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FINAL RECORD OF DECISION FOR AIR FORCE PLANT 4 NAS FORT WORTH TX
7/1/1996
RUST GEOTECH

NAVAL AIR STATION
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ADMINISTRATIVE RECORD
COVER SHEET

AR File Number 301

Final

Record of Decision

Air Force Plant 4
Tarrant County, Texas

July 1996

U.S. Department of the Air Force
Headquarters Aeronautical Systems Center
Wright-Patterson Air Force Base, Ohio

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GJPO-TP-11

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Prepared by Rust Geotech under
DOE Contract No. DE-AC04-94AL96907 for the
U.S. Department of Energy
Albuquerque Operations Office
Grand Junction Projects Office

Record of Decision
Air Force Plant 4

Declaration

Statutory Preference for Treatment
as a Principal Element Is Met
and Five-Year Review Is Required

Site Name and Location

Air Force Plant 4
Tarrant County, Texas

Statement of Basis and Purpose

This decision document presents the selected remedial actions for Air Force Plant 4 in Tarrant County, Texas. The selected remedial actions were chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, 42 *United States Code* Section 9601 et seq. Selection of the remedial actions also considered the National Contingency Plan, to the extent practicable, and are based on information in the Administrative Record for Air Force Plant 4.

Assessment of the Site

Actual or threatened releases of hazardous substances from Air Force Plant 4, if not addressed by implementing the response actions selected in this Record of Decision (ROD), may present an imminent and substantial endangerment to public health, welfare, or the environment.

Description of Selected Remedies

This ROD addresses the final response actions planned for all areas of Plant 4, including soil, sediment, and groundwater. No previous RODs or decision documents have been issued for Plant 4. All of Plant 4 is considered one operable unit, but the operable unit has been divided into different areas. The baseline risk assessment conducted as part of the remedial investigation identified six areas on Plant 4 that have the potential for excess risk or risk that exceeds the lower threshold level of 1.0×10^{-6} incremental lifetime cancer risk (ILCR). These six areas are

- Landfill No. 4
- Landfill No. 3
- Meandering Road Creek
- Paluxy Aquifer and Upper Sand Groundwater
- East Parking Lot Groundwater Plume
- Building 181

Three areas—Landfill No. 4, Landfill No. 3, and Meandering Road Creek—are grouped together and considered as one area. Soil areas on Air Force Plant 4 that did not cause excess risk or exceed the lower threshold of acceptable risk were grouped together as the No Further Action Sites. The final response actions for the six areas and the No Further Action Sites are briefly described in the following sections.

Landfill No. 4, Landfill No. 3, and Meandering Road Creek

Landfill No. 4, Landfill No. 3, and Meandering Road Creek are grouped together because they have similar soil contamination problems (i.e., metals). No Action is the selected remedy for soil at Landfill No. 4 and Landfill No. 3 and for sediments in Meandering Road Creek. The selected remedy does not take any action to mitigate risk but monitors contaminant levels to ensure that the risk remains within acceptable levels for both human health and the environment. This is the final action planned. The purpose of the selected action is to ensure that risk to human health and the environment are within acceptable limits. Monitoring is the only activity included in the selected remedy. This monitoring will involve surface-water sampling in Meandering Road Creek and in Lake Worth.

The primary ecological threat is from metals contamination in the soil on or near the surface at Landfill No. 4 and Landfill No. 3 and from silver and polychlorinated biphenyls in the sediments in Meandering Road Creek and the inlet to Lake Worth. The ecological risk assessment was conducted in a conservative manner that likely overestimated the risk and no action was deemed acceptable. The primary human health risk at Landfill No. 4 is from benzo[*a*]pyrene in the soil that causes a human health risk of 1.6×10^{-6} ILCR. This risk is within the acceptable risk range of 1.0×10^{-6} to 1.0×10^{-4} ILCR.

Paluxy Aquifer and Upper Sand Groundwater

No previous actions have addressed contamination in the Paluxy aquifer. The primary threat to the Paluxy aquifer is trichloroethene (TCE) and 1,2-dichloroethene (1,2-DCE) contamination. The selected response action for the Paluxy aquifer and Upper Sand groundwater—Groundwater Extraction and Treatment With Near-Zero Off-Gas Emissions—addresses TCE and 1,2-DCE contamination and is the final action planned.

The purpose of this response action is to reduce contamination levels in the Paluxy aquifer to below regulatory levels and to prevent contamination in the Upper Sand groundwater from causing contamination in the Paluxy aquifer to exceed regulatory levels. The source of contamination in the Paluxy aquifer under Landfill No. 3 has been eliminated. The source of contamination for the Upper Sand groundwater is addressed by the selected remedy for the East Parking Lot Groundwater Plume. Cleanup levels for the Paluxy aquifer are 5.0 micrograms per liter (µg/L) for TCE, 70 µg/L for *cis*-1,2-DCE, and 100 µg/L for *trans*-1,2-DCE. Major components of the selected remedy include

- Extracting contaminated groundwater from the Paluxy aquifer near Landfill No. 3, from the Paluxy aquifer near the East Parking Lot (if contamination concentrations exceed maximum contaminant levels [MCLs]), and from the Upper Sand groundwater near the East Parking Lot. Exceedance of MCLs will be determined on a statistical basis.

- Treating the extracted groundwater with ultraviolet oxidation, or another technology with off-gas treatment that results in near-zero emissions to the atmosphere, and discharging the treated water to surface water or to a publicly owned treatment works (POTW).

- Monitoring the movement of contamination in the Paluxy aquifer and Upper Sand groundwater and installing additional monitoring wells.

Upper Sand groundwater is not used for drinking water purposes but is of concern because it is hydraulically connected to the Paluxy aquifer and is the pathway through which contamination in the East Parking Lot Plume reaches the Paluxy aquifer.

East Parking Lot Groundwater Plume

No previous RODs or decision documents have been issued concerning the East Parking Lot Groundwater Plume, located in the Terrace Alluvial flow system. The selected response action for the East Parking Lot Plume—Enhanced Dense Nonaqueous Phase Liquid (DNAPL)/ Groundwater Extraction and Treatment With Air Stripping and Destruction of Contaminants—addresses the contamination that causes excess risk in the Paluxy aquifer and is the final response action planned.

The purpose of the response action is to reduce TCE concentrations in the East Parking Lot Plume to levels that will not cause MCLs to be exceeded in the Paluxy aquifer. Cleanup goals for the East Parking Lot are 400 µg/L for TCE in the Window Area; removal of DNAPL, as demonstated by TCE concentrations of less than 10,000 µg/L; and MCLs for groundwater migrating off Air Force Plant 4 or Naval Air Station Fort Worth boundaries. The Window Area is the name given to the area under the East Parking Lot where the Terrace Alluvial flow system is hydraulically connected to the Upper Sand groundwater. Major components of the selected remedy include

- Removing DNAPL by enhanced dissolution into the groundwater and then extracting the groundwater.

- Treating the extracted groundwater with air stripping before discharging the treated water to surface water or to a POTW. Air discharged from the air stripper will be treated with an off-gas treatment system that results in near-zero emission of contaminants to the atmosphere.

- Potentially using a barrier, physical or hydraulic, to separate the Window Area of the Terrace Alluvial flow system from areas upgradient of the Window Area. Use of a barrier will depend on whether separation of the Window Area is required to meet remediation goals. Determination of whether a barrier is needed at the beginning of the remedial action will be made during remedial design.

- Initiating institutional controls to restrict future use of the Terrace Alluvial groundwater on Air Force Plant 4 and on Naval Air Station Fort Worth (located adjacent to Plant 4).

- Monitoring to track contamination movement and levels in the Terrace Alluvial flow system (includes the East Parking Lot Plume, the North Plume, and the West Plume), Meandering Road Creek, Lake Worth, and Farmers Branch Creek. Additional monitoring wells also will be installed.

- Initiating containment actions, if necessary, to prevent groundwater contamination above MCLs from migrating beyond the Air Force Plant 4 or the Naval Air Station Fort Worth boundaries.

Terrace Alluvial groundwater under Plant 4 and Naval Air Station Fort Worth is not used as a drinking water source. TCE contamination in the East Parking Lot Plume is a concern because it is the source of contamination in the Upper Sand groundwater and in the Paluxy aquifer under the East Parking Lot. The Air Force has initiated a groundwater extraction and treatment system for Terrace Alluvial groundwater in the East Parking Lot as an interim measure. This interim measure will continue operation until a final remedy is implemented for contamination in the East Parking Lot Plume.

Building 181

No previous RODs or decision documents have been issued concerning Building 181. The selected response action, Soil-Vapor Extraction, addresses the contamination under Building 181 and is the final response action planned. The purpose of the response action is to prevent the migration of TCE contamination from the vadose zone to the Terrace Alluvial groundwater that may ultimately result in exceedance of MCLs in the Paluxy aquifer. TCE in the vadose zone under Building 181 is of concern because it is a source of TCE contamination in the East Parking Lot Plume. The East Parking Lot Plume, in turn, is the source of the contamination in the Paluxy aquifer. Major components of the selected remedy include

- Using vapor-recovery wells to extract volatilized TCE.

- Removing contaminants from the extracted air before release to the atmosphere. Contaminants will be removed with an off-gas treatment technology that results in near-zero emission of contaminants to the atmosphere.

- Using vacuum-enhanced recovery wells to remove groundwater that is encountered during installation of the vapor extraction wells.

- Treating the extracted groundwater with air stripping and a near-zero off-gas emission system. Air discharged from the air stripper will be treated with an off-gas treatment system that results in near-zero emission of contaminants to the atmosphere.

- Installing soil-gas probes to monitor performance of the selected remedy. Monitoring will continue as long as remedial activities are ongoing.

The Air Force initiated a pilot-scale soil-vapor extraction system for TCE contamination in the vadose zone under this building. In March 1996, the system was modified to incorporate treatment of perched groundwater. Operation of the soil-vapor extraction system will continue as an interim measure until the final remedial action is implemented.

No Further Action Sites

No previous RODs or decision documents have been issued concerning the soil at the No Further Action Sites. No action is necessary to ensure protection of human health and the environment. The selected remedy does not include monitoring of soil contaminant levels. The soil areas included in the No Further Action Sites are

- Landfill No. 1
- Landfill No. 2
- Fire Department Training Area No. 2
- Fire Department Training Area No. 3
- Fire Department Training Area No. 4
- Fire Department Training Area No. 5
- Fire Department Training Area No. 6
- Chrome Pit No. 1
- Chrome Pit No. 2
- Chrome Pit No. 3
- Die Yard Chemical Pits
- Fuel Saturation Area No. 1
- Fuel Saturation Area No. 2
- Fuel Saturation Area No. 3
- Former Fuel Storage Area
- Solvent Lines
- Nuclear Aerospace Research Facility
- Wastewater Collection Basins
- West Compass Rose
- Jet Engine Test Stand
- Underground Storage Tank No. 19
- Underground Storage Tank No. 20
- Underground Storage Tank No. 24A
- Underground Storage Tank No. 24B
- Underground Storage Tank No. 25A
- Underground Storage Tank No. 30

Statutory Determinations

The following sections describe how the selected remedies meet the statutory requirements of Section 121 of CERCLA.

Landfill No. 4, Landfill No. 3, and Meandering Road Creek

The selected remedy, No Action, is protective of human health and the environment; complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action; and is cost effective. This remedy uses permanent solutions to the maximum extent practicable for this site. However, because treatment of the principal threats was not found to be practicable, this remedy does not satisfy the statutory preference for treatment as a principal element of the remedy. Treatment was not necessary because the risk associated with existing contamination at the site is within accepable limits. However, the selected remedy will ensure that the remediation goals are met.

Because the remedy will not result in hazardous substances remaining on site above health-based levels, a 5-year review will not be conducted.

Paluxy Aquifer and Upper Sand Groundwater

The selected remedy, Groundwater Extraction and Treatment With Near-Zero Off-Gas Emissions, is protective of human health and the environment; complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action; and is cost effective. This remedy uses permanent solutions to the maximum extent practicable for this site and satisfies the statutory preference for remedies employing treatment that reduces toxicity, mobility, or volume as a principal element.

Because the remedy will result in hazardous substances remaining on site above health-based levels, a review will be conducted within 5 years after the start of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

East Parking Lot Groundwater Plume

The selected remedy, Enhanced DNAPL/Groundwater Extraction and Treatment With Air Stripping and Destruction of Contaminants, is protective of human health and the environment; complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action; and is cost effective. This remedy uses permanent solutions to the maximum extent practicable for this site and satisfies the statutory preference for remedies employing treatment that reduces toxicity, mobility, or volume as a principal element.

