608 analyses for pesticides and PCBs by GC/MS showed that no target analytes were recovered. The laboratory routinely calibrates for these analytes as part of the instrument tuning

TABLE 4.4-5. SUMMARY OF SURROGATE SPIKED SAMPLE RECOVERIES FOR WATER SAMPLES ANALYZED FOR PURGEABLE HALOCARBONS AND AROMATICS

Parameter	Number of Samples[a]	Mean % Recovery	% Relative Standard Deviation[b]	Number Below Acceptance Limits	Number Above Acceptance Limits	Acceptance Criteria[c] (% Recovery)
Method 601						
Bromochloromethane	134	105	10	1	3	84-126
2-Bromo-1-chloropropane	134	110	13	4	2	81-139
Method 602						
a,a,a-Trifluorotoluene	140	104[d]	8[d]	4	6	87-121

[a] The number of spiked sample analyses performed on routine samples.

[b] Relative Standard Deviation of mean % recovery.

[c] Taken as $\bar{x} \pm 2$ standard deviations (N-1).

[d] One outlier, 298% recovery, was not used in this statistic.

TABLE 4.4-6. SUMMARY OF EPA METHOD 625 SURROGATE SPIKE RECOVERY RESULTS FOR WATER SAMPLES

Parameter	Number of Samples[a]	Mean % Recovery	% Relative Standard Deviation[b]	Number Below Acceptance Limits	Number Above Acceptance Limits	Acceptance Criteria[c] (% Recovery)	EPA-CLP Expected Recovery[d] (% Recovery)
<u>Acid Fraction</u>							
d_5-Phenol	106	59	43	1	8	8-110	10-94
2-Fluorophenol	106	88	35	2	2	26-150	21-100
2,4,6-Tribromophenol	106	78	48	1	2	3-153	10-123
<u>Base Fraction</u>							
d_5-Nitrobenzene	106	81	36	0	2	23-139	35-114
2-Fluorobiphenyl	106	68	31	0	9	17-119	43-116
d_{14}-Terphenol	106	105	39	4	1	23-187	33-141

---

[a] The number of routine samples and field duplicates considered in evaluating surrogate recovery. (NOTE: Laboratory blanks, field blanks, and matrix spike analyses were not included.)

[b] Relative Standard Deviation of mean % recovery.

[c] The mean % recovery ± 2 standard deviations (N-1). This is the range of % recovery within which >90% of the surrogate spike recovery results lie.

[d] EPA-CLP range of expected surrogate spike recovery results for low/medium organic level water samples by Method 625.

TABLE 4.4-7. SUMMARY OF MATRIX SPIKED SAMPLE RECOVERIES FOR WATER SAMPLES ANALYZED FOR PURGEABLE HALOCARBONS AND AROMATICS

Parameter	Number of Samples[a]	Mean % Recovery	% Relative Standard Deviation[b]	Number Below Acceptance Limits	Number Above Acceptance Limits	Acceptance Criteria[c] (% Recovery)
Method 601						
Methylene Chloride	14	94	14	0	0	25-162
1,1-Dichloroethane	14	75	13	0	0	28-167
trans-1,2-Dichloroethene	14	96	10	0	0	38-155
Chloroform	14	138	13	0	8	49-133
1,2-Dichloroethane	14	90	21	0	1	51-147
1,1,1-Trichloroethane	14	108	9	0	0	41-138
Carbon tetrachloride	14	106	11	0	0	43-143
Bromodichloromethane	14	114	8	0	0	42-172
1,2-Dichloropropane	14	105	9	0	0	44-156
Trichloroethylene	14	122	25	0	3	35-146
Dibromochloromethane	14	78	34	0	0	24-191
Bromoform	14	108	11	0	0	13-159
Chlorobenzene	14	114	12	0	0	38-150
Tetrachloroethylene	14	85	13	0	0	26-162
Method 602						
Benzene	11	119	10	0	0	39-150
Toluene	11	122	26	0	2	46-148
Ethylbenzene	11	110	13	0	0	32-160
o-Xylene	11	101	17	-	-	NS
m-Xylene	11	131	23	-	-	NS
p-Xylene	11	117	12.	-	-	NS

[a] The number of spiked sample analyses performed on routine samples and field duplicates.

[b] Relative Standard Deviation of mean % recovery.

[c] As specified for QC check samples in Method 601 and 602.

NS - Not specified.

TABLE 4.4-8. SUMMARY OF EPA METHOD 625 MATRIX-SPIKED RECOVERY RESULTS FOR WATER SAMPLES

Parameter	Number of Samples[a]	Mean % Recovery	% Relative Standard Deviation[b]	Number Below Acceptance Limits	Number Above Acceptance Limits	Acceptance Criteria[c] (% Recovery)	EPA-CLP Expected Recovery[d] (% Recovery)
Acid Fraction							
2,4,6-Trichlorophenol	8	66	51	0	0	D-134	
4-Chloro-3-methylphenol	8	78	35	0	0	24-132	
2-Chlorophenol	8	70	32	0	0	24-115	23-97
2,4-Dichlorophenol	8	65	38	0	0	16-115	27-123
2,4-Dimethylphenol	8	46	28	0	0	21-72	
2-Nitrophenol	8	67	43	0	0	10-124	
4-Nitrophenol	8	65	76	0	0	D-165	10-80
2,4-Dinitrophenol	8	42	104	2	1	D-129	
2-Methyl-4,6-dinitrophenol	8	87	58	1	0	D-189	
Pentachlorophenol	8	90	94	1	0	D-260	9-103
Phenol	8	65	18	0	0	42-89	12-89
Base Fraction							
Acenaphthene	8	83	26	0	0	40-126	
Benzidine	8	24	203	2	1	D-121	
1,2,4-Trichlorobenzene	8	86	21	0	0	49-123	39-98
Hexachlorobenzene	8	106	20	0	0	64-147	
Hexachloroethane	8	82	18	0	0	51-112	
Bis(2-chloroethyl)ether	8	75	25	0	0	38-112	
2-Chloronaphthalene	8	84	28	0	0	37-130	
1,2-Dichlorobenzene	8	80	20	0	0	48-111	
1,3-Dichlorobenzene	8	77	16	0	0	52-102	
1,4-Dichlorobenzene	8	73	15	0	0	52-94	36-97
3,3-Dichlorobenzidine	8	374	178	1	1	D-1714	
2,4-Dinitrotoluene	8	93	30	0	0	38-148	24-96
2,6-Dinitrotoluene	8	93	30	0	0	38-149	
Fluoranthene	8	92	15	0	0	65-119	
4-Chlorophenyl phenyl ether	8	92	28	0	0	40-143	
N-Nitrosodimethylamine	8	40	118	1	0	D-134	
N-Nitrosodiphenylamine	8	345	160	0	1	D-1451	
N-Nitrosodi-n-propylamine	8	72	30	0	0	28-116	41-116

(Continued)

TABLE 4.4-8. (Continued)

Parameter	Number of Samples[a]	Mean % Recovery	% Relative Standard Deviation[b]	Number Below Acceptance Limits	Number Above Acceptance Limits	Acceptance Criteria[c] (% Recovery)	EPA-CLP Expected Recovery[d] (% Recovery)
Bis(2-ethylhexyl)phthalate	8	88	18	0	0	56-120	
Butyl benzyl phthalate	8	47	38	0	0	11-83	
Di-butyl phthalate	8	88	19	0	0	54-121	
Di-n-octyl phthalate	8	74	26	0	0	35-113	
Dietyl phthalate	8	81	27	0	0	38-125	
Dimethyl phthalate	8	59	31	0	0	23-95	
Benzo(a)anthracene	8	91	13	0	0	67-115	
Benzo(a)pyrene	8	87	8	0	0	72-101	
Benzo(b)fluoranthene	8	95	47	0	1	5-185	
Benzo(k)fluoranthene	8	90	34	0	1	28-152	
Chrysene	8	92	16	0	0	63-121	
Acenaphthlyene	8	82	22	0	0	46-117	46-118
Anthracene	8	98	13	0	0	72-124	
4-Bromophenyl phenyl ether	8	105	22	0	0	60-150	
Bis(2-chloroisopropyl)ether	8	76	36	0	0	22-130	
Bis(2-chloroethoxy)methane	8	76	18	0	0	48-104	
Hexachlorobutadiene	8	77	47	1	0	4-150	
Hexachlorocyclopentadiene	8	7	141	1	1	D-27	
Isosphorone	8	79	18	0	0	51-107	
Naphthalene	8	77	20	0	0	47-107	
Nitrobenzene	8	75	23	0	0	39-110	
Benzo(ghi)perylene	8	85	32	0	0	30-139	
Fluorene	8	85	22	0	0	48-123	
Phenanthrene	8	90	13	0	0	67-113	
Dibenzo(a,h)anthracene	8	80	37	1	0	21-138	
Indeno(1,2,3-cd)pyrene	8	77	46	0	0	6-149	
Pyrene	8	89	18	0	0	56-121	26-127

[a] The number of spiked sample analyses performed on routine samples and field duplicates.

[b] Relative Standard Deviation of mean % recovery.

[c] The mean recovery ± 2 standard deviations (N-1). This is the range of % recovery within which >90% of the reported matrix spike recovery results lie.