Because the remedy will result in hazardous substances remaining on site above health-based levels, a review will be conducted within 5 years after the start of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

Building 181

The selected remedy, Soil-Vapor Extraction, is protective of human health and the environment; complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action; and is cost effective. This remedy uses permanent solutions to the maximum extent practicable for this site and satisfies the statutory preference for remedies employing treatment that reduces toxicity, mobility, or volume as a principal element.

The remedy is projected to remove hazardous substances remaining on site above health-based levels within 5 years after the start of remediation. Therefore, a 5-year review to ensure that the remedy continues to provide adequate protection of human health and the environment is not planned. However, if remeditation goals have not been met within 5 years after the start of remediation, a review will be conducted.

No Further Action Sites

No remedial action is necessary for the soil at the No Further Action Sites to ensure protection of human health and the environment.

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Signature

LAWRENCE P. FARRELL, JR.
Lieutenant General, USAF
Vice Commander
Air Force Materiel Command

2 Aug 96
Date

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Signature

Jane N. Saginaw
Regional Administrator, Region 6
U.S. Environmental Protection Agency

AUG 2 6 1996

Date

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7-9-96

Dan Pearson
Executive Director
Texas Natural Resource Conservation Commission

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Abbreviations, Acronyms, and Initialisms

ARAR	applicable or relevant and appropriate requirement
BAP	benzo[*a*]pyrene
BRA	baseline risk assessment
CAS	Chemical Abstracts Services
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
BAP	benzo[*a*] pyrene
CDI	chronic daily intake
COE	U.S. Army Corps of Engineers
COPC	chemical of potential concern
CP–1	Chrome Pit No. 1
CP–2	Chrome Pit No. 2
CP–3	Chrome Pit No. 3
CT	central tendency
CWA	Clean Water Act
DCA	1,1-dichloroethane
DCE	1,2-dichloroethene
DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FDTA–2	Fire Department Training Area No. 2
FDTA–3	Fire Department Training Area No. 3
FDTA–4	Fire Department Training Area No. 4
FDTA–5	Fire Department Training Area No. 5
FDTA–6	Fire Department Training Area No. 6
FFSA	Former Fuel Storage Area
FSA–1	Fuel Saturation Area No. 1
FSA–2	Fuel Saturation Area No. 2
FSA–3	Fuel Saturation Area No. 3
ft	foot
gal/min	gallons per minute
HARM	Hazard Assessment Rating Methodology
HI	Hazard Index
HQ	Hazard Quotient
ILCR	incremental lifetime cancer risk
in.	inch
IRP	Installation Restoration Program
JETS	Jet Engine Test Stand
LF–1	Landfill No. 1
LF–2	Landfill No. 2
LF–3	Landfill No. 3
LNAPL	light nonaqueous phase liquid

Abbreviations, Acronyms, and Initialisms (continued)

MCL	maximum contaminant level
MCLG	maximum contaminant level goal
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
NARF	Nuclear Aerospace Research Facility
NCP	National Contingency Plan
ND	not detected
NFA	No Further Action Site
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
O&M	operation and maintenance
OSWER	Office of Solid Waste and Emergency Response
PA/SI	Preliminary Assessment/Site Inspection
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
pCi/g	picocuries per gram
POTW	publicly owned treatment works
PRGs	preliminary remediation goals
RAB	Restoration Advisory Board
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SF	slope factor
SVOC	semivolatile organic compound
TAC	Texas Administrative Code
TCA	1,1,2-trichloroethane
TCE	trichloroethene
TNRCC	Texas Natural Resource Conservation Commission
TRC	Technical Review Committee
UST	underground storage tank
UST-19	Underground Storage Tank No. 19
UST-20	Underground Storage Tank No. 20
UST-24A	Underground Storage Tank No. 24A
UST-24B	Underground Storage Tank No. 24B
UST-25A	Underground Storage Tank No. 25A
UST-30	Underground Storage Tank No. 30
VOC	volatile organic compound
yd^3	cubic yard

1.0 Site Name, Location, and Description

Air Force Plant 4 is a government-owned, contractor-operated facility consisting of 602 acres adjacent to the northwest boundary of the city of Fort Worth (Figure 1-1) in Tarrant County, Texas. The plant is bounded on the north by Lake Worth, on the east by Naval Air Station Fort Worth (formerly known as Carswell Air Force Base), and on the south and west by the city of White Settlement. The plant has manufactured military aircraft since 1942 and is currently operated by Lockheed Martin Corporation.

The manufacturing operations and associated processes at the plant have resulted in the generation of waste oils, waste fuels, paint residues, used solvents, and process chemicals. Presently, contamination from the disposal of these wastes exists in the soil beneath the site, in the surface water, and in the groundwater.

Plant 4 and the surrounding areas to the south and east are highly urbanized and, consequently, do not contain much natural vegetation for wildlife. Approximately 70 percent of the Plant 4 surface area is covered by buildings, concrete, or asphalt. The remaining 30 percent of the surface area (the west and north portions of Plant 4) is primarily grass-covered soil. The area west-northwest of Plant 4 is mainly residential with an abundance of natural vegetation. Lake Worth provides recreational boating, fishing, and water skiing. This lake also furnishes municipal water to the city of Fort Worth and is a recharge source to the underlying Paluxy aquifer that supplies municipal water to the city of White Settlement.

Residential housing is immediately adjacent to Plant 4 on the south and west. Six schools are within a 2-mile radius of Plant 4; the closest school is 0.5 mile south of the facility. The area is accessed by two major interstate highways, I-820 from the north and south and I-30 from the east and west. Plant 4 is accessed directly from I-30 by State Highway 341. The communities of White Settlement, Lake Worth Village, Westworth Village, River Oaks, and Sansom Park Village lie within a 3-mile radius of Plant 4.

The topography of the land surrounding Plant 4 is generally flat, with the exception of areas adjacent to Meandering Road Creek and Lake Worth. Elevations at the site range from 590 feet (ft) above mean sea level along the shore of Lake Worth to approximately 670 ft above mean sea level at the southwest corner of the site. On the basis of results from a 1982 flood insurance study, neither a 100- nor a 500-year flood event will directly affect Plant 4.

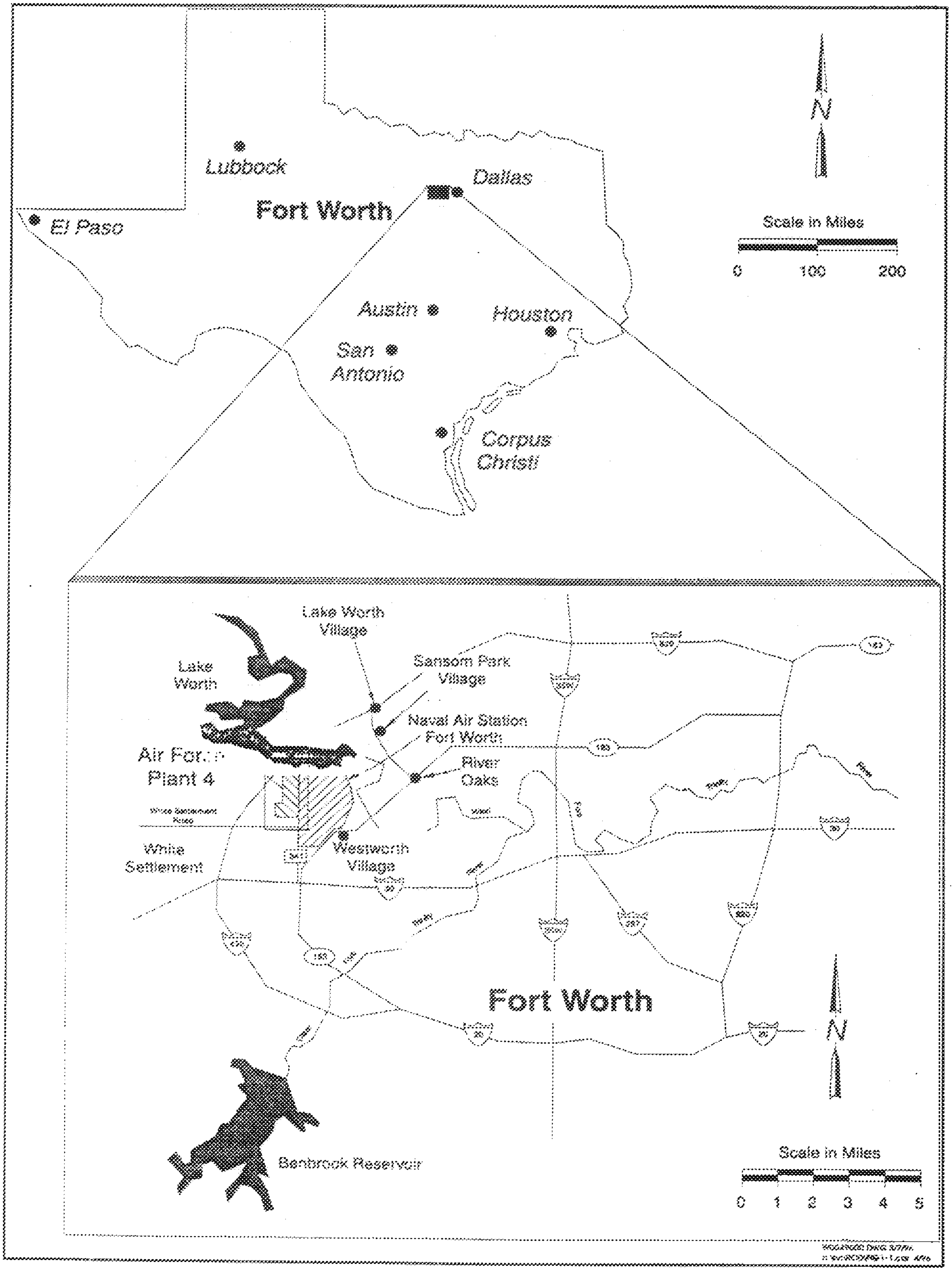

Figure 1–1. Air Force Plant 4 Location Map

2.0 Site History and Enforcement Activities

Air Force Plant 4 became operational in 1942 and began manufacturing the B-24 bomber for national defense during World War II. The facility has since produced B-36, B-58, F-111, and F-16 aircraft. In addition, Plant 4 produces spare parts, radar units, and missile components.

Waste oil, solvents, and fuels generated during the manufacturing operations were disposed of at on-site landfills or were burned in fire-training exercises during most of the plant's operation. Chemical process wastes were initially discharged to the sanitary sewer system and treated by the city of Fort Worth's treatment system. Beginning in the 1970s, chemical process wastes were treated on site at a newly constructed chemical waste-treatment system before being discharged to the sanitary sewer system. Currently, waste oils and solvents are disposed of off site; burning of these wastes on site has been discontinued. Chemical process wastes continue to be treated on site.

Potential contamination at Plant 4 was first noted by a private citizen in September 1982. General Dynamics, the contractor operating Plant 4 from 1953 to 1993, was notified and took immediate action. The source of the observed contamination was thought to be leachate from a landfill.

A Technical Review Committee (TRC) for Plant 4 was established in 1983 consisting of representatives from the U.S. Environmental Protection Agency (EPA), Region 6; the Texas Natural Resource Conservation Commission (TNRCC); the city of Fort Worth; the city of White Settlement; the U.S. Air Force; the U.S. Army Corps of Engineers (COE); U.S. Geological Survey; and Lockheed Martin, current operator of Plant 4. Periodic TRC meetings have been held since 1983 to keep the local authorities and the community informed of environmental restoration activities at Plant 4.

The TRC was converted to a Restoration Advisory Board (RAB) in 1995. The RAB brings together a diverse cross section of the community to act as a focal point for the exchange of information regarding restoration activities. The Air Force Plant 4 RAB has held monthly meetings since March 1995 and is currently meeting every other month.

2.1 CERCLA Enforcement Activities

Characterization activities have been ongoing at Plant 4 since the 1982 observance of contamination. The following Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) enforcement activities were initiated before the remedial investigation was started:

- October 1982 — General Dynamics constructed French Drain No. 1 (at Landfill No. 1) to prevent migration of contaminated groundwater toward Meandering Road Creek and to divert the flow of surface water from the outfall.

- November 1982 — Aeronautical Systems Center (formerly Aeronautical Systems Division), through General Dynamics, retained Hargis & Montgomery, Inc., to investigate the potential for groundwater contamination at Plant 4. Hargis & Montgomery and later Hargis + Associates, Inc., drilled approximately 260 soil borings, of which approximately 160 were constructed as monitoring wells.