[d] EPA-CLP range of expected range of recovery for low/medium organic level water samples by Method 625.

procedures for conducting Method 625 analyses. They can also report results for the pesticide and PCB analytes from the same sample injections made for determination of Method 625 analytes. However, the laboratory did not routinely spike pesticide or PCB analytes into the matrix-spiked samples during the period that these samples were analyzed. The reported values of "ND" are correct for these analytes. This is not felt to be a problem since the determination of pesticides and PCBs was not required in the scope of work and the results have been provided at no charge to the client. The Method 608 by GC/MS results for analytes should be considered valid, based on the calibration data, but unqualified, since no surrogate or matrix spike data exist to confirm that the analytes of interest could have been recovered had they been added to each sample.

Of the 14 Method 601 (purgeable halocarbon) target analytes, only the matrix spike results for chloroform indicated unexpected bias. Results for the recovery of chloroform spiked into the matrix indicate a mean percent recovery of 138 percent with eight of 14 spiked sample results outside the acceptance criteria of 49 to 133 percent. This high bias for chloroform should not present a problem unless chloroform was detected in field samples at levels of environmental concern. The possibility of positive bias (relative to the Method 601 published expectations for bias) should be considered when interpreting results. With the exception of the 37 ug/L of chloroform reported at well HM-24, all other positive values for chloroform were less than 10 ug/L, so the bias effect will be negligible.

4.4.2.2.2 Spiked Sample Results for Metals Analyses

Approximately 10 percent of water samples analyzed for metals were spiked with target analytes to assess analytical accuracy in the sample matrices. Spiked sample recovery results for metals analyses in water samples are summarized in Table 4.4-9. These results indicate significant matrix interferences for selenium, lead and cadmium. Sample parameters for which spike recovery results were outside the 75-125 percent recovery range were

TABLE 4.4-9. SUMMARY OF MATRIX-SPIKED SAMPLE RECOVERIES FOR METALS ANALYSES IN WATER SAMPLES

Parameter	Number of Samples[a]	Mean % Recovery	% Relative Standard Deviation[b]	Number Below Acceptance Limits	Number Above Acceptance Limits	Acceptance Criteria[c]
Silver	22	88	11.3	2	0	75-125
Arsenic	28	94	9.9	1	0	75-125
Barium	22	91	6.3	0	0	75-125
Cadmium	22	81	14.8	9	0	75-125
Chromium	22	87	8.7	1	0	75-125
Mercury	19	101	17.3	1	1	75-125
Lead	32	79	80.8	13	1	75-125
Selenium	37	64	51.4	17	0	75-125

[a] The number of spiked sample analyses performed on routine samples.

[b] Relative Standard Deviation of mean % recovery.

[c] Acceptable range of % recovery for indicated analyte.

flagged as suspect. Not every sample was spiked. For this reason, Se, Cd, and Pb results for samples from similar matrices should also be considered suspect because of matrix interferences.

Mean spiked sample recoveries were 64 percent for selenium and 101 percent for mercury. Spiked sample results (mean +1 standard deviation) for cadmium were biased low to a small degree, at 81±12 percent mean recovery, with nine of the 22 spiked sample results less than 75 percent recovery. Results for lead and selenium were also biased low, at 79±64 and 64±32 mean percent recovery, respectively. Thirteen of 32 lead and 17 of 37 selenium spiked sample results showed less than 75 percent recovery, indicating significant matrix interferences. Furthermore, six spiked sample results for selenium showed zero percent recovery. In light of these spiked sample recoveries, reported results for cadmium and lead should be considered to be biased low by about 20 percent. Positive results for selenium should also be considered biased low. Not detected (ND) results for selenium that are flagged or that are from matrices similar to those flagged should be considered with caution.

In several cases, spiked samples that failed the acceptance criteria of 75-110 percent recovery were diluted by a factor of 10, reanalyzed, spiked, and reanalyzed. This procedure usually resulted in acceptable spike recoveries (in the diluted sample) and "not detected" for the endogenous level but a 10-fold increase in the limit of detection. A detailed listing of spike recovery data for metals analyses appears in Appendix A-4.

Quality control check samples (QCCS) containing metals at known concentrations were analyzed to assess analytical performance in the absence of matrix effects. Table 4.4-10 summarizes QCCS recoveries for metals analyses in water samples. Mean percent recoveries were within the laboratory bias objective of 90-110 percent for all eight metals analyzed, and repeatability, expressed as the relative standard deviation (RSD) of QCCS results, was acceptable, ranging from 2.3 to 8.7 percent RSD.

TABLE 4.4-10. SUMMARY OF QCCS RECOVERIES FOR METALS ANALYSES IN WATER SAMPLES

Parameter	Number of Samples[a]	Mean % Recovery	% Relative Standard Deviation[b]	Number Below Acceptance Limits	Number Above Acceptance Limits	Acceptance Criteria[c]
Silver	14	97	8.7	2	0	90-110
Arsenic	38	99	7.1	2	1	90-110
Barium	14	102	2.3	0	0	90-110
Cadmium	14	102	2.4	0	0	90-110
Chromium	14	101	2.2	0	0	90-110
Mercury	36	99	7.2	0	0	80-120
Lead	35	102	5.1	0	4	90-110
Selenium	28	96	7.6	6	0	90-110

[a] The number of QCCS analyses performed with routine samples.

[b] Relative Standard Deviation of mean % recovery.

[c] Acceptable range of % recovery for indicated analyte.

4.4.2.3 Duplicate Samples and Duplicate Analyses

The QC protocol for Plant 4 groundwater and surface water sampling included collection of duplicate samples as well as the performance of duplicate analyses in the laboratory. Duplicate sample results measure overall variability in sample collection and analysis. Results for the duplicate analysis of individual samples are a measure of analytical precision.

Table 4.4-11 summarizes results of the analyses of duplicate samples. Sampling plus analytical variability averaged 20 percent RSD for Method 601 analyses of duplicate samples, 70 percent for duplicate samples analyzed by Method 602, and 15 percent for analyses of duplicate samples by Method 625 (acid and base/neutral extractable organics).

Table 4.4-12 presents precision estimates for laboratory duplicates for the analyses of volatile organics by Methods 601 and 602. Table 4.4-13 presents the same information for acid and base/neutral extractable organics by EPA Method 625. Analytical variability was as expected for most results, averaging 15 percent RSD for volatile halocarbons, 35 percent for volatile aromatics, and 39 percent for acid and base/neutral extractable organics. The results indicate that results for low levels of phthalates and toluene may be highly variable.

Table 4.4-14 summarizes the metals analyses results for duplicate analysis and duplicate sample variability. Sampling plus analytical variability, expressed as the RSD of duplicate sample results, was 22 percent for arsenic, 23 percent for barium and 72 percent for chromium. Concentrations of the other five metals in the duplicate sample pairs were reported at concentrations less than the limit of reliable quantitation so no variability estimates were possible. Analytical variability, expressed as the RSD for duplicate analyses, ranged from 5 percent for barium to 20 percent for silver.

TABLE 4.4-11. ANALYSES OF FIELD DUPLICATE WATER SAMPLES FOR ORGANIC PARAMETERS

Parameter	Monitor Well	Routine Value (ug/L)	Duplicate Value (ug/L)	Mean Concentration (ug/L)	Standard Deviation[a]	% Relative Standard Deviation[b]
Method 601						
Vinyl Chloride	P-10U	0.20	0.74	0.47	0.38	81
Methylene Chloride	P-10U	48.7	91.2	70.0	30.1	43
trans-1,2-Dichloroethene	P-10M	0.30	0.25	0.28	0.035	12
trans-1,2-Dichloroethene	HM-58	1.94	2.02	1.98	0.057	2.9
Chloroform	HM-52	4.25	3.79	4.02	0.325	8.1
Chloroform	OF1-1730	2.79	2.57	2.68	0.156	5.8
Trichloroethylene	P-10U	1.01	0.82	0.92	0.13	14
Trichloroethylene	HM-47	10,979	12,066	11,522	768.63	6.7
Trichloroethylene	HM-70	10,983	10,866	10,924	82.731	0.8
Trichloroethylene	HM-52	0.93	0.95	0.94	0.014	1.5
Trichloroethylene	HM-58	0.74	0.84	0.79	0.071	9.0
Dibromochloromethane	HM-52	0.42	0.72	0.57	0.21	37
Dibromochloromethane	OF1-1730	5.58	4.45	5.02	0.799	16
Bromoform	OF1-1730	2.00	1.78	1.89	0.156	8.2
Chlorobenzene	HM-47	308	771	540	327	61
Bromodichloromethane	OF1-1730	4.69	3.68	4.18	0.714	17

(Continued)

TABLE 4.4-11. (Continued)

Parameter	Well Number	Routine Value (ug/L)	Duplicate Value (ug/L)	Mean Concentration (ug/L)	Standard Deviation[a]	% Relative Standard Deviation[b]
Method 602						
Chlorobenzene	HM-47	738	709	723	20.5	2.8
Toluene	P-10M	15.8	2.79	9.30	9.20	99
Toluene	HM-52	2.96	0.90	1.9	1.5	79
Toluene	HM-34	1.46	125[c]	63	87	140[c]
Toluene	P-20	7.39	11.1	9.24	2.62	28
Method 625						
di-butyl phthalate	P-20	4	3	3.5	0.71	20
bis(2-ethylhexyl)phthalate	P-20	5	6	5.5	0.71	10

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[a] Standard deviation of mean concentration.