- March 1984 — CH2M Hill, Inc., conducted a Phase I Records Search as part of the Installation Restoration Program (IRP). CH2M Hill used the U.S. Air Force's Hazard Assessment Rating Methodology (HARM) in August 1984 to rank 20 identified disposal sites.

- June 1985 — COE was contracted to further delineate groundwater conditions along the southern boundary and under the East Parking Lot area of Plant 4. COE drilled 28 soil borings and constructed 6 monitoring wells.

- September 1985 — Radian Corporation was contracted to perform the Phase II, Stage I, Confirmation/Quantification of the IRP. Radian Corporation drilled 26 soil borings and constructed 14 groundwater monitoring wells. Additional work included a confirmation sampling round of all existing monitoring wells.

- December 1985 — Intellus Corporation was contracted to conduct an IRP Phase IV Remedial Action Plan for 10 potential disposal sites and a Phase IV-A Remedial Action Plan and a Phase IV-B Design and Construction for Fuel Saturation Areas No. 1 and No. 3. In support of these tasks, Intellus Corporation drilled 36 soil borings and constructed 24 groundwater monitoring wells.

Environmental contamination identified at the facility during these site investigations resulted in Plant 4 being placed on the National Priorities List (NPL) in August 1990. Pursuant to CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, the Air Force, EPA Region 6, and TNRCC entered into a Federal Facility Agreement, in November 1990, to address environmental effects of past waste-disposal practices at Plant 4.

In October 1990, Rust Geotech, formerly known as UNC Geotech, Inc., through a Memorandum of Agreement between the U.S. Air Force and the U.S. Department of Energy (DOE), began a Preliminary Assessment/Site Inspection (PA/SI) and a Remedial Investigation/ Feasibility Study (RI/FS).

The PA/SI activities delineated possible contaminant source areas beneath the Assembly Building/Parts Plant and investigated the locations of previously removed underground storage tanks. The RI activities characterized the nature and extent of contamination at Plant 4 and assessed the potential risk to human health and the environment associated with the contamination. The FS developed remedial alternatives to address contamination that exceeded risk threshold values as calculated by the baseline risk assessment (BRA). The Plant 4 RI/FS was approved in September 1995 by EPA Region 6 and TNRCC.

The Proposed Plan was issued in November 1995. It presented outlines of the results of the remedial investigation activities, summaries of the results of the BRA and the remedial action alternatives identified in the FS, and discussions of the preferred alternatives for six sites and other areas of concern at Plant 4. The public meeting on the proposed plan was held December 14, 1995.

2.2 Interim Remedial Actions

The Air Force has implemented several interim remedial actions in an attempt to mitigate the effects [illegible] the site until final remedies [illegible]. These interim remedial actions [illegible] before completion of the BR[illegible] of results of the BRA, some o[illegible] discontinued because the contamination at that site does not present an excess risk to human health and the environment.

Landfill No. 3—Vacuum-Enhanced Extraction System

Landfill No. 3 (Figure 2–1) is a 3-acre site that has been covered with dirt and rubble and graded to its present state. It has not been covered with an engineered cap. A vacuum-enhanced extraction system has been installed at Landfill No. 3 to minimize contamination in the Terrace Alluvial groundwater that may discharge to Meandering Road Creek. Before the baseline risk assessment was completed, the Air Force installed a fence across Meandering Road Creek (near Landfill No. 3) as a precautionary measure to prevent access to the creek. Operation of the system is not required by the selected remedy for groundwater under Landfill No. 3, (i.e., the West Plume of the Terrace Alluvial flow system). However, the Air Force plans to voluntarily operate the system.

This system consists of 42 extraction wells spaced 20 ft apart and a trench 150 ft long with four extraction points. The wells and the trench are located along the western edge of Landfill No. 3. The trench was installed where the depth to the bedrock (i.e., the Walnut Formation) is shallow, approximately 4 ft.

The vacuum-enhanced extraction system was chosen for this site because of the low permeability of the aquifer in this area. The extraction wells are designed to extract contaminated groundwater using a drop tube inside the well casing and also to extract volatile organic compounds (VOCs) in the vadose zone with a vacuum applied to the well. Treatment of the extracted groundwater will be with an air stripper or ultraviolet oxidation. If an air stripper is used, the contaminants in the air will be treated with vapor-phase carbon adsorption or catalytic oxidation before discharge from the unit. The vapor extracted from the wells will be treated with an off-gas treatment system that results in near-zero emission of contaminants to the atmosphere.

French Drains No. 1 and No. 2

French Drains No. 1 and No. 2 were installed to mitigate contamination related to Landfill No. 1 (Figure 2–1). French Drain No. 1 was installed in November 1982 in response to complaints of odors coming from Stormwater Outfall No. 5, which drains into Meandering Road Creek. The

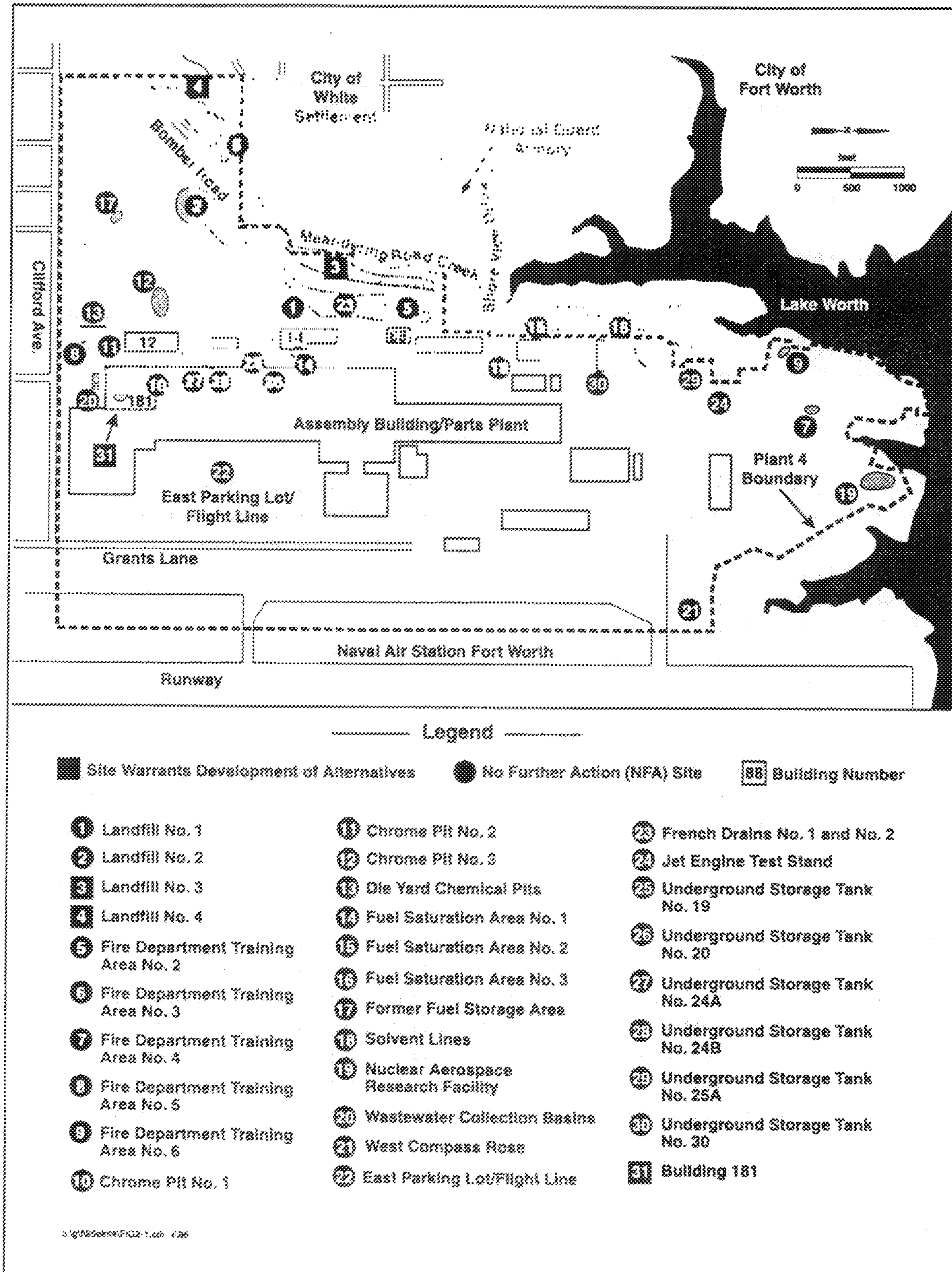

Figure 2-1. Air Force Plant 4 Sites and Areas of Concern

French drain system consists of 90 ft of perforated 4-inch (in.) drain pipe. The pipe is placed on bedrock east of Stormwater Outfall No. 5. Two 6-in. perforated pipes that were found during excavation, installed before the parking lot was paved in 1967, were connected to the French drain system. French Drain No. 2 was installed in 1983 in the area of the former waste oil pits.

This area was excavated to bedrock, and six 24-in. drainlines were placed in the bottom of the excavation and were connected to a collector box.

Before French Drain No. 2 was installed, French Drain No. 1 was evacuated daily. Initially, the evacuated water was disposed of by deep-well injection at an off-site location; later, the disposal method was incineration. After operation of French Drain No. 2 began, groundwater collected from French Drain No. 1 was diverted to the sanitary sewer. Evacuation to the sanitary sewer was no longer considered feasible after May 1990, and these drains remained inactive until October 1992 when the evacuated groundwater was treated at Fuel Saturation Area No. 1 (FSA-1).

Building 181—Soil-Vapor Extraction System

A pilot-scale soil-vapor extraction system was installed at Building 181 (Figure 2–1) and began operation in December 1993 to extract trichloroethene (TCE) contamination from the vadose zone under the building. The presence of TCE in the vadose zone under Building 181 is the result of spills and leaks from TCE tanks in that building. Some of the TCE contamination in the vadose zone migrates down to the Terrace Alluvial groundwater and has the potential to work its way to the Paluxy aquifer through the Window Area in the East Parking Lot. Accurate information is not available on the total amount of TCE that has spilled or leaked from the tanks, how much TCE is in the vadose zone, and how much TCE is in the Terrace Alluvial groundwater.

A pilot-scale test was run with the objectives to remove as much TCE from the subsurface as possible within the time period of the test, 90 days, and to develop pilot-test parameters necessary to evaluate the applicability of a full-scale soil-vapor extraction system. The pilot-scale soil-vapor extraction system used eight extraction wells to withdraw TCE from the soil. The extracted vapor was treated with carbon adsorption after condensate removal.

During the 90-day test, approximately 4,400 pounds (367 gallons) of TCE was extracted from the vadose zone, as measured by carbon vessel removal. A full-scale soil-vapor extraction system is the selected alternative for Building 181. In March 1996, the system was modified to incorporate treatment of groundwater from three groundwater extraction wells. Recovered groundwater is being treated with an air stripper. The soil-vapor extraction system has been expanded to include three vacuum-enhanced pumping wells and will continue to operate until the final remedy can be implemented.

East Parking Lot—Groundwater Treatment System

Air Force Plant 4 installed a groundwater extraction and treatment system for Terrace Alluvial groundwater in the Window Area of the East Parking Lot (Figure 5–3 in Section 5.0) in January 1993 and continues to operate that system. This system includes extraction wells, a treatment system, and piping to convey the extracted groundwater to the treatment system. The treatment system consists of an equalization tank, an air stripper, and carbon adsorption units used as a polishing step for the treated groundwater. Treated water is discharged to the sanitary sewer system. TCE concentrations in samples obtained at the influent to the treatment system have ranged from approximately 10,000 to 20,000 micrograms per liter (µg/L).

Contamination in the East Parking Lot Plume is the source of contamination in the Paluxy aquifer because the Terrace Alluvial flow system and the Upper Sand groundwater are hydraulically connected through the Window Area. The BRA determined that TCE contamination in the Paluxy aquifer will exceed human health risk threshold values if the domestic drinking water wells are affected by this contaminant in the future. The Air Force will continue to operate the groundwater extraction system until the final remedy for the East Parking Lot is implemented.

Fuel Saturation Area No. 1 (FSA–1)—Groundwater Treatment System

The Air Force implemented a groundwater treatment system at FSA–1 (Figure 2–1) that has operated intermittently since it was installed in 1992. This site was contaminated by fuels leaking from an underground distribution system and three leaking underground storage tanks (USTs). The system at FSA–1 is designed to extract groundwater and fuel floating on the groundwater and then treat the extracted fuel or groundwater. It has a design capacity of 70 gallons per minute (gal/min) and consists of an oil/water separator, an air stripper, and carbon adsorption units. Groundwater is recovered from two extraction wells. Groundwater evacuated from French Drains No. 1 and No. 2 also was treated at FSA–1.

The Air Force has also tested a pilot-scale bioventing system at FSA–1. The bioventing system is designed to enhance natural biodegradation of fuel-related hydrocarbons by supplying oxygen to the subsurface. The system, which is fairly simple, includes vent wells where the oxygen is injected into the subsurface, monitoring points, and a blower to force oxygen into the vent wells.

The BRA determined that contaminant levels in the soil and groundwater near FSA–1 do not cause excess risk to human health or the environment because there is no exposure pathway. Because there is no excess risk, remedial action in this area is not required.

Fuel Saturation Area No. 3 (FSA–3)—Groundwater Treatment System

The Air Force implemented a groundwater treatment system at FSA–3 (Figure 2–1) that has operated intermittently since it was installed in 1992. This site was contaminated by fuels leaking from an underground distribution system and one leaking UST. The system at FSA–3 is designed to extract groundwater and fuel on the groundwater and then treat the extracted fuel or groundwater. It has a design capacity of 20 gal/min and consists of an oil/water separator, an air stripper, and carbon adsorption units. Groundwater is recovered from two extraction wells.

The Air Force has also tested a pilot-scale bioventing system at FSA-3 that is similar to the system at FSA-1.

The BRA determined that contaminant levels in the soil and groundwater near FSA-3 do not cause excess risk to human health or the environment because there is no exposure pathway. Because there is no excess risk, remedial action in this area is not required. Therefore, the Air Force does not plan to continue operation of the groundwater treatment system or the bioventing system.

Naval Air Station Fort Worth Landfills No. 4 and No. 5—Groundwater Treatment System

The Air Force implemented a groundwater extraction and treatment system located immediately downgradient of Landfills No. 4 and No. 5 on Naval Air Station Fort Worth (Figure 5-3 in Section 5.0). Although the site is located on Naval Air Station Fort Worth, Air Force Plant 4 undertook this action because contamination from the East Parking Lot Plume has migrated onto Naval Air Station Fort Worth. Upgradient of Landfills No. 4 and No. 5, the TCE plume is caused entirely by contamination originating at Air Force Plant 4. TCE concentrations are higher downgradient of the landfills than they are upgradient of the landfills. This increase in TCE concentrations indicates that contamination in the landfills is responsible for a portion of the downgradient TCE plume. Dissolved TCE concentrations in samples obtained from extraction wells range from 300 to 4,000 µg/L, averaging around 1,500 µg/L at the influent to the treatment system.

The dissolved TCE in the groundwater discharges to surface water, causing TCE contamination in surface waters on Naval Air Station Fort Worth. However, the BRA determined that present levels of TCE in surface waters on Naval Air Station Fort Worth do not cause excess human health or ecological risk. Also, the selected alternative for the East Parking Lot Plume will reduce TCE concentrations in the groundwater, resulting in reduced TCE concentrations in surface waters on Naval Air Station Fort Worth.

The Air Force does not plan to continue operation of the groundwater treatment system on Naval Air Station Fort Worth but may operate the system as a corrective measure if remediation goals are not being met. Section 9.4, "The Selected Remedy," discusses the conditions under which a corrective measure may be needed.

No Further Action Sites

Contaminated soil was removed from several of the No Further Action Sites and was taken to an off-site location. These actions were completed before Air Force Plant 4 was placed on the National Priorities List. The selected remedy for soil at the No Further Action Sites is No Action. The No Further Action Sites are described in Section 5.5 under "No Further Action Sites."

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3.0 Highlights of Community Participation

In March 1995, the Air Force Plant 4 Restoration Advisory Board (RAB) was set up as a forum for exchange of information on environmental issues at Plant 4. This board is designed to identify and to educate interested citizens on how they can become active participants in the decision-making process during cleanup.

The RAB is composed of local citizens and a community cochairperson and meets every other month at the White Settlement Senior Services Center. The public is invited to all meetings as well as regulators, Plant 4 personnel, Air Force representatives, contractors, and news media representatives. The RAB charter was accepted at the November 1995 meeting.

The RI and FS for Air Force Plant 4 were released to the public in September 1995, including members of the RAB. The Proposed Plan was released to the public in November 1995. These three documents were made available to the public in the Administrative Record maintained at the White Settlement Public Library.

The public comment period for the Proposed Plan was held from November 22, 1995, through January 22, 1996. A public meeting on the Proposed Plan was held on December 14, 1995. Representatives from the Air Force, EPA, TNRCC, Rust Geotech, other site contractors, and government support agencies attended this meeting and answered questions about problems at the site and the remedial alternatives under consideration. Responses to comments received at the public meeting and during the public meeting are included in Appendix A, "Responsiveness Summary," of this Record of Decision (ROD).

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4.0 Scope and Role of Response Actions

This ROD addresses the final response actions planned for all areas of Plant 4. No previous RODs or decision documents have been issued for Plant 4. All of Plant 4 is considered one operable unit; however, the operable unit has been divided into different areas. The BRA that was conducted as part of the RI identified six areas on Plant 4 that have the potential for excess risk or risk that exceeds the lower threshold of the allowable risk range. The final response actions for these six areas and other areas that did not cause excess risk are defined in this ROD.

The six areas that have the potential to cause excess risk are

- Contamination in the soil at Landfill No. 4, based on the potential for excess ecological risk and human health risk that exceeded the lower threshold of the allowable risk range.
- Contamination in the soil at Landfill No. 3, based on the potential for excess ecological risk.
- Contamination in the sediments in Meandering Road Creek and in the inlet of Meandering Road Creek to Lake Worth, based on the potential for excess ecological risk.
- Contamination in the Paluxy aquifer and Upper Sand groundwater, based on excess human health risk.
- Contamination in the East Parking Lot Groundwater Plume, based on excess human health risk.
- Contamination in soil in the vadose zone under Building 181, based on excess human health risk.

Areas with soil contamination that did not cause excess risk, either human health or ecological risk, are grouped together as No Further Action Sites. These sites are

- Landfill No. 1
- Landfill No. 2
- Fire Department Training Area No. 2
- Fire Department Training Area No. 3
- Fire Department Training Area No. 4
- Fire Department Training Area No. 5
- Fire Department Training Area No. 6

- Chrome Pit No. 1
- Chrome Pit No. 2
- Chrome Pit No. 3
- Die Yard Chemical Pits
- Fuel Saturation Area No. 1
- Fuel Saturation Area No. 2
- Fuel Saturation Area No. 3
- Former Fuel Storage Area
- Solvent Lines
- Nuclear Aerospace Research Facility
- Wastewater Collection Basins
- West Compass Rose
- Jet Engine Test Stand
- Underground Storage Tank No. 19
- Underground Storage Tank No. 20
- Underground Storage Tank No. 24A
- Underground Storage Tank No. 24B
- Underground Storage Tank No. 25A
- Underground Storage Tank No. 30

4.1 Landfill No. 4, Landfill No. 3, and Meandering Road Creek Soils and Sediments

Landfill No. 4, Landfill No. 3, and Meandering Road Creek are grouped together because they have similar contamination problems. The primary threat at Landfill No. 4 is from metals contamination on or near the surface. Concentrations of arsenic, cadmium, and copper have the potential to cause excess risk to terrestrial prey species (e.g., mice). Contamination in the soil at

Landfill No. 4 also caused a human health risk of 1.6×10^{-6} incremental lifetime cancer risk (ILCR). This risk is within the acceptable risk range of 1.0×10^{-6} to 1.0×10^{-4} ILCR, but exceeds the lower limit of the risk range. The contaminant causing the human health risk is benzo[*a*]pyrene (BAP).

Concentrations of copper, lead, and zinc at Landfill No. 3 also have the potential to cause excess risk to mice. The contaminant silver, found in the sediments of Meandering Road Creek and the inlet to Lake Worth, has the potential to cause excess risk to aquatic prey species (e.g., minnows and aquatic organisms living in the sediments). It also was determined that Aroclor-1254 (a polychlorinated biphenyl [PCB] compound) detected in the sediments in the inlet where Meandering Road Creek enters Lake Worth has the potential to cause excess risk to largemouth bass.

The selected action, No Action, for Landfill No. 4, Landfill No. 3, and Meandering Road Creek manages the risk to acceptable levels for both human health and the environment and is the final action planned. The goal of the selected action is to ensure risks to human health and the environment are within acceptable limits. Remediation goals for Landfill No. 4, Landfill No. 3, and Meandering Road Creek are presented in Section 7.0.

4.2 Paluxy Aquifer and Upper Sand Groundwater

No previous actions have addressed contamination in the Paluxy aquifer. The primary threat to the Paluxy aquifer is TCE and 1,2-dichloroethene (1,2-DCE) contamination. Both TCE and 1,2-DCE are at concentrations in the Paluxy aquifer above the maximum contaminant levels (MCLs). TCE contamination in the Paluxy aquifer could cause a future human health risk that is above the upper limit of the acceptable risk range (1.0×10^{-4} ILCR).

TCE and 1,2-DCE contamination is also present in the Upper Sand groundwater. This groundwater is not used for drinking water purposes but is of concern because it is hydraulically connected to the Paluxy aquifer and is the pathway through which contamination in the East Parking Lot Plume reaches the Paluxy aquifer.

The selected response action of Groundwater Extraction and Treatment With Near-Zero Off-Gas Emissions for the Paluxy aquifer and the Upper Sand groundwater addresses TCE and 1,2-DCE contamination and is the final action planned. The purpose of this response action is to reduce contamination levels in the Paluxy aquifer to below regulatory levels and to keep contamination in the Upper Sand groundwater from causing contamination in the Paluxy aquifer above remediation goals. Remediation goals for the Paluxy aquifer and the Upper Sand groundwater are presented in Section 8.0.

4.3 East Parking Lot Groundwater Plume

The Air Force has initiated a groundwater extraction and treatment system in the East Parking Lot as an interim measure for the Terrace Alluvial groundwater. This interim measure will continue operation until a final remedy is implemented for the contamination in the East Parking Lot Plume.

Terrace Alluvial groundwater under Plant 4 and Naval Air Station Fort Worth is not used as a drinking water source. However, TCE contamination in the East Parking Lot Plume is the source of contamination in the Upper Sand groundwater and in the Paluxy aquifer under the East Parking Lot.

The selected response action of Enhanced DNAPL/Groundwater Extraction and Treatment With Air Stripping and Destruction of Contaminants for the East Parking Lot Plume addresses the contamination that causes excess risk in the Paluxy aquifer and is the final response action planned. The purpose of the response action is to reduce TCE concentrations in the East Parking Lot Plume so contamination that reaches the Upper Sand groundwater will not exceed allowable levels and, therefore, will not cause MCLs to be exceeded in the Paluxy aquifer. Remediation goals for the East Parking Lot Plume are presented in Section 9.0.

4.4 Building 181

The Air Force has initiated a pilot-scale soil-vapor extraction system for TCE contamination in the vadose zone under Building 181. Operation of the pilot-scale system is being continued as an interim measure until the final remedial action is implemented.

TCE in the vadose zone under Building 181 is of concern because it is a source of TCE contamination in the East Parking Lot Plume, which is the source of contamination in the Paluxy aquifer. The selected response action of Soil-Vapor Extraction addresses the contamination under Building 181 and is the final response action planned. The purpose of the response action is to prevent TCE contamination in the vadose zone from exceeding allowable levels in the Terrace Alluvial groundwater. Remediation goals for Building 181 are presented in Section 10.0.

4.5 No Further Action Sites

No action is the selected remedy for soil at the No Further Action Sites. No action is necessary because the concentrations of contaminants in the soil do not cause excess human health risk or excess ecological risk. No monitoring of contamination levels in the soil is required for the selected remedy.

5.0 Summary of Site Characteristics

5.1 Climatic Conditions

The climate at Plant 4 is typified by hot summers and cool, dry winters. Mean annual precipitation is 31.6 inches, with some precipitation occurring every month. Precipitation typically consists of a mixture of rain and snow during the late fall and winter months. Snowfall amounts are generally greatest in January and February, when average snowfalls of 1 in. can be expected. Although average snowfall amounts are typically low, snowfall amounts to 12 in. during 1 month have been recorded.