[b] Relative Standard Deviation of % replicate analyses.

[c] Raw data explained that sample had a top layer of organics.

TABLE 4.4-12. LABORATORY DUPLICATE ANALYSES OF WATER SAMPLES FOR METHOD 601 AND 602 ORGANIC PARAMETERS

Parameter	Sample ID	Routine Value (ug/L)	Duplicate Value (ug/L)	Mean Concentration (ug/L)	Standard Deviation[a]	% Relative Standard Deviation[b]
Method 601						
Vinyl Chloride	860153	968	1,114	1,041	103.2	9.9
1,1-Dichloroethene	860216	3.9	5.3	4.6	0.99	22
trans-1,2-Dichloroethene	860153	26,206	29,709	27,957	2,477	8.9
trans-1,2-Dichloroethene	860146	8.48	7.81	8.14	0.474	5.8
Chloroform	860216	0.36	0.56	0.46	0.14	30
1,1,1-Trichloroethane	860216	16.7	21.5	19.1	3.39	18
Trichloroethylene	860153	2,274	3,351	2,812	761.6	27
Trichloroethylene	860146	26.4	22.3	24.4	2.90	12
Trichloroethylene	860216	8.0	10.5	9.2	1.8	20
Trichloroethylene	860179	10,983	12,492	11,738	1,067	9.1
Trichloroethylene	860166	2,367	2,201	2,284	117.4	5.1
Trichloroethylene	860163	177	176	176	0.707	0.40
Tetrachloroethylene	860153	150	237	194	61.5	0.32
Tetrachloroethylene	860146	1.31	0.74	1.0	0.40	40
Tetrachloroethylene	860194	0.09	0.08	0.08	0.007	9

(Continued)

TABLE 4.4-12. (Continued)

Parameter	Routine Sample ID	Routine Value (ug/L)	Duplicate Value (ug/L)	Mean Concentration (ug/L)	Standard Deviation[a]	% Relative Standard Deviation[b]
Method 602						
Toluene	860156	1.43	1.07	1.25	0.255	20.4
Toluene	860159	1.79	1.76	1.78	0.021	1.2
Toluene	860167	0.83	0.76	0.80	0.049	0.062
Toluene	860175[c]	10.0	0.87	5.44	6.46	119[c]
Toluene	860192[c]	0.84	ND	[d]	[d]	[d]
Toluene	Field Blank	2.19	2.14	2.17	0.35	16
Toluene	Trip Blank	2.50	1.17	1.84	0.940	51.1

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[a] Standard deviation of mean concentration.

[b] Relative Standard Deviation of % replicate analyses.

[c] Data sheet was annotated: "There is a top layer that was in the first run but not in the second run".

[d] Cannot be calculated or result not meaningful.

ND - Not detected.

TABLE 4.4-13. LABORATORY DUPLICATE ANALYSES OF WATER SAMPLES FOR METHOD 625 ORGANIC PARAMETERS

Parameter	Routine Sample ID	Routine Value (ug/L)	Duplicate Value (ug/L)	Mean Concentration (ug/L)	Standard Deviation[a]	% Relative Standard Deviation[b]
Method 625						
Phenol	860126	2	3	2.5	0.71	28
Phenol	86-01-242[c]	2	3	2.5	0.71	28
Phenol	86-01-116[c]	1	3	2.0	1.4	70
di-butyl phthalate	86-02-058[c]	2 BL	4 BL	3.0	1.4	47
di-butyl phthalate	860221	12 BL	5 BL	8.5	5.0	59
di-butyl phthalate	86013	2 BL	8 BL	5.0	4.2	84
di-butyl phthalate	860152	3 BL	4 BL	3.5	0.71	20
bis(2-ethylhexyl)phthalate	860221	5	4	4.5	0.71	16
bis(2-ethylhexyl)phthalate	86013	3	3	3.0	0	0

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[a] Standard Deviation of mean concentration.

[b] Relative Standard Deviation of % replicate analyses.

[c] Work Order number.

BL - Data qualifier used by the analytical laboratory indicating that the compound was also detected in the laboratory blank.

TABLE 4.4-14. SUMMARY OF PRECISION ESTIMATES BASED ON DUPLICATE WATER SAMPLES AND ANALYSES FOR METALS

Parameter	Number of Field Duplicate Pairs[a]	Sampling Plus Analytical Variability[b]	Number of Analytical Duplicate Pairs[a]	Analytical Variability[c]
Silver	0	NC	5	20
Arsenic	2	22	7	13
Barium	6	23	17	5.4
Cadmium	0	NC	0	NC
Chromium	5	72	8	5.5
Mercury	0	NC	1	7.5
Lead	0	NC	11	8.8
Selenium	0	NC	0	NC

NC - not calculated. All values less than limit of quantitation.

[a] Number of duplicate pairs where at least one concentration is greater than the limit of quantitation.

[b] % Pooled Relative Standard Deviation for duplicate samples reported above quantitation limit; represents total variability of the measurement process.

[c] Pooled Relative Standard Deviation for replicate analyses of individual samples reported above quantitation limit; represents analytical variability independent of sampling variability.

The concentrations of cadmium and selenium were below the limit of quantitation in all duplicate analysis pairs, so no precision estimates for these two parameters could be made.

4.4.3 QA/QC Results for Soil Sample Analyses

Quality control efforts associated with the collection and analysis of soil samples used in characterization of Plant 4 sites included:

- Analysis of laboratory blank samples;
- Analysis of spiked samples;
- Collection and analysis of duplicate samples; and
- Duplicate analyses.

Results for these QC analyses are discussed in the following sections.

4.4.3.1 Blank Sample Results

Only laboratory blanks were analyzed as part of the QC efforts associated with Plant 4 soil sample analyses. Blank sample results of the analysis for purgeable halocarbons and aromatics, acid and base/neutral extractable organic compounds, and trace metals are discussed below. The laboratory blank analyses indicate that no significant sample contamination was due to handling during analysis. Background levels of certain organic compounds must be considered in the interpretation of results.

The laboratory (reagent) blank samples for the soil sample analyses were prepared using the same reagents and preservatives as for the preparation and analyses of field samples. Table 4.4-15 summarizes the results for laboratory blanks reported at concentrations exceeding the QC limits for soil samples analyzed for halogenated volatile organics (Method 8010) and aromatic volatile organics (Method 8020). The results show high blank sample levels for the volatile halocarbons, 1,1,1-trichloroethane, trichloroethylene, and tetrachloro- ethylene, and for the aromatic hydrocarbons, benzene, toluene, and ortho-, meta-, and para-xylene. Any contribution compounds found in

TABLE 4.4-15. REAGENT BLANK DATA REPORTED ABOVE THE METHOD DETECTION LIMIT FOR SOIL SAMPLES ANALYZED FOR ORGANIC PARAMETERS

Parameter	Date Analyzed	Concentration (ug/L)	Method Detection Limit (ug/L)	QC Limit[a] (ug/L
Method 8010				
1,1,1-Trichloroethane	5/14/86	1.26	0.03	0.04
1,1,1-Trichloroethane	5/15/86	1.78	0.03	0.04
Trichloroethylene	5/14/85	0.59	0.12	0.18
Trichloroethylene	5/15/86	1.03	0.12	0.18
Trichloroethylene	1/29/86	0.13	0.12	0.18
Tetrachloroethylene[b]	1/29/86	0.17[b]	0.03	0.04
Tetrachloroethylene	5/14/86	0.34	0.03	0.04
Tetrachloroethylene	5/15/86	0.32	0.03	0.04
Tetrachloroethylene	1/28/86	0.13	0.03	0.04
Method 8020				
Benzene	1/31/86	0.91	0.2	0.3
Benzene	5/24/86	3.72	0.2	0.3
Toluene	1/30/86	5.45	0.2	0.3
Toluene	1/31/86	6.64	0.2	0.3
Toluene	5/24/86	3.77	0.2	0.3
p-Xylene	1/31/86	0.89	0.2	0.3
p-Xylene	5/24/86	0.77	0.2	0.3
m-Xylene	1/31/86	1.24	0.2	0.3
m-Xylene	5/24/86	1.43	0.2	0.3
o-Xylene	1/31/86	0.99	0.2	0.3
o-Xylene	5/24/86	1.03	0.2	0.3

[a] Estimated as 1.5 times reported detection limit.

[b] Data sheet did not distinguish between 1,1,2,2-tetrachloroethylene and tetrachloroethylene.

laboratory blanks can be related to field soil samples by using the mass of sample extracted, extract volume and final dilution factor if these compounds were reported above detection limits in any field samples. Analyses of reagent blanks by Method 8270 acid and (base/neutral extractable organics) showed no compounds were reported at concentrations above the detection limits.

Laboratory reagent blanks were analyzed as part of the metals analyses of soil samples. Table 4.4-16 summarizes the results for laboratory blanks reported at concentrations above the laboratory method detection limits. These results indicate no serious contamination. Half of the blank results for barium were above the detection limit of 0.001 mg/L. Those results above the detection limit averaged 0.004 mg/L. Blank samples analyzed by ICP for arsenic, lead and selenium in certain soil extracts reflected the higher detection limit for analysis of these metals by ICPES rather than by AA.