During most of the year, the predominant wind direction is from the south. During the winter months (i.e., December through February), the predominant wind direction is from the north. Constant winds with an average speed of 7 knots are typical year round. The average cloud cover in the area is 50 percent. Average relative humidity values range from 57 percent in July and August to 70 percent in May. Average relative humidity is 63 percent; the area has a mean annual temperature of 66 °F.

5.2 Geology

Geologic units of concern at the site include fill material, alluvium, terrace deposits, Goodland Limestone, the Walnut Formation, and the Paluxy Formation. The following sections describe the physical characteristics and thickness of each of these units in the vicinity of Plant 4.

Alluvial Deposits

Unconsolidated terrace and alluvial deposits are present at ground surface across much of Plant 4. These deposits consist of interbedded clay, silt, sand, and gravel. The terrace alluvium varies in thickness from several feet to 60 ft, reflecting the presence of hills and valleys in the underlying bedrock surface. On the west and north sides of Plant 4, the terrace alluvial deposits were excavated and replaced with the fill material now present in Landfill Nos. 1 through 4 and in various waste pits.

Goodland Limestone and Walnut Formation

Limestone bedrock of the Goodland Limestone and the Walnut Formation underlies the terrace alluvial deposits. The limestone has eroded to varying degrees, but averages approximately 25 to 35 ft thick. One area where the limestone aquitard is eroded or thin is known as the "Window Area." The Window Area is in the vicinity of the East Parking Lot.

Paluxy Formation

The Paluxy Formation underlies the limestone deposits and averages approximately 170 to 180 ft thick. It consists predominantly of fine-grained sandstone with several thin interbeds of shale. In the vicinity of the East Parking Lot, the uppermost 5 to 10 ft of the Paluxy Formation is characterized by layers of sandstone, shale, siltstone, and claystone. These characteristics of the uppermost portion of the Paluxy Formation beneath the East Parking Lot, referred to as the Upper Sand, are not found in the rest of the Plant 4 area. Figure 5–1 is a conceptual model of the geology and groundwater areas for Plant 4.

5.3 Groundwater

As noted in the preceding section, three distinct types of subsurface material are of interest beneath Air Force Plant 4, specifically, the terrace alluvium, the limestone aquitard (includes the Goodland Limestone and Walnut Formation), and the Paluxy Formation. Groundwater is present in the terrace alluvium and in the Paluxy Formation. Figure 5–1 is a schematic showing the water-bearing zones in the terrace alluvium and in the Paluxy Formation.

Terrace Alluvial Flow System

The water-bearing or saturated portion of the terrace alluvium is referred to as the Terrace Alluvial flow system. Most of the groundwater contamination at Plant 4 occurs in the Terrace Alluvial flow system. Because the natural water quality of the Terrace Alluvial groundwater is generally poor and because sustainable withdrawal rates are often small, Terrace Alluvial groundwater is not used as a water supply in the Plant 4 area. Instead, wells are drilled into underlying groundwater systems such as the Paluxy or Twin Mountains Formations.

Groundwater in the Terrace Alluvial flow system is separated from groundwater in the deeper Paluxy Formation by the Goodland Limestone and the Walnut Formation. The limestone rock of these two formations does not easily transmit water and behaves as an aquitard that serves to restrict the downward flow of water from the terrace alluvium to the Paluxy Formation.

Natural recharge to the Terrace Alluvial flow system in the vicinity of Plant 4 occurs through direct infiltration of precipitation and surface runoff. Extensive paved areas and buildings restrict natural infiltration of precipitation over much of the Plant 4 site. In addition, recharge occurs as leakage from Plant 4 pipe systems (including water-supply lines, fire-fighting pipe systems, and cooling-water systems) and storm sewers. This recharge influences the direction and rate of contaminant transport and contributes to the dilution of groundwater contamination.

Discharge from the Terrace Alluvial flow system occurs primarily as seeps into Meandering Road Creek, base flow into Farmers Branch Creek (which flows into the West Fork of the Trinity River), and as vertical leakage through the aquitard into the Paluxy Formation.

Discharge through the aquitard into the Paluxy Formation is generally confined to a localized area under the East Parking Lot where the limestone rock of the aquitard is relatively thin. In this area, referred to as the Window Area (Figure 5–1), groundwater drains slowly from the bottom of the Terrace Alluvial flow system, passes vertically through the thin section of the limestone aquitard, and enters the Upper Sand portion of the Paluxy Formation.

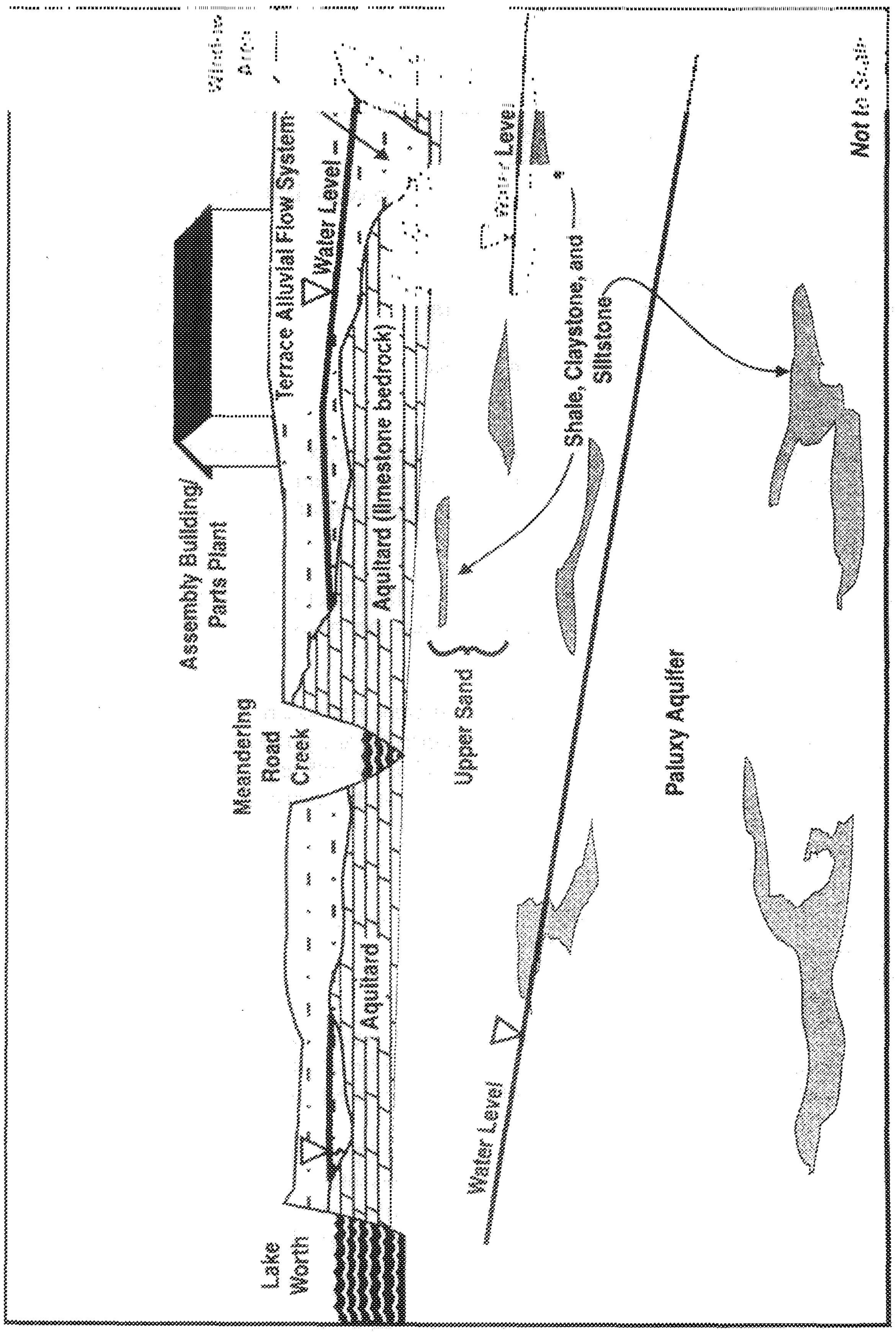

Figure 5-1. Air Force Plant 4 Geology and Groundwater Areas

Paluxy Formation

The Paluxy aquifer is the continuously saturated portion of the Paluxy Formation. In the Plant 4 area, the Paluxy Formation is approximately 170 to 180 ft thick. The upper 10 to 20 ft of the formation is generally unsaturated; the lower 150 to 160 ft of the formation is continuously saturated and constitutes the Paluxy aquifer.

In the vicinity of the East Parking Lot, the uppermost portion of the Paluxy Formation is composed of low-permeability rock that is recharged by groundwater seeping through the aquitard from the overlying Terrace Alluvial flow system. This setting has produced a localized area beneath the East Parking Lot in which the uppermost portion of the Paluxy Formation is variably saturated. This localized, variably saturated portion of the Paluxy Formation is referred to as the Upper Sand. Groundwater in the Upper S[illegible]n groundwater in the Paluxy aquifer by approximately 10 ft of unsaturat[illegible] sandstone and shale (Figure 5-1).

Natural recharge to the Paluxy aquifer occurs as infiltration of precipitation falling on formation outcrops north and west of Plant 4 and as infiltration of water from the south and east portions of Lake Worth. Limited additional recharge occurs as infiltration of water from streams flowing across exposed sections of the formation.

Discharges from the Paluxy aquifer include withdrawals from private and municipal wells and base flow to streams during dry periods. Discharge also occurs as seepage into Lake Worth along the northwest portion of the lake.

Groundwater flow in the Paluxy aquifer is generally from west to east, reflecting the effect of large groundwater withdrawals for municipal, commercial, and private use in the vicinity of east Fort Worth and Dallas. Near Plant 4, recharge from Lake Worth and pumping from White Settlement wells has produced flow directions directed to the southeast.

5.4 Surface Water

The primary surface water features at Plant 4 include Meandering Road Creek, Lake Worth, and Farmers Branch Creek. Farmers Branch Creek is on Naval Air Station Fort Worth but was included in the Plant 4 remedial investigation.

Meandering Road Creek borders Plant 4 to the west and flows north to Lake Worth. Stream flow in Meandering Road Creek is intermittent and is derived from rainfall runoff. Groundwater from the Terrace Alluvial flow system also contributes to flow in Meandering Road Creek.

Farmers Branch Creek originates in White Settlement and flows easterly across the southern portion of Naval Air Station Fort Worth and then empties into the West Fork of the Trinity River. Farmers Branch Creek also flows intermittently and derives most of its flow from rainwater runoff, with some contribution from groundwater in the Terrace Alluvial flow system.

Lake Worth borders Plant 4 to the north. An inlet from Lake Worth that connects with Meandering Road Creek also borders the northwest portion of Plant 4. The lake was constructed in 1914 as a municipal water supply for the city of Fort Worth

5.5 Sources and Characteristics of Contamination

Soil and Sediment

During the remedial investigation, approximately 2,500 soil and sediment samples were collected between February 1991 and May 1992 at various sites to assess potential effects of past operations. The following sites were identified as having contaminant concentrations that potentially pose an excess risk to human health or the environment or exceed the lower threshold of the acceptable risk range: (1) soil associated with Landfills No. 3 and No. 4, (2) sediment along Meandering Road Creek and the inlet of Meandering Road Creek to Lake Worth, and (3) soil under Building 181. The remaining sites on Plant 4 are discussed in the "No Further Action Sites" section. Figure 2-1 shows the locations of areas investigated at Plant 4.

Landfill No. 3

Landfill No. 3, located along the western boundary of Plant 4 adjacent to Meandering Road Creek, is a grass-covered area approximately 3 acres in size (Figure 5-2). The landfill is presently enclosed by a chainlink fence. Miscellaneous wastes, including mixed oils and solvents, were discarded at this site from 1942 to 1945; the landfill was inactive from 1945 to 1966. Dirt and rubble were used to fill and grade the landfill during 1966 and 1967.

Fifty-six soil samples were collected at 2-ft intervals from depths to 19.3 ft, in 16 soil borings drilled in Landfill No. 3. The ranges of concentrations for key chemicals of potential concern (COPCs) detected in samples from Landfill No. 3 are

- TCE (not detected [ND]–19 milligram per kilogram [mg/kg])
- Cadmium (ND–96.2 mg/kg)
- Copper (ND–5,590 mg/kg)
- Lead (2–10,400 mg/kg)
- Zinc (3.8–17,400 mg/kg)

The highest metal concentrations were detected in samples collected on the western edge of the landfill and east of Meandering Road Creek. The two Landfill No. 3 samples shown on Figure 5-2 (CS-005 and CS-007) are the only two samples with concentrations of metals high enough to potentially cause excess ecological risk. The highest concentrations of the other constituents were reported for samples collected in historic drainage ditches that have been filled.