Since no soil field blanks or trip blanks were collected during this study, no estimate of the contribution of sample handling to overall measurement variability can be made.

4.4.3.2 Spiked Sample Analysis Results

Surrogate-spiked samples were used to monitor method control for EPA Method 8010 (volatile halocarbons), 8020 (volatile aromatics), 8240 (volatile organics) and 8270 (BNA extractable organics) analyses of soil samples. Surrogate spike results for these analyses are summarized in Table 4.4-17 for Methods 8010 and 8020 and in Table 4.4-18 for GC/MS Methods 8270 and 8240. The results of these analyses indicate acceptable measurement bias and good repeatability. The mean percent recovery for surrogate spike recovery by Method 601 ranged from 101 to 112 percent for the two surrogate compounds. Relative standard deviations for the surrogate recoveries were 8 and 11 percent. The mean recovery for the Method 602 surrogate compounds was 101 percent, with a relative standard deviation of 5 percent for the 19 measurements. Mean surrogate recoveries for GC/MS acid and base/neutral extractable

TABLE 4.4-16. LABORATORY BLANK DATA REPORTED ABOVE DETECTION LIMITS FOR METALS ANALYSES OF SOIL SAMPLES

Parameter	Number of Samples[a]	Mean Concentration[b] (mg/L)	Number Above Detection Limit (mg/L)	Detection Limit (mg/L)
Silver	6	0.003	1	0.002
Arsenic	3	-	0	0.006
Barium	6	0.004	3	0.001
Cadmium	6	-	0	0.002
Chromium	7	0.006	1	0.005
Mercury	7	-	0	0.0002
Lead	3	-	0	0.002[c]
Selenium	3	-	0	0.001[c]

[a] Total number of reagent blank analyses.

[b] Mean concentration only for values greater than detection limit.

[c] ICP detection limit is 0.06 mg/L for As and 0.08 mg/L for Pb and Se.

TABLE 4.4-17. SUMMARY OF SURROGATE-SPIKED SAMPLE RECOVERIES FOR SOIL SAMPLES ANALYZED FOR PURGEABLE HALOCARBONS AND AROMATICS

Parameter	Number of Samples[a]	Mean % Recovery	% Relative Standard Deviation[b]	Number Below Acceptance Limits	Number Above Acceptance Limits	Acceptance Criteria[c] (% Recovery)
Method 8010						
Bromochloromethane	18	111	8	0	0	92-130
2-Bromo-1-chloropropane	10	112	11	0	1	87-137
Method 8020						
a,a,a-Trifluorotoluene	19	101	5	1	0	90-112

[a] The number of spiked sample analyses performed on routine samples.

[b] Relative Standard Deviation of mean % recovery.

[c] Taken as $\bar{x} \pm 2$ standard deviations (N-1).

TABLE 4.4-18. SUMMARY OF EPA METHOD 8270 SURROGATE-SPIKED RECOVERY RESULTS FOR SOIL SAMPLES

Parameter	Number of Samples[a]	Mean % Recovery	% Relative Standard Deviation[b]	Number Below Acceptance Limits	Number Above Acceptance Limits	Acceptance Criteria[c] (% Recovery)	EPA-CLP Expected Recovery[d] (% Recovery)
Method 8270							
Acid Fraction							
d_5-Phenol	7	64	20	0	0	38-90	24-113
2-Fluorophenol	7	44	44	0	0	6-82	25-121
2,4,6-Tribromophenol	7	101	27	0	0	47-155	19-122
Base Fraction							
d_5-Nitrobenzene	7	77	26	0	0	37-117	23-120
2-Fluorobiphenyl	7	106	13	0	0	78-134	30-115
d_{14}-Terphenol	7	58	13	0	0	43-73	18-137
Method 8240							
d_4 1,1-Dichloroethane	4	91	7.5	0	0	76-106	70-121
d_8 Toluene	4	97	4.9	0	0	87-107	81-117
Bromofluorobenzene	4	92	14.6	0	0	63-121	74-121

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[a] The number of routine samples and field duplicates considered in evaluating surrogate recovery. (NOTE: Laboratory blanks, field blanks, and matrix spike analyses were not included.)

[b] Relative Standard Deviation of mean % recovery.

[c] The mean % recovery ± 2 standard deviations (N-1). This is the range of % recovery within which >90% of the surrogate spike recovery results lie.

[d] EPA-CLP range of expected surrogate spike recovery results for low/medium organic level soil samples by Method 8270.

organics were more widely varied, ranging from 58 to 101 mean percent recovery for six surrogate compounds. All recoveries were within the ±2 standard deviation limit and agreed well with the EPA Contract Laboratory Program (CLP) expected recovery limits. Surrogate compound recoveries for Method 8240 analyses ranged from 91 to 97 mean percent recovery. All recoveries were within the EPA-CLP expected recovery limits.

Soil samples analyzed for acid and base/neutral extractable organics by GC/MS Method 8270 were also spiked with target analytes (matrix spikes). Table 4.4-19 summarizes the Method 8270 analytical results for soil matrix-spiked samples. These results show that parameter recoveries in the sample matrices tested were within the expected ranges. For compounds that have CLP expected recovery criteria, recoveries were also within the expected limits.

The quality assurance review of these data noted that several matrix spike reports for Method 608 (pesticides and PCBs) were present in the data volume (Appendices A-2 and A-3). The results were all reported as "ND". An inquiry revealed that the analyses for pesticides and PCBs by GC/MS had been included as part of the Method 625 analytical run for each sample. Each pesticide and some PCBs were calibrated for, but none were included in the matrix spikes. The correct result for these matrix spike analyses is "ND". No other QC data exist to support Method 608 by GC/MS results.

Matrix effects were not a problem in the analyses of soil for metals, except for selenium, and to a lesser extent, cadmium. The results of matrix spike analyses for the eight metals in soil samples ranged from 72 to 102 mean percent recovery. The mean percent recovery was outside the acceptance criteria of 75-125 percent for both cadmium and selenium. Sample results accompanied by spiked sample recovery data that indicate matrix interference are flagged, but results for similar samples should also be evaluated in light of the spike recovery data. Table 4.4-20 summarizes the matrix-spiked sample recoveries for metals analyses of soil samples.

TABLE 4.4-19. SUMMARY OF EPA METHOD 8270 MATRIX-SPIKED RECOVERY RESULTS FOR SOIL SAMPLES

Parameter	Number of Samples[a]	Mean % Recovery	% Relative Standard Deviation[b]	Number Below Acceptance Limits	Number Above Acceptance Limits	Acceptance Criteria[c] (% Recovery)	EPA-CLP Expected Recovery[d] (% Recovery)
Acid Fraction							
2,4,6-Trichlorophenol	2	108	7.9	0	0	91-125	
4-Chloro-3-methylphenol	2	100	9.9	0	0	80-120	
2-Chlorophenol	2	92	6.2	0	0	81-103	25-102
2,4-Dichlorophenol	2	99	10	0	0	79-119	
2,4-Dimethylphenol	2	63	67	0	0	D-148	
2-Nitrophenol	2	78	17	0	0	51-104	
4-Nitrophenol	2	100	22	0	0	56-143	11-114
2,4-Dinitrophenol	2	31	11	0	0	23-38	
2-Methyl-4,6-dinitrophenol	2	98	19	0	0	61-135	
Pentachlorophenol	2	121	19	0	0	76-166	17-109
Phenol	2	76	0.0	0	0	76-76	26-90
Base Fraction							
Acenaphthene	2	103	18	0	0	66-140	
Benzidine	2	35	135	0	0	D-129	
1,2,4-Trichlorobenzene	2	101	1.4	0	0	98-104	38-107
Hexachlorobenzene	2	103	24	0	0	53-152	
Hexachloroethane	2	291	96	0	0	D-851	
Bis(2-chloroethyl)ether	2	85	12	0	0	63-106	
2-Chloronaphthalene	2	102	17	0	0	66-137	
1,2-Dichlorobenzene	2	92	3.0	0	0	86-98	
1,3-Dichlorobenzene	2	94	3.7	0	0	86-101	
1,4-Dichlorobenzene	2	86	5.7	0	0	76-95	28-104
3,3-Dichlorobenzidine	2	167	48	0	0	7-326	
2,4-Dinitrotoluene	2	101	3.5	0	0	93-108	28-89
2,6-Dinitrotoluene	2	122	7.5	0	0	103-140	
Fluoranthene	2	126	18	0	0	81-171	
4-Chlorophenyl phenyl ether	2	110	17	0	0	73-147	26-103
N-Nitrosodimethylamine	2	58	62	0	0	D-130	
N-Nitrosodiphenylamine	2	116	30	0	0	46-185	
N-Nitrosodi-n-propylamine	2	93	18	0	0	60-125	41-126

(Continued)

TABLE 4.4-19. (Continued)