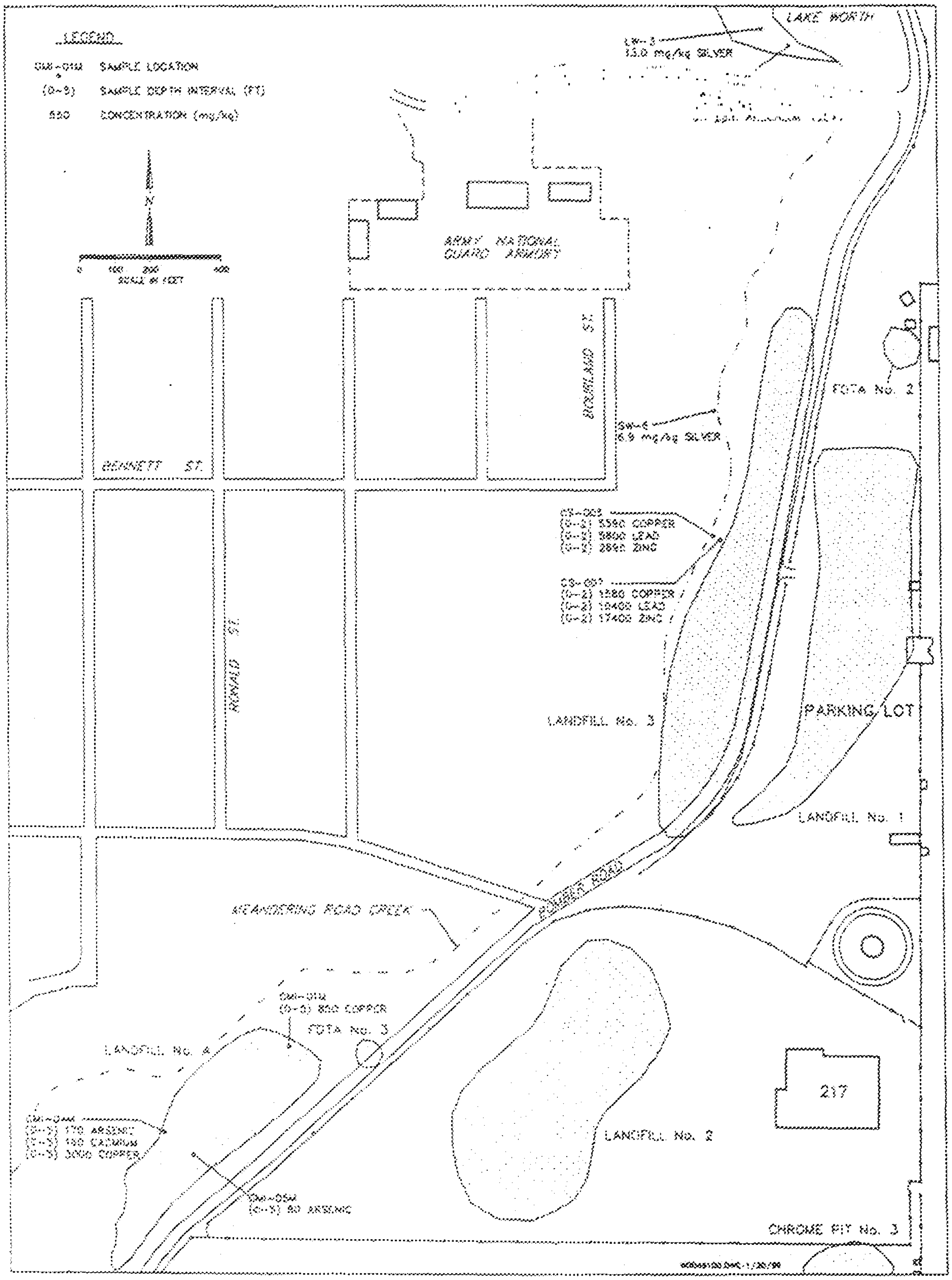

Figure 5–2. Contamination That May Cause Excess Ecological Risk at Air Force Plant 4

Landfill No. 4

Landfill No. 4, located near the southwest boundary of the Plant 4 facility, occupies approximately 2 acres of land between Bomber Road (sometimes referred to as Meandering Road) and Meandering Road Creek (Figure 5–2). Landfill No. 4 is grass covered but is not capped with an engineered cap. This landfill was used for disposal of construction rubble from 1956 to the early 1980s. Other types of wastes may have been disposed there between 1966 and 1973. These wastes are thought to have included small quantities of solvents, oils, fuels, and thinners.

Soil borings were drilled to bedrock and samples were collected at 2-ft intervals in Landfill No. 4. The highest concentrations of metals and semivolatile organic compounds (SVOCs) were detected in samples collected along the western shoulder of the landfill. The three Landfill No. 4 samples shown on Figure 5–2 (GMI–01M, GMI–04M, and GMI–05M) are the only samples near the surface with metals concentrations high enough to potentially cause excess ecological risk. The ranges of concentrations for key COPCs detected in all samples from Landfill No. 4 are

- TCE (ND–0.03 mg/kg)
- Benzo[*a*]pyrene (ND–13 mg/kg)
- Arsenic (2.4–170 mg/kg)
- Cadmium (ND–160 mg/kg)
- Copper (ND–3,200 mg/kg)
- Zinc (4.6–12,200 mg/kg)

Meandering Road Creek and Lake Worth

Sediment samples were collected at seven locations along Meandering Road Creek. The ranges of concentrations for key COPCs detected in samples of Meandering Road Creek sediments are

- Arsenic (3.1–6.1 mg/kg)
- Cadmium (ND–2.4 mg/kg)
- Copper (13.4–17.8 mg/kg)
- Lead (10–77.4 mg/kg)
- Silver (ND–6.9 mg/kg)
- Zinc (17.8–87 mg/kg)

Twenty-five Lake Worth sediment samples were collected offshore north of Plant 4, in a cove at the northwest corner of Plant 4, and in the inlet that connects to Meandering Road Creek. Several organic compounds, including TCE, were detected in seven sediment samples at concentrations less than 1.0 mg/kg. SVOCs were detected at concentrations between 1.3 and 7.9 mg/kg. In addition, two PCB compounds, Aroclor-1254 and Aroclor-1260, were detected in two sediment samples at concentrations of 0.1 and 0.11 mg/kg, respectively. The three Meandering Road Creek and Lake Worth samples on Figure 5–2 (SW–6, LW–2, and LW–3) are the only samples with concentrations high enough to potentially cause excess risk. The ranges of concentrations for key metal COPCs detected in samples of Lake Worth sediments are

- Arsenic (3.5–6 mg/kg)
- Cadmium (0.4–11.4 mg/kg)
- Copper (8.5–88.4 mg/kg)
- Lead (8–444 mg/kg)
- Silver (ND–13 mg/kg)
- Zinc (21.9–303 mg/kg)

Building 181

The Assembly Building/Parts Plant is a mile-long building located in the approximate center of Plant 4 (Figure 2–1). Building 181, the Chemical Process Facility, is part of the Assembly Building/Parts Plant. Past spills of TCE have reportedly occurred within the Chemical Process Facility. Trenches, sumps, floor drains, and buried pipelines are present throughout this manufacturing facility and are possible pathways for soil contamination under this building.

The key COPC at Building 181 is TCE. The presence of this organic compound was detected at concentrations ranging from ND to 0.22 mg/kg in samples collected from 35 soil borings drilled to depths of approximately 59 ft near the perimeter of Building 181. However, soils saturated with TCE were found during the installation of a soil-vapor extraction system under Building 181. No analyses were performed on these saturated soils. TCE in the soil under Building 181 is the main source of TCE contamination in the East Parking Lot Plume.

Groundwater

Terrace Alluvial Flow System

The three flow directions within the Terrace Alluvial flow system beneath the Assembly Building/Parts Plant have resulted in three separate plumes with organic constituents. These plumes are (1) the East Parking Lot Plume, (2) the West Plume, and (3) the North Plume (Figure 5–3). Thirty-seven monitoring wells were installed in the Terrace Alluvial flow system, ranging in depth from 12.3 to 58.8 ft.

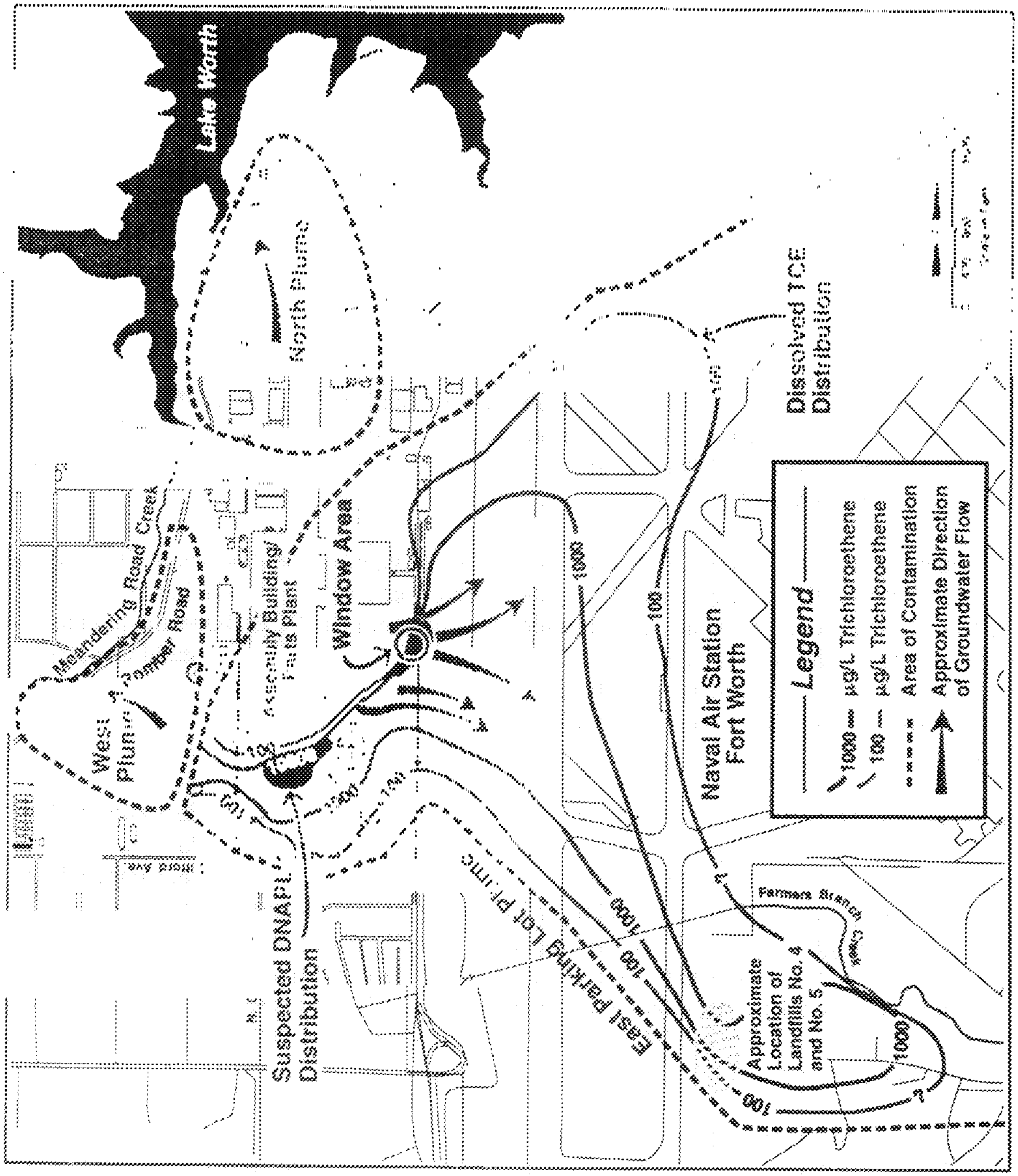

Figure 5–3. Contamination in the Terrace Alluvial Flow System at Air Force Plant 4

The largest plume of groundwater contamination is the East Parking Lot Plume. This plume begins at the groundwater divide located south and west of the Assembly Building/Parts Plant and Building 12. The plume also has source areas west of the Assembly Building in the vicinity of Warehouse Building 14 and Plant Maintenance Building 88 (Figure 2–1). From the main source area south of the Parts Plant, the plume extends in an easterly and northeasterly direction toward the East Parking Lot and later spreads east and southeast in the direction of Naval Air Station Fort Worth (Figure 5–3). On Naval Air Station Fort Worth, the plume has merged with Naval Air Station Fort Worth source areas located at Naval Air Station Fort Worth Landfills No. 4 and No. 5, Landfill No. 6 north of Farmers Branch Creek, and the North Apron.