Parameter	Number of Samples[a]	Mean % Recovery	% Relative Standard Deviation[b]	Number Below Acceptance Limits	Number Above Acceptance Limits	Acceptance Criteria[c] (% Recovery)	EPA-CLP Expected Recovery[d] (% Recovery)
Bis(2-ethylhexyl)phthalate	2	105	61	0	0	D-232	
Butyl benzyl phthalate	2	33	56	0	0	D-70	
Di-butyl phthalate	2	102	33	0	0	34-170	
Di-n-octyl phthalate	2	115	58	0	0	D-249	
Dietyl phthalate	2	92	37	0	0	24-160	
Dimethyl phthalate	2	76	85	0	0	D-204	
Benzo(a)anthracene	2	108	26	0	0	52-163	
Benzo(a)pyrene	2	113	41	0	0	20-206	
Benzo(b)fluoranthene	2	123	45	0	0	11-234	
Benzo(k)fluoranthene	2	103	25	0	0	50-155	
Chrysene	2	109	38	0	0	27-191	
Acenaphthlyene	2	98	15	0	0	68-127	31-137
Anthracene	2	67	112	0	0	D-217	
4-Bromophenyl phenyl ether	2	107	36	0	0	29-184	
Bis(2-chloroisopropyl)ether	2	98	0.7	0	0	96-99	
Bis(2-chloroethoxy)methane	2	87	9.8	0	0	70-104	
Hexachlorobutadiene	2	107	0.7	0	0	105-108	
Hexachlorocyclopentadiene	2	59	141	0	0	D-226	
Isosphorone	2	105	26	0	0	49-160	
Naphthalene	2	87	5.6	0	0	77-96	
Nitrobenzene	2	87	1.6	0	0	84-90	
Benzo(ghi)perylene	2	106	27	0	0	49-163	
Fluorene	2	98	19	0	0	59-136	
Phenanthrene	2	106	10	0	0	84-127	
Dibenzo(a,h)anthracene	2	110	24	0	0	57-162	
Indeno(1,2,3-cd)pyrene	2	106	25	0	0	53-158	
Pyrene	2	104	44	0	0	13-195	35-142

[a] The number of spiked sample analyses performed on routine samples and field duplicates.

[b] Relative Standard Deviation of mean % recovery.

[c] The mean recovery ± 2 standard deviations (N-1). This is the range of % recovery within which >90% of the reported matrix spike recovery results lie.

[d] EPA-CLP range of expected range of recovery for low/medium organic level soil samples by Method 625.

TABLE 4.4-20. SUMMARY OF MATRIX-SPIKED SAMPLE RECOVERIES FOR METALS ANALYSES OF SOIL SAMPLES

Parameter	Number of Samples[a]	Mean % Recovery	% Relative Standard Deviation[b]	Number Below Acceptance Limits	Number Above Acceptance Limits	Acceptance Criteria[c]
Silver	5	82	19	1	0	75-125
Arsenic	5	89	12	1	0	75-125
Barium	5	102	38	0	1	75-125
Cadmium	5	72	17	3	0	75-125
Chromium	7	85	6.6	0	0	75-125
Mercury	3	93	12	0	0	75-125
Lead	4	87	13	0	0	75-125
Selenium	7	74	40	3	0	75-125

[a] The number of spiked sample analyses performed on routine samples.
[b] Relative Standard Deviation of mean % recovery.
[c] Acceptable range of % recovery for indicated parameters.

In addition to matrix spikes, QC check samples (QCCS) were analyzed to monitor analytical accuracy in the absence of matrix effects. Table 4.4-21 summarizes the QCCS recoveries for metals analyses of soil samples. The results show mean percent recoveries for all eight metals of interest within the acceptance criterion of 90-110 percent recovery. QCCS results were low (76 mean percent recovery) for silver analyses on 23 March, but overall measurement bias was not significant for silver or any other metal of interest. Based on QCCS results, bias estimates for the eight target metals ranged from 94±10 percent for silver to 102±3 percent for cadmium.

4.4.3.3 Duplicate Samples and Duplicate Analyses

Duplicate analysis results for volatile organic analyses of soil samples yielded limited analytical precision data since most compounds were not detected. Positive values were reported for two sets of duplicate analyses by Method 8010. The mean relative standard deviation for 1,1,1-trichloroethane in the two duplicate analysis pairs was 8 percent. Those results are presented in Table 4.4-22.

No duplicate soil samples were collected and analyzed for metals, but duplicate analyses were performed for approximately 10 percent of the field samples. Table 4.4-23 summarizes the results for duplicate analyses when at least one of the duplicate results is greater than the limit of quantitation. The limit of reliable quantitation for metals analyses is taken as five times the limit of detection. Values between the limit of detection and limit of quantitation are semi-quantitative, since uncertainty at this level approaches 100 percent. Analytical variability for metals in soil samples ranged from zero to 12 percent RSD, averaging four percent RSD for the eight metals analyzed.

TABLE 4.4-21. SUMMARY OF QCCS RECOVERIES FOR METALS ANALYSES OF SOIL SAMPLES

Parameter	Number of Samples[a]	Mean % Recovery	% Relative Standard Deviation[b]	Number Below Acceptance Limits	Number Above Acceptance Limits	Acceptance Criteria[c]
Silver	15	94	10.2	3	0	90-110
Arsenic	8	105	8.7	0	3	90-110
Barium	15	101	3.0	0	0	90-110
Cadmium	15	102	2.6	0	0	90-110
Chromium	17	101	3.0	0	0	90-110
Mercury	13	97	5.0	0	0	80-120
Lead	10	97	5.2	2	0	90-110
Selenium	12	97	6.7	2	0	90-110

[a] The number of spiked sample analyses performed on routine samples.

[b] Relative Standard Deviation of mean % recovery.

[c] Acceptable range of % recovery for indicated parameters.

TABLE 4.4-22. DUPLICATE ANALYSES FOR SOIL SAMPLES FOR ORGANIC ANALYSES

Parameter	Routine Sample ID	Routine Value (ug/kg)	Duplicate Value (ug/kg)	Mean Concentration (ug/kg)	Standard Deviation[a]	% Relative Standard Deviation[b]
Method 8010						
1,1,1-Trichloroethane	86-05-072-01	20	21	20.5	0.71	3.5
1,1,1-Trichloroethane	86-05-072-02	21	18	19.5	2.1	11

[a] Standard Deviation of mean concentration.
[b] Relative Standard Deviation of % replicate analyses.

TABLE 4.4-23. SUMMARY OF PRECISION ESTIMATES BASED ON DUPLICATE SOIL SAMPLE ANALYSES FOR METALS

Parameter	Number of Analytical Duplicate Pairs	Analytical Variability[a]
Silver	4	12
Arsenic	1	3.2
Barium	5	5.7
Cadmium	1	0.6
Chromium	5	8.5
Mercury	1	2.7
Lead	1	0.0
Selenium	1	1.9

[a] Pooled relative standard deviation for replicate analyses of individual samples reported above quantitation limit; represents analytical variability independent of sampling variability.

4.4.4 QA/QC Results for Oil and Grease and Total Hydrocarbons Analyses in Water and Soil Samples by IR

QC procedures associated with analyses for oil and grease and for hydrocarbons by infrared spectroscopy included analysis of

- Quality control check samples (QCCS);
- Duplicate analyses; and
- Analysis of duplicate samples.

Results for these QC tests appear in Appendix A and are discussed below. No problems were identified.

4.4.4.1 QCCS Results

QCCS results showed acceptable accuracy and repeatability for IR analyses. The results of QCCS analyses for oil and grease averaged 96 percent recovery, ranging from 89 to 99 percent. Hydrocarbon fuel QCCS results averaged 104 percent recovery, ranging from 92 to 118 percent recovery. The RSD for QCCS results was approximately 8 percent for hydrocarbon analyses and 5 percent for oil and grease analyses.

4.4.4.2 Duplicate Analyses

Duplicate analyses were performed on aliquots split from one sample before sample preparation. Oil and grease duplicate analyses showed a variability of 21 percent (about 15 percent RSD); the hydrocarbon duplicate results were identical.

4.4.4.3 Duplicate Samples

Duplicate samples collected and analyzed for oil and grease and fuel hydrocarbons were free of contamination, but provided little precision information. The only parameters detected in the duplicate sample pairs were oil and grease, reported at 1 mg/L in three of the samples in two duplicate pairs; the fourth value was below the detection limit of 1 mg/L. Duplicate sample results were also obtained for temperature, pH and conductivity; all were identical for each of the duplicate pairs.

4.4.5 Radioactivity Analyses

Standard QA/QC methods for radioanalytical work include the use of:

- Check sources and standard sources;
- Background and blank samples;
- Replicate samples and counts;
- Spiked samples; and
- Special samples and counts.

Results for these procedures are discussed below. Detailed radioanalytical QA/QC results appear in Appendix A.

According to Nuclear Regulatory Commission (NRC) regulations, the maximum concentration for quantities of unknown mixtures of radionuclides is 3×10^{-8} uCi/ml or 3×10^{-8} uCi/g for solids (i.e., 30 pCi/L or pCi/kg). Gross alpha and gross beta counts were less than 6 and 8 pCi/L, respectively, in liquid samples. Alpha and beta radiation levels in solid samples were much higher, reported at ≤12,000 pCi/kg gross alpha and ≤24,000 pCi/kg gross beta, but no blank soil radioactivity was subtracted. Natural radioactivity in soils may be this high, and without knowing the endogenous level, anthropogenic contamination is not an acceptable conclusion. For cesium-137, the concentration limit in an unrestricted area is 20,000 pCi/kg for soluble species and 40,000 pCi/kg for insoluble species. Cesium-137 gamma radiation was less than 10 pCi/kg in liquid samples and less than 50 pCi/kg in solid samples. Nuclear fission by-product contamination or radioactive fallout would be clearly evidenced by the presence of cesium-137, which is a stable, strong indicator of nonnatural radioactivity.

4.4.5.1 Check Sources and Standard Solutions

National Bureau of Standards (NBS)-traceable check sources and standard solutions are used to verify that the instrument is operating properly. Counting rates for check sources that fall outside of statistically valid ranges indicate an instrument malfunction, contamination, or improper instrument settings that need correction. Standard solutions are also used to determine efficiency factors for unique geometries and energies. The results for analysis of americium-241 and strontium-90 stock standard solutions were within acceptable limits for gross alpha and gross beta radioactivities, as were results for gamma ray standard cesium-137 in both teflon jars and Marinelli beakers.

4.4.5.2 Background and Blank Samples

Cosmic radiation and natural radioactivity associated with a detector result in a positive background rate that is usually subtracted from the measured sample activity. Increases in the background rate from historical values can indicate contamination of the detector. For samples containing natural radioactivity in addition to the radioactivity of interest, blank samples can be used for the same purpose. (Blank samples are also used in determining unknown sample net rates.) Deionized water blanks showed less than 0.4 pCi/L gross alpha and less than 0.7 pCi/L gross beta radiation. Deionized water blanks showed less than 100 pCi/kg gamma radiation for samples in teflon jars and less than 5.1 pCi/L in Marinelli beakers.

4.4.5.3 Replicate Samples and Counts

Radiochemistry and sample preparation procedures can result in variations in the activities of aliquots of the same sample. Not all of these may be corrected by chemical yield determinations. Electronic instrumentation also can cause variation in measured sample activities over time. For these reasons, replicate samples and sample counts are performed on some of the samples within an analytical batch. Replicate activities should agree within statistically determined limits. The analytical results for two duplicate sample pairs for gross alpha and gross beta radiation demonstrated acceptable replicability, with an average RSD of 8 percent for gross alpha determinations and 27 percent for gross beta. Duplicate counts performed on individual samples also demonstrated acceptable replicability, with an average RSD for duplicate gamma counts of 5 percent. Duplicate alpha and beta counts were also performed, but the radiation was too near the background level to allow estimation of analytical variability.

4.4.5.4 Spiked Samples

The ability of a detector system to accurately measure the activity of a sample should not vary with a small amount of additional "spiked" radioactivity. The detection "recovery" of the spike activity (after the subtraction of the normal sample activity) should approach 100 percent. Non-uniform dispersion of an alpha spike within the sample matrix can result in under- or over-correction due to absorption of the alpha particle within the sample mass. Spiked beta activity is less susceptible to the within-mass absorption. Samples were spiked with americium-241 for alpha activity and with strontium-90 for beta activity. Spike recoveries were 53 and 86 percent for alpha and beta activity, respectively, in a liquid sample, and 450 and 130 percent for alpha and beta activity in a solid sample. Recovery values for the liquid samples were reasonable, considering that the spike added was corrected by a factor of 15 before being used in the recovery equation. The recovery values for the solid sample are expected to be large, though closer to 100 percent for the higher energy beta activity than for alpha activity. The large alpha value is due to adsorption of the spiking solution on the surface of the sample particles, resulting in an overcorrection for adsorption.

4.4.5.5 Special Samples and Counts

EPA unknown samples and samples prepared by unique radiochemical techniques are used at various times to determine the overall precision and bias of laboratory procedures. Special samples are also used to define alpha and beta sorption by the sample matrix. Other samples are used to monitor the energy discrimination windows in an alpha/beta counter. Analysis of an EPA interlaboratory unknown standard for cesium-137 demonstrated good performance, with a theoretical "recovery" of 112 percent, well within the EPA acceptability limit for the sample.

4.4.6 Second Column Confirmation for GC Analyses

As part of the quality assurance review of these data a random sample of EPA Methods 601 and 602 analyses of water samples where organics had been reported was conducted. Table 4.4-24 summarizes the results of this review. Chromatograms for both the first column and second column analyses were obtained from the laboratory and compared. Each of the six sets of analytical results was found to have been correctly assessed and reported by the laboratory. While all of the second column results were not compared during this review, this sample population can be considered to be representative of the rest of Methods 601 and 602 analyses.

TABLE 4.4-24. SECOND COLUMN CONFIRMATION RESULTS FOR METHODS 601 AND 602

Monitor Well	Compound	First Column Result (ug/L)	First Column Analytical Date	Second Column Analytical Date	Confirmation (Yes/No)
Method 601					
P-4	trans-1,2-Dichloroethylene	328	1/31/86	2/3/86	No
HM-7	trans-1,2-Dichloroethylene	11.4	2/14/86	2/17/86	No
HM-7	Vinyl Chloride	55.6	2/14/86	2/17/86	Yes
HM-7	Methylene Chloride	2.22	2/14/86	2/17/86	Yes
HM-7	1,1-Dichloroethane	4.23	2/14/86	2/17/86	Yes
HM-7	1,2-Dichlorobenzene	16.8	2/14/86	2/17/86	Yes
P-22	Vinyl Chloride	20.4	4/15/86	4/16/86	Yes
P-22	Trichloroethylene	46.3	4/15/86	4/16/86	Yes
HM-83	Trichloroethylene	7.42	8/26/86	8/26/86	Yes
HM-83	Tetrachloroethylene	0.10	8/26/86	8/26/86	Yes
Method 602					
HM-340	Toluene	125	2/28/86	3/4/86	Yes
HM-7	Benzene	60.7	2/14/86	2/15/86	Yes
HM-7	Ethyl Benzene	585	2/14/86	2/15/86	Yes
HM-7	1,2-Dichlorobenzene	44.0	2/14/86	2/15/86	Yes

5.0 ALTERNATIVE MEASURES

This section discusses all major options for further IRP activities at AF Plant 4. It is preceded by a discussion of general considerations for further Phase II actions at AF Plant 4. The alternatives were developed after a thorough review of the data compiled from all investigations at AF Plant 4, including the current IRP Phase II Stage 1 study.

The recommendations developed in Section 6.0 are drawn directly from the alternative measures discussed in this section. The categories of alternative Phase II measures to be considered include:

- Continued monitoring of existing wells;
- Soil gas surveys;
- Soil sampling and analysis;
- Installation of additional monitor wells;
- Records search/field reconnaissance; and
- No further activities.

For those sites anticipated to require Phase IV Remedial Actions, a general, conceptual discussion of remedial options is provided. Since General Dynamics is initiating complete, plant-wide remedial action planning at the present time, the purpose of the following is to provide a limited overview, not to anticipate the results of the detailed planning that will take place.

5.1 General Considerations

Site conditions at AF Plant 4 have been extensively studied and are, in general, well known. General Dynamics has carried out extensive hydrogeologic investigations and has also initiated remedial action at many of the sites. This Phase II Stage 1 investigation was designed to complement those past and ongoing actions. Since the site investigation and remediation work sponsored by General Dynamics has also continued throughout this investigation, a detailed discussion of alternative measures is neither possible nor appropriate. In lieu of such a discussion, this section focuses on those sites where ambiguities remain or where significant findings of this study do not overlap those of General Dynamics' activities.

In anticipation of the categorization of sites in Section 6, alternative measures for sites in a given category are discussed together. As part of the IRP program, existing sites are to be grouped as:

o	Category 1	No further IRP activities (including remedial action) required;
o	Category 2	Additional Phase II effort required; or
o	Category 3	Ready for IRP Phase IV actions.

There are eight Category 1 sites, one Category 2 site and twelve Category 3 sites (three of which comprise Zone 1).

5.2 Category 1 Sites

The following sites were investigated during this and previous studies and found to currently contain little or no hazardous material. On the basis of this finding, no further action is considered or recommended. For all listed sites, sufficient monitoring points exist.

- Site 17, Former Fuel Storage Site;
- Site 2, Landfill 2;
- Site 4, Landfill 4;
- Site 6, Fire Department Training Area 3;
- Site 7, Fire Department Training Area 4;
- Site 18, Solvent Lines;
- Site 19, Nuclear Aerospace Research Facility Area; and
- Jet Engine Test Stand, Building 21.

Individual wells at the various sites, however, should continue to be considered for the plant-wide monitoring program discussed in Section 4.

5.3 Category 2 Site

Site 15, Fuel Saturation Area 2, was the only site identified for Category 2 during this investigation.

5.3.1 Additional Phase II Activities at FSA 2

Site 15, Fuel Saturation Area 2, was studied during this program, but insufficient data exist to fully characterize the nature and extent of contamination. Additional Phase II investigations are therefore recommended.