The East Parking Lot Plume appears to have several sources of contamination. One major potential source is the degreaser tanks T–534 and T–544 located within Building 181. One documented release from tank T–534 was discovered in June 1991, but the volume of this TCE release is not known. The size of the East Parking Lot Plume indicates other releases of organic solvents may have occurred at this location during the past 40 years of operation.

Other potential sources of VOC contamination in the western portion of the East Parking Lot Plume include Chrome Pits Nos. 1, 2, and 3; Die Yard Chemical Pits; FDTA–5; and the Wastewater Collection Basins. These potential sources are located along the groundwater divide in the south-central portion of Plant 4. Historically, high concentrations (approaching saturation) of TCE have been reported in the south central portion of Plant 4.

The extent of the East Parking Lot Plume is defined by elevated concentrations of TCE, *cis-* and *trans-*1,2-dichloroethene, vinyl chloride, 1,1,2-trichloroethane (TCA), 1,1-dichloroethane (DCA), 1,1-dichloroethene, methylene chloride, tetrachloroethene (PCE), benzene, toluene, xylene, acetone, chlorobenzene, and chloroform. By far the greatest occurrence of any single organic compound is TCE. During the RI, TCE was detected in concentrations exceeding the detection limit in samples from 50 monitoring wells. All TCE results listed exceed the MCL of 5 μg/L.

During the RI, the highest TCE concentrations detected in samples from the East Parking Lot Plume were from monitoring wells located along a paleochannel in the East Parking Lot, including wells HM–094, W–149, W–158, and W–159. TCE concentrations in samples from these monitoring wells ranged from 15,000 to 31,000 μg/L. The magnitude of these concentrations suggests that TCE may be migrating along the paleochannel in the form of a dense nonaqueous phase liquid (DNAPL). Before the RI, TCE concentrations exceeding 10,000 μg/L were reported in samples from monitoring wells F–218, F–220, and HM–082. Samples from monitoring well F–220 have had TCE concentrations in excess of 100,000 μg/L; monitoring well F–220 is located within Chrome Pit No. 3.

The second largest plume of groundwater contamination in the Terrace Alluvial flow system is the West Plume (Figure 5–3). The West Plume extends from near the Assembly Building/Parts Plant westward toward Meandering Road Creek. Groundwater flow is toward the west. TCE concentrations in samples from the West Plume range from ND to 490,000 μg/L near FDTA–2. Potential source areas for the West Plume include chlorinated organic solvent contamination from FDTA–2, leachate contamination from Landfills No. 1 and No. 3, and leaking fuel-line contamination from an area between Building 14 and the Parts Plant. Because of the groundwater divide, Chrome Pit No. 3, the Die Yard Chemical Pit, and Fire Department Training Area No. 5 can also be considered potential source areas.

The North Plume underlies the north portion of the Assembly Building/Parts Plant (Figure 5–3). Groundwater flow is to the north. TCE concentrations in samples from this plume range from ND to 530 µg/L. In addition, JP–4 jet fuel has been identified on top of the groundwater in six monitoring wells in the vicinity of the North Plume. The potential source of this contamination is leaking fuel supply lines and storage tanks surrounding the Jet Engine Test Stand. Groundwater flow in the North Plume is toward Lake Worth, but the flow is restricted by higher elevations of bedrock. Contaminant concentrations in samples from Lake Worth have not exceeded MCLs.

Paluxy Aquifer and Upper Sand Groundwater

Five monitoring wells were installed in the Paluxy aquifer, ranging in depth from 94 to 157 ft. TCE has been detected in samples of the Upper Sand groundwater beneath Plant 4 in the vicinity of the Window Area (Figure 5–4). Vertical migration of TCE from the Terrace Alluvial flow system has likely occurred through the Window Area into the Upper Sand groundwater. TCE concentrations in samples of the Upper Sand groundwater range from ND to 11,000 µg/L.

TCE has been detected in Paluxy aquifer samples from an area near Landfill No. 3 and near the East Parking Lot (Figure 5–5). TCE most likely reached the area under Landfill No. 3 by vertical migration down a monitoring well that may not have been constructed according to design specifications. This well has been abandoned and sealed, thus preventing further TCE contamination. TCE concentrations in samples from the Paluxy aquifer near Landfill No. 3 range from ND to 100 µg/L. As shown in Figure 5–5, the lateral extent of TCE in the Paluxy aquifer is relatively small. TCE concentrations in the Paluxy aquifer near the East Parking Lot currently are less than MCLs.

Surface Water

To assess the potential effect of chemical constituents on surface-water features, water samples were collected from Meandering Road Creek, Farmers Branch Creek, and Lake Worth. Forty samples were collected during seven sampling rounds from Meandering Road Creek between February 1990 and October 1991; nine surface water samples were collected from Lake Worth in October 1991, and up to five locations in Farmers Branch Creek were sampled quarterly between April 1992 and February 1995. COPCs identified in the BRA for surface water are the VOCs *cis*-1,2-DCE and vinyl chloride.

Meandering Road Creek

Neither vinyl chloride nor *cis*-1,2-DCE was detected in 40 water samples obtained from Meandering Road Creek. However, the presence of TCE was detected in 7 of the 40 samples at concentrations ranging between 8 and 140 µg/L.

001 52

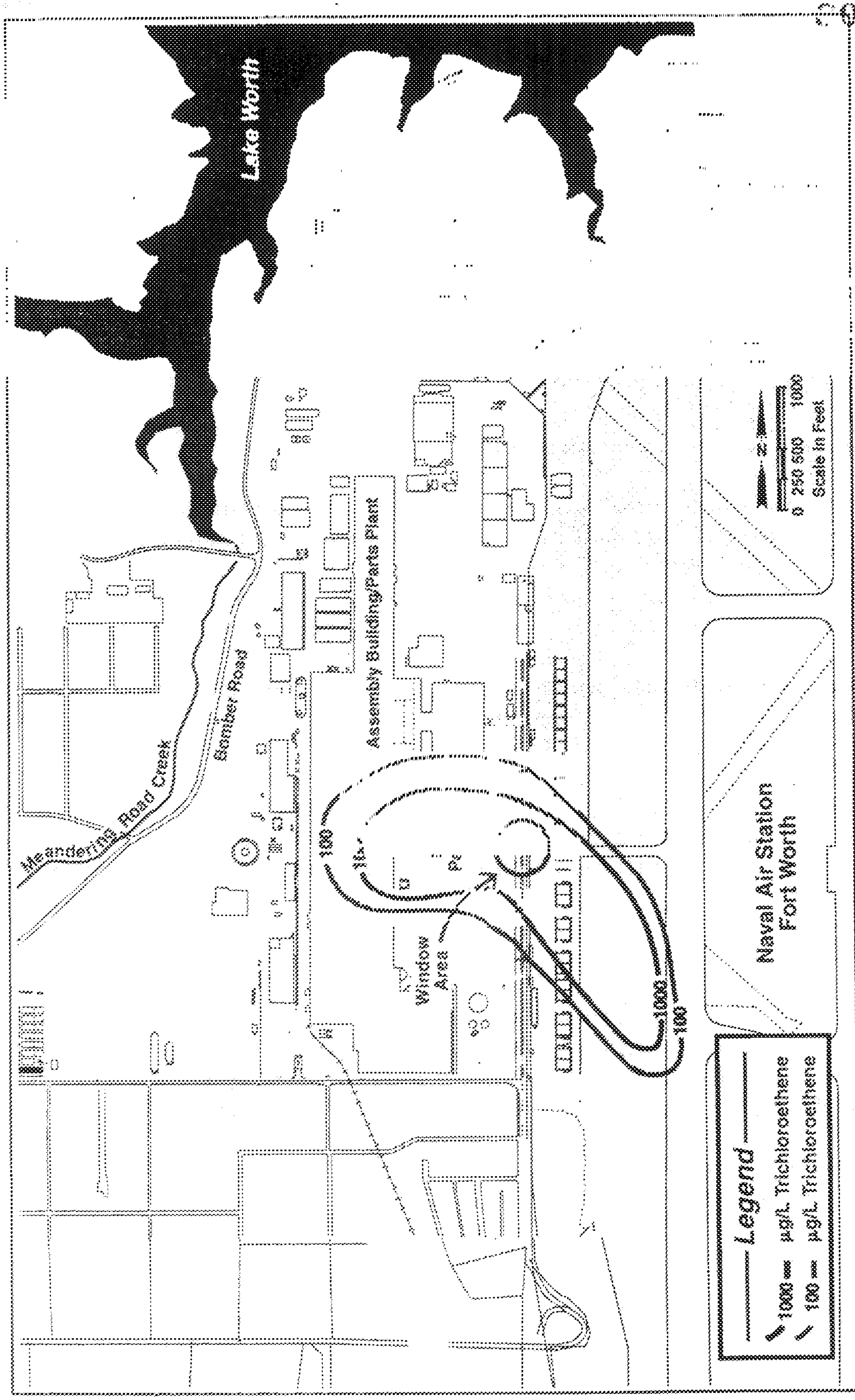

Figure 5-4. Contamination in the Upper Sand Groundwater at Air Force Plant 4

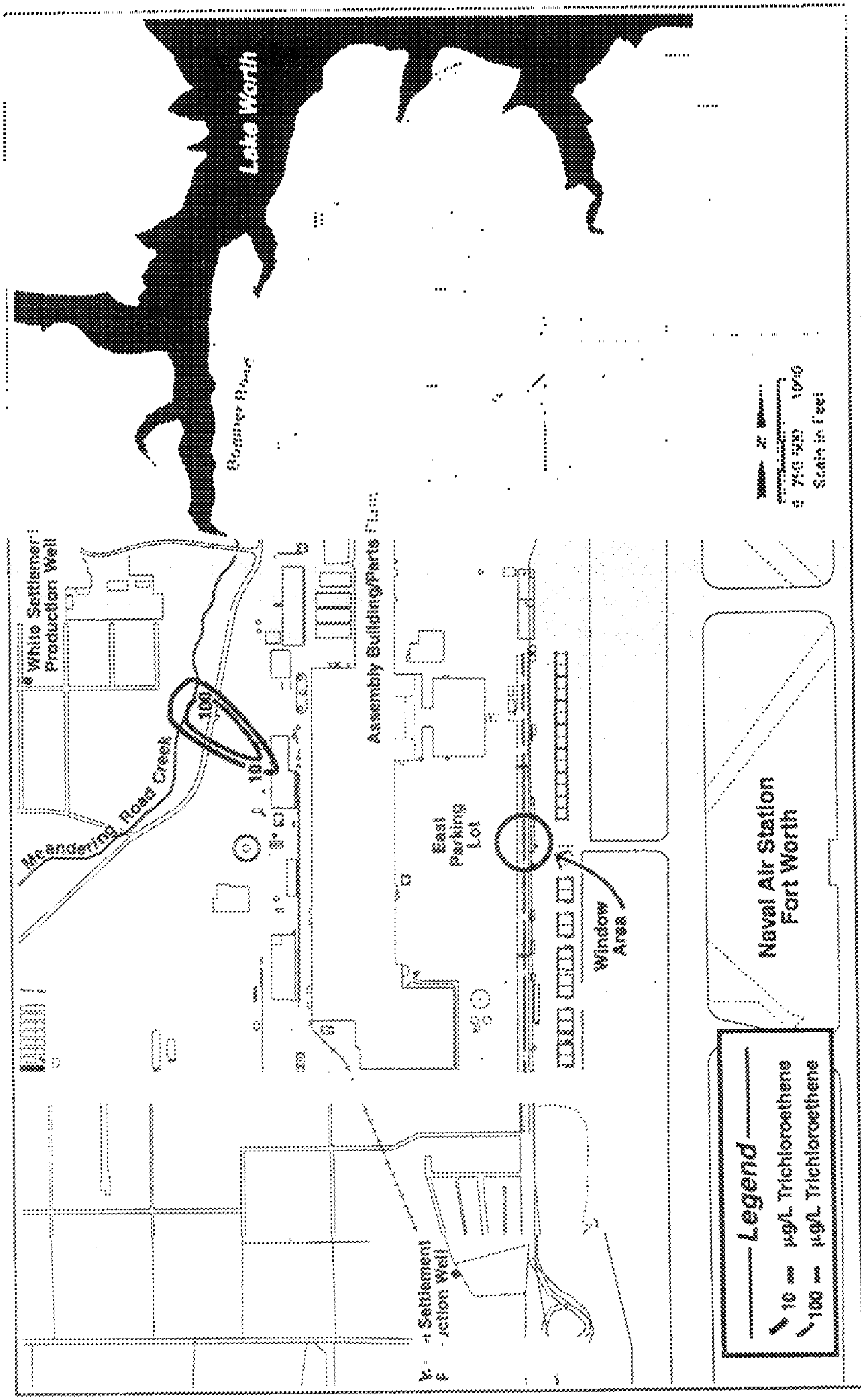

Figure 5-5. Contamination in the Paluxy Aquifer at Air Force Plant 4

Farmers Branch Creek

Concentrations of TCE and [illegible] samples from five surface-water sampling points in Farmers [illegible] concentrations were highest in 1992 when 880 µg/L was measu[illegible] concentrations have ranged between 1 and 500 µg/L. [illegible] were highest in 1992 when 380 µg/L was detected in a sample; concentrations since that time have ranged between 84 and 250 µg/L.