The analytical results of soil samples recovered indicate the presence of fuel contamination at this site. However, since the existing upper zone monitor wells appear to be upgradient of the site, the existence and extent of groundwater contamination remain unknown. Alternatives for this site include:

- Execution of an extensive program of soil borings and sample analysis to determine the extent of fuel contamination;
- Performance of a soil gas survey to delineate the maximum areal extent of fuel contamination; or
- Installation of up to two groundwater monitor wells downgradient (west and north) of the site, to determine the character of the upper zone groundwater exiting the site.

Either soil borings or a soil gas survey program would delineate the maximum area affected. Soil borings have the added benefit of determining geologic materials at depth, as well as contaminant concentration variations with depth. Even though the site is currently paved, the soil gas survey would likely be faster and less expensive. However, until the migration of materials away from the site is confirmed, additional site investigations appear premature. Installation of two monitor wells in the upper zone, at or near the location of the borings made for this study, is recommended.

5.3.2 Remedial Alternatives at FSA 2

Fuel Saturation Area 2 was identified as requiring additional Phase II monitoring; therefore, a requirement for any remedial action cannot yet be fully defined. Based on the limited data available, it appears that excavation and redisposal of a limited additional amount of contaminated soil would eliminate any immediate threat to the environment. This alternative would have no continuing operation and maintenance (O&M) requirements, and only standard excavation safety practices would be needed. Further investigation is needed to fully define the extent of contamination associated with this site and to verify the need for any remedial action.

5.4 Category 3 Sites

The following sites were investigated during this and previous studies and found to contain varying levels of hazardous materials. However, all these sites currently have sufficient monitoring points and existing data which fully describe the nature of the problem. Many are the subject of current or past remedial action. Further, active remedial action planning is ongoing at AF Plant 4. Therefore, these existing, well-characterized sites should be released for Phase IV planning, as appropriate.

- Site 1, Landfill 1;
- Site 3, Landfill 3;
- Site 12, Chrome Pit 3;
- Zone 1 (Sites 13, Die Pits; 11, Chrome Pit 2; and 8, FDTA 5);
- Site 20, Wastewater Collection Basins;

- Site 16, Fuel Saturation Area 3;
- Site 9, Fire Department Training Area 6;
- Site 10, Chrome Pit 1;
- Site 5, Fire Department Training Area 2; and
- Site 14, Fuel Saturation Area 1.

In addition to considering these sites for Phase IV planning, individual wells at the various sites should continue to be considered for the plant-wide monitoring program discussed in Section 4.

5.5 Remedial Alternatives

The following subsections discuss available remedial options for each of the Category 3 sites studied at AF Plant 4.

Sites 1, 3, 12, 20, 16, 9, 10, 5 and 14, as well as Zone 1 (Sites 13, 11, and 8) are recommended for release for Phase IV planning. This section presents a brief discussion of remedial action alternatives at each of the sites. Each alternative will be discussed with respect to engineering considerations, environmental effects, reliability and implementability, operation and maintenance requirements, off-site disposal needs, and safety considerations.

Two options have been identified at most of the sites. For those sites where some action has already been taken (e.g., excavation) only one additional alternative may be discussed. The no-action alternative is available for each site but has not been discussed in detail for every location. At some sites, groundwater extraction and treatment is identified as a possible option. Even though the option is discussed site by site, the actual implementation of any extraction alternative needs to consider the entire area's groundwater flow characteristics. If groundwater is to be extracted, a regional extraction field that addresses widespread contamination of the upper zone should be designed and implemented. Selection of specific treatment technologies will depend on the nature of the contaminated groundwater (kinds and amounts of contaminants to be removed) and on an assessment of treatability by various methods.

5.5.1 Site 1 - Landfill 1

Alternative 1 - Further Excavation

Even though the waste oil pits, suspected to be the main source of contamination, were excavated in 1983, other parts of the landfill were used for disposal of drums and bulk liquids. Under this alternative, these other areas would be identified, excavated, tested and disposed of off site in an appropriate, approved disposal facility. Because of the proximity of the landfill to drainageways leading to Meandering Road Creek, special care would need to be taken to prevent the introduction of contaminated run-off and soils into the creek during excavation. Temporary erosion control procedures would also be required after backfilling with clean soil until repaving of the employee parking lot had been accomplished.

Special safety measures such as supplied air and skin protection, would be required since contaminated soils would be excavated. This alternative would require no O&M after reconstruction of the employee parking lot.

This alternative could reliably remove the source(s) of contamination, but would not address contamination that has migrated beneath or off the site. Also, groundwater contamination upgradient of the landfill (HM-53, HM-20) would not be addressed by this alternative.

Alternative 2 - Water Extraction and Treatment

Implementation of this alternative would entail the installation of extraction (and possibly injection) wells. The wells and well field would be designed to extract contaminated groundwater from directly beneath and

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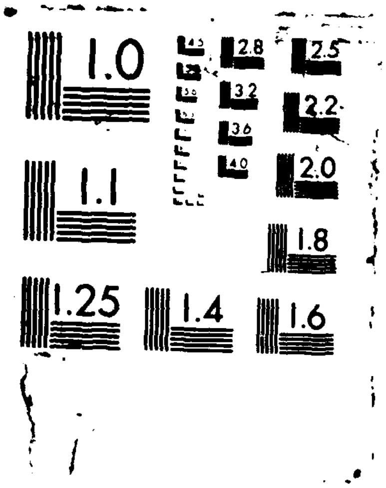
1.0
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surrounding the landfill. Injection wells may be of benefit to help mobilize contaminants for more efficient collection through the extraction wells. Groundwater quality data from this investigation have shown the highest levels of contaminants upgradient (*east*) of the landfill at HM-20 and HM-63. The extracted water would be treated before discharge or introduction to the wastewater treatment system. The proper treatment of extracted contaminated water would prevent further environmental degradation. Treatment for the organic compounds present could include carbon adsorption or possibly biological degradation in an existing domestic wastewater treatment facility.

This alternative would demand reasonably extensive O&M activity for the duration of the pumping and treatment. Only standard drilling safety procedures, including skin and respiratory protection, would be required.

With proper design of the well field, this alternative would reliably extract contaminated groundwater in the vicinity of the landfill.

5.5.2 Site 3 - Landfill 3

Alternative 1 - Excavation

This alternative would involve the excavation and redisposal of contaminated soil at an approved off-site facility. Extensive effort would be required to prevent contaminated run-off and soils from entering adjacent Meandering Road Creek during excavation. Erosion-control measures would also be required after backfilling with clean soil until revegetation has occurred.

Special safety measures such as supplied air and skin protection, would be required, especially in the vicinity of well HM-38, since contaminated soils would be excavated using this alternative. This alternative would require no O&M after revegetation was completed.

This alternative could reliably remove the source of contamination, but would not address contamination that had migrated beneath or off the site.

Alternative 2 - Water Extraction and Treatment

Implementation of this alternative would entail the installation of extraction (and possibly injection) wells, as well as an interceptor trench between the landfill and Meandering Road Creek. Since alluvium and fill materials are generally less than 10 feet thick, an interceptor trench would probably be more cost effective than extraction wells for collecting contaminated groundwater. The trench would have a membrane placed at its downgradient wall, collection pipes and sumps installed, and be backfilled.

The water collected by the trench or extracted by the well would be treated before discharge or introduction to the wastewater treatment system. The proper treatment of the extracted contaminated water would prevent further negative environmental effects. This treatment could include a process to precipitate the metals in the groundwater and carbon adsorption to remove the organic compounds present. Provisions to prevent sediment introduction to Meandering Road Creek during trench installation would be required.

This alternative would demand reasonably extensive O&M activity for the duration of the pumping and treatment. Only standard construction and drilling safety procedures, including skin and respiratory protection, would be required.

With proper design of the well field and interceptor trench, this alternative could reliably extract contaminated groundwater in the vicinity of the landfill. However, the presence of thin and low-permeability soils would result in low withdrawal rates, thereby limiting the effectiveness of this alternative.

5.5.3 Site 12 - Chrome Pit 3

Water Extraction and Treatment

Since previous excavation removed all contaminated soils, only an alternative to address existing groundwater contamination is presented. The principal groundwater contaminant at Chrome Pit 3 is TCE. Implementation of this alternative would entail the installation of extraction (and possibly injection) wells. The wells and well field would be designed to extract contaminated groundwater from beneath and in the vicinity of the pit. The extracted water would be treated before discharge or introduction to the wastewater treatment system. The proper treatment of extracted contaminated water would prevent further negative environmental impacts. This treatment could include a process to precipitate metals in the groundwater and carbon adsorption to remove the organic compounds present.

This alternative would demand reasonably extensive O&M activity for the duration of the pumping and treatment. Only standard drilling safety procedures, including skin and respiratory protection, would be required.

With proper design of the well field, this alternative would reliably extract contaminated groundwater in the vicinity of the pit.

5.5.4 Zone 1 (Site 13, Die Pits; Site 11, Chrome Pit 2; Site 8, FDTA 5)

Alternative 1 - Excavation

Soil testing is recommended to define the extent of contaminated soils. After the extent of contamination is determined this alternative would entail excavating the soil and disposing of it off site in an appropriate, approved disposal facility.

Since the ground surface in Zone 1 is flat and paved, containment of run-off and sediment during excavation and repaving should be relatively simple. Special safety measures may be required, depending on the levels of contamination encountered. These measures may include supplied air and skin protection. This alternative would require no O&M after repaving is completed.

This alternative could reliably remove the contaminated soils to the depth of excavation, but would not address contamination at greater depths.

Alternative 2 - Water Extraction and Treatment

Implementation of this alternative would entail the installation of extraction (and possibly injection) wells. The wells and well field would be designed to extract contaminated groundwater from beneath and in the vicinity of the pits and FDTA. The extracted water would be treated before discharge or introduction to the wastewater treatment system. The proper treatment of extracted contaminated water would prevent further negative environmental effects. The treatment could include a process to precipitate metals in the groundwater and carbon adsorption to remove the organic compounds present.

This alternative would demand reasonably extensive O&M activity for the duration of the pumping and treatment. Only standard drilling safety procedures, including skin and respiratory protection, would be required.

With proper design of the well field, this alternative would reliably extract contaminated groundwater in the vicinity of the pits and FDTA 5.

5.5.5 Site 20 - Wastewater Collection Basins

Water Extraction and Treatment

Since results of Phase II investigations indicate that only groundwater contamination is associated with this site, only one alternative is discussed. The basins and/or leaking drains need to be sealed. Further, a spill prevention program is needed to eliminate the opportunity for inappropriate chemicals to be introduced to the basins. Since this site is very close to and shares hydrogeologic conditions with Zone 1 sites, any remedial alternative would need to be evaluated with companion studies at Zone 1.

Implementation of this alternative would entail the installation of extraction (and possibly injection) wells. The wells and well field would be designed to extract contaminated groundwater from beneath and in the vicinity of the basins. The extracted water would be treated before discharge or introduction to the wastewater treatment system. The proper treatment of extracted contaminated water would prevent further negative environmental effects. The treatment could include a process to precipitate metals in the groundwater and carbon adsorption to remove the organic compounds present.

This alternative would have reasonably high O&M demands for the duration of the pumping and treatment. Only standard drilling safety procedures, including skin and respiratory protection, would be required.

With proper design of the well field, this alternative would reliably extract contaminated groundwater in the vicinity of the basins.

5.5.6 Site 16, Fuel Saturation Area 3

Water Extraction and Treatment

Remedial action alternatives for this site have been developed by Intellus, under contract to General Dynamics. The action presently defined by Intellus consists of the installation of extraction and injection wells to remove contaminated groundwater. The recovered groundwater would then be treated before discharge or use as make-up water.

The O&M requirements for this action would be relatively extensive. Only standard drilling safety measures, including skin and respiratory protection, would be needed.

This method of addressing contaminated groundwater uses existing technology and, if the well field is properly designed, should alleviate contamination.

5.5.7 Site 9, Fire Department Training Area 6

Alternative 1 - Excavation

Even though excavation has previously been conducted at this site, Phase II Stage 1 activities have found evidence of contaminated soil.

This alternative would entail further excavation and off-site disposal of contaminated soils at an appropriate, approved facility.

The extent of safety measures required will depend on the actual levels of contamination present, but the low concentrations of volatiles found indicate that extraordinary measures will probably not be needed. This alternative would require no O&M after revegetation is complete.

This alternative will not mitigate any effects beyond the depth of excavation.

Alternative 2 - Landfarming

This alternative would involve landfarming the near-surface soils to enhance biological degradation of the organic compounds present. Nutrients would be added and the site tilled and irrigated periodically until organic contaminant levels have been reduced to an acceptable level. However, since soil is thin to nonexistent at this site, landfarming would probably not be an effective remedial alternative.

Alternative 3 - Long-term Monitoring

Upper zone materials do not occur at this site, so no shallow groundwater is present to monitor. Paluxy monitor well P-3 is appropriately located to monitor the impact of the site, but since it is screened throughout the thickness of the aquifer, the lack of positive analytical results for samples from this well is not sufficient evidence to rule out contamination at the site. Possibly, contaminants occurring in the upper Paluxy are not being withdrawn by the well, which would draw the majority of its water from the more productive middle and lower Paluxy. The existing Paluxy monitor well will be sufficient to monitor any massive release of contaminants, but would probably not be sufficient to monitor small releases. In light of the past remedial action, which removed most of the contaminants that might have been present, the existing Paluxy well is marginally sufficient to serve as the continuing monitor well for the site.

5.5.8 Site 10 - Chrome Pit 1

Water Extraction and Treatment

Because the actual disposal pit is beneath Building No. 181, the contamination resulting from activities at this site can only be addressed by extracting contaminated groundwater and treating it before discharge.

The wells and well field would be designed to capture groundwater in the vicinity of the pit. The design of any extraction system would need to consider remedial actions contemplated at Zone 1 and the Wastewater Collection Basins. The extracted water would be treated before discharge or introduction to the wastewater treatment system. The proper treatment of extracted contaminated water would prevent further negative environmental impacts. Phase II activities identified organic contamination (i.e., trichloroethylene). This contamination could be removed using a carbon adsorption process.

This alternative would demand reasonably extensive O&M activity for the duration of pumping and treatment. Only standard drilling safety procedures, including skin and respiratory protection, would be required.

With proper design of the well field this alternative would reliably extract contaminated groundwater in the vicinity of the pit.

5.5.9 Site 5 - Fire Department Training Area 2

Alternative 1 - Excavation

If further soil testing indicates that near surface soils still contain high levels of contamination, these soils would be excavated to eliminate the source of groundwater contamination. The excavated soils would be disposed of off site at an approved facility.

This alternative would have no O&M requirements after repaving of the employee parking lot was complete. No special safety measures beyond normal excavation practices would be needed. Excavation will reliably remove contamination from the actual areas where soils is removed, but it will not benefit other areas.

Alternative 2 - Water Extraction and Treatment

Implementation of this alternative would entail the installation of extraction (and possibly injection) wells. The wells and well field would be designed to extract contaminated groundwater from beneath and in the vicinity of the FDTA.

The extracted water would be treated before discharge or introduction to the wastewater treatment system. The proper treatment of extracted contaminated water would prevent further negative environmental effects. The organic compounds present in the groundwater could be removed using a carbon adsorption process.

This alternative would demand reasonably extensive O&M activity for the duration of the pumping and treatment. Only standard drilling safety procedures, including skin and respiratory protection, would be required.

With proper design of the well field, this alternative would reliably extract contaminated groundwater in the vicinity of the FDTA.

5.5.10 Site 14 - Fuel Saturation Area 1

Water Extraction and Treatment

Intellus has developed remedial action alternatives for this site. The action presently defined by Intellus consists of the installation of extraction and injection wells and interceptor trenches to remove contaminated groundwater. The recovered groundwater would then be treated before discharge or use as make-up water.

The O&M requirements would be relatively extensive but only standard drilling and excavation safety measures, including skin and respiratory protection, would be needed.

This method of addressing contaminated groundwater uses existing technology and, if the well field and trenches are properly designed and placed, should alleviate near-surface groundwater contamination.

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6.0 RECOMMENDATIONS

This section is a consolidated discussion of all major recommendations for further IRP activities at AF Plant 4. Consideration of remedial action alternatives was discussed in Section 5, but no recommedations were made concerning preferred remedial actions.

6.1 Category 1 Sites

The following sites were investigated during this and previous studies and found to currently contain little or no hazardous material. On the basis of this finding, no further action is considered or recommended for:

- Site 17, Former Fuel Storage Site;
- Site 2, Landfill 2;
- Site 4, Landfill 4;
- Site 6, Fire Department Training Area 3;
- Site 7, Fire Department Training Area 4;
- Site 18, Solvent Lines;
- NARF Area; and
- Jet Engine Test Stand, Building 21.

Individual wells at the various sites should continue to be considered for a plant-wide monitoring program.

6.2 Category 2 Site

Site 15, Fuel Saturation Area 2, was studied during this program but insufficient data exist to fully characterize the nature and extent of contamination. Additional Phase II investigations will be required. The following actions are recommended:

- Installation of two monitor wells in the upper zone, downgradient (west and north) of the site, to determine the character of upper zone groundwater exiting the site.

6.3 Category 3 Sites

The following sites were investigated during this and previous studies and found to contain varying levels of hazardous materials. All of these well-characterized sites should be released for Phase IV planning, as appropriate. Since General Dynamics is in the process of detailed planning of remedial actions on a plant-wide basis, specific recommendations for remedial action are not presented here. General categories of remedial technologies that should be considered in the planning process are listed by site:

- Site 1, Landfill 1
  - further excavation
  - water extraction and treatment;
- Site 3, Landfill 3
  - excavation,
  - water extraction and treatment;
- Site 12, Chrome Pit 3
  - water extraction and treatment;
- Zone 1 (Sites 13, 11 and 8)
  - excavation,
  - water extraction and treatment;
- Site 20, Wastewater Collection Basin
  - water extraction and treatment;
- Site 16, Fuel Saturation Area 3
  - water extraction and treatment;
- Site 9, Fire Department Training Area 6
  - excavation,
  - landfarming,
  - long-term monitoring;
- Site 10, Chrome Pit 1
  - water extraction and treatment;
- Site 5, Fire Department Training Area 2
  - excavation,
  - water extraction and treatment; and

- Site 14, Fuel Saturation Area 1
  - water extraction and treatment

Individual wells at the various sites should also continue to be considered for a plant-wide monitoring program.

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