Lake Worth

Water samples were collected from seven sampling locations in Lake Worth along the northern border of Plant 4. The presence of only one VOC, carbon disulfide, was detected in the Lake Worth surface-water samples collected north of Plant 4. This compound was detected in three samples at concentrations ranging from 18 to 200 µg/L. Concentrations of no other volatile, semivolatile, or metal compounds were detected.

No Further Action Sites

Information on the sources and characteristics of soil contamination at the No Further Action Sites is presented in Section 11.0, along with the justification for the selected remedy for each site. Figure 2-1 shows the locations of the No Further Action Sites.

6.0 Summary of Site Risks

An evaluation of the potential risks to human health and the environment from site contaminants was conducted as part of the BRA, which was part of the RI. The methods used to develop the human health risk assessment are based on *EPA Risk Assessment Guidance for Superfund—Human Health Evaluation Manual* (EPA 1989a). The method used to develop the ecological risk assessment are based on *Framework for Ecological Risk Assessment* (EPA 1992).

The objectives of the BRA were (1) to identify COPCs for human health and ecological risk, (2) to provide a basis for determining residual chemical levels that are adequately protective of human health and the environment, (3) to help determine if response actions are necessary at the site, and (4) to provide a basis for comparing potential effects on human health of various remedial alternatives. The BRA consists of two parts: a quantitative human health risk assessment and a semiquantitative study of the effects on significant ecological communities at and near Plant 4 (i.e., the ecological risk assessment).

The approach for the Plant 4 risk assessment was to first conduct a sitewide risk assessment, using sampling data from across the site, to determine which contaminants and media were present in sufficient concentrations and quantities to pose an unacceptable risk for the site as a whole. The sitewide assessment was used to narrow the focus of evaluations performed for individual units (e.g., landfills, tanks); only contaminants that were unacceptable from a sitewide standpoint were considered in evaluating individual units. The sitewide risk assessment also was used to develop contaminant concentration levels that were deemed to be acceptable in each medium of concern. These acceptable levels were used in developing preliminary remediation goals (PRGs).

6.1 Human Health Risk Assessment

Chemicals of Potential Concern

The initial step in developing the human health risk assessment is to identify the site-related COPCs. COPCs are hazardous compounds that may be present at or released from a site that may pose health risks to humans coming in contact with them. COPCs were determined for four different media at Plant 4: groundwater, surface water, soil and sediments, and air. Table 6–1 presents the list of COPCs (and associated Chemical Abstracts Services [CAS] Registry Numbers) at Plant 4 and indicates the media with which they are associated. The list includes noncarcinogenic and carcinogenic compounds.

Exposure Assessment

The objective of the exposure assessment is to identify the populations that may be most exposed to site-related chemicals; the pathways by which exposure may occur; and the magnitude, frequency, and duration of the exposures. The results of the exposure assessment are the pathway-specific chemical intakes of identified COPCs.

Table 6–1. Chemicals of Potential Concern[a]

CAS No.	Chemical	Groundwater	Surface Water	Soil	Air
7440-38-2	Arsenic	X			
71-43-2	Benzene	X		X	X
56-55-3	Benzo(a)anthracene			X	
7440-47-3	Chromium	X		X	X
7439-92-1	Lead	X		X	X
91-20-3	Naphthalene	X		X	
7440-02-0	Nickel			X	
85-01-8	Phenanthrene			X	
129-00-0	Pyrene			X	
108-88-3	Toluene	X		X	
71-55-6	1,1,1-Trichloroethane	X			

[a]Exposure concentrations are provided in Tables 6–2 through 6–5 for chemicals and media marked with an X.

Table 6–1 (continued). Chemicals of Potential Concern[a]

CAS No.	Chemical	Groundwater	Surface Water	Soil	Air
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
[illegible]	[illegible]				[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
75-01-4	Vinyl Chloride		X		
[illegible]				[illegible]	[illegible]

[a]Exposure concentrations are provided in Tables 6–2 through 6–5 for chemicals and media marked with an X.

Exposed Populations and Exposure Pathways

The populations on and near the site were characterized to assess the likelihood and extent of exposure to site contaminants. Plant 4 is adjacent to residential communities on the south and west sides. The public has recreational access to Lake Worth, which borders the north side of the site. Naval Air Station Fort Worth lies to the east of the site. Plant 4 has been a military facility since 1941. It covers 602 acres, of which 70 percent is covered by asphalt, concrete, or buildings. Because of the history of this facility and the existing military and industrial infrastructure, it is anticipated that Plant 4 and Naval Air Station Fort Worth will continue to be used for industrial purposes while the surrounding areas will continue to be residential.

The site conceptual exposure model presented in Figure 6–1 illustrates the pathways by which contaminants can make their way from contaminant sources to potential receptors. The model indicates that the major sources of contamination are surface and subsurface soils (including landfill contents) and the groundwater in the Terrace Alluvial flow system. The complete exposure pathways that were used in the BRA are

- Ingestion of groundwater from White Settlement production wells by future residents (adults).
- Inhalation of and dermal contact with VOCs from groundwater by future residents (adults) during showering in water from White Settlement production wells.
- Dermal contact with contaminated surface water (Lake Worth) by current residents (adults).
- Ingestion and dermal contact with contaminated soil by current Plant 4 personnel.
- Inhalation of contaminated air by current Plant 4 personnel.

Exposure Point Concentrations

Exposure point concentrations are the chemical concentrations to which a receptor is assumed to be exposed to when contact is made with a specific environmental medium. Tables 6–2 through 6–5 provide concentrations used in the BRA for each contaminant in each medium. Concentrations for future exposure estimates for groundwater and surface water were made using a 30-year interval. To estimate potential risks associated with using water from White Settlement production wells, the concentrations were calculated in an analytical groundwater contaminant transport model. To be conservative, the highest calculated concentrations were used. Surface water exposures were modeled for swimming only. The highest reported concentrations were used in the model for a conservative estimate.

For soil and air, the upper 95-percent confidence limit of the arithmetic means of concentrations measured in soil and air during characterization of the site were used as exposure concentrations. A concentration of one-half the sample quantitation limit was used for all nondetects in the soil samples.

Table 6–2. Concentrations for Chemicals of Potential Concern in Groundwater

CAS No.	Chemical	Concentration (µg/L)	Receptor Well
7440-39-3	Barium	100	P-12UN
[illegible]	[illegible]	[illegible]	[illegible]
79-01-6	Trichloroethene	980	WS-12

Table 6–3. Concentrations for Chemicals of Potential Concern in Surface Water

CAS No.	Chemical	Concentration (µg/L)
[illegible]	[illegible]	[illegible]

Table 6-4. Concentrations for Chemicals of Potential Concern in Soil

CAS No.	Chemical	Concentration (mg/kg)
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
7440-50-8	Copper	2020
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
7440-02-0	Nickel	193.3
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Table 6-5. Concentrations for Chemicals of Potential Concern in Air

CAS No.	Chemical	Concentration ($\mu g/m^3$)
71-43-2	Benzene	0.89
[illegible]	[illegible]	[illegible]
76-13-1	Freon 113	1.66
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
7440-66-6	Zinc	0.0253

Chemical Intake

The magnitude of human exposures to COPCs at the site is described as the potential dose or intakes by each receptor. The magnitude of exposure to a chemical (or intake) is a function of a number of variables, including exposure concentration and variables that describe the exposed population (e.g., contact rate, exposure frequency and duration, body weight). Each of the variables can be described by a range of parameters. For purposes of this assessment, two measures of exposure have been defined using two sets of exposure variables: a reasonable maximum exposure (RME) and a central tendency (CT) exposure (when applicable).

The RME gives a reasonable upper-bound estimate of the potential magnitude of an individual exposure to chemicals from the sites. The intent of the RME is to estimate a conservative, well above average exposure case that is still within the range of possible exposures. CT provides a more typical or average value than RME. Table 6–6 lists the exposure assumptions used in the BRA. The majority of these assumptions are derived from EPA guidance (EPA 1991a, EPA 1989a). Tables 6–7 through 6–9 present calculated intakes for each COPC via each relevant exposure pathway. Note that intake values are given for both carcinogenic and noncarcinogenic effects because carcinogenic intakes are averaged over an expected lifetime for an individual, whereas noncarcinogenic intakes are based on actual expected daily exposures during the period of exposure.

Toxicity Assessment

The purpose of the toxicity assessment is to evaluate the toxicity of site-related COPCs and to estimate the dose-response relationship for each of these chemicals. The evaluation of the toxicity of the site-related chemical determined if exposure to a chemical could cause an increase in the incidence of a particular adverse health effect (carcinogenic or noncarcinogenic) and if the adverse health effect would likely occur in humans. The second step, dose-response relationship, quantitatively evaluated the toxicity information and characterized the relationship between the dose of the chemical received and the potential for incidence of adverse health effects in an exposed population.

Noncarcinogenic responses are generally characterized by a threshold: a certain minimum intake of a substance below which the likelihood of adverse deleterious effects is expected to be low. Carcinogenic responses are assumed to have no threshold. This assumption means that there is some cancer risk no matter how small the dose.

The two principal indices of toxicity are the reference dose (RfD) and slope factor (SF). These values are derived by EPA for the most commonly occurring chemicals and the most toxic chemical generally associated with chemical releases to the environment for which adequate, scientific, dose-response data are available. An RfD is the intake or dose per unit of body weight per day that is unlikely to result in noncarcinogenic (toxic) effects to human populations, including sensitive subgroups (e.g., the very young or old).

Table 6–6. Parameters Used To Estimate Exposure in Baseline Risk Assessment

Parameter	Value Used[a]		Rationale
	RME	CT	
[illegible]			
[illegible]			[illegible]
[illegible]			[illegible]
[illegible]			[illegible]
[illegible]			
[illegible]			[illegible]
[illegible]			[illegible] per year
[illegible]			[illegible]
Body Weight (kg)	70		EPA 1991b
[illegible]			[illegible] 1991b)
Exposure Time (hours per day)	3.2		[illegible] maximum (EPA 1991b)
[illegible]			[illegible]
[illegible]			
[illegible]			[illegible]
[illegible]			[illegible]
[illegible]			[illegible]
[illegible]			[illegible]
Dermal Exposure to Contaminated Surface Water During Swimming			
Skin Surface Area (square meters)	1.94		50th percentile total body surface area (EPA 1989a)
[illegible]			[illegible]
[illegible]	[illegible]		[illegible]
[illegible]			[illegible] 1991b); Rauscher 1992 for CT
Body weight (kg)	70		EPA 1991b
[illegible]			[illegible] per year
Exposure Duration (years)	25	9.0	Assumes 25-year work period; Rauscher 1992 for CT
Body Weight (kg)	70		EPA 1991b

[a]The left side of this column contains data for RME calculations; the right side of the column is for CT calculations. CT data are only provided when applicable.

[b]Child exposure values are provided for comparison.

Table 6–7. Results of the Exposure Assessment—Ingestion

[illegible]	Chemical	Chronic Daily Intake (mg/kg/d): Carcinogenic Effects	Chronic Daily Intake (mg/kg/d): Noncarcinogenic Effects
[illegible]			
[illegible]	[illegible]		[illegible]
	[illegible]		[illegible]
	[illegible]		[illegible]
	[illegible]		[illegible]
	Toluene	—[a]	1.9 x 10[illegible]
	[illegible]	[illegible]	—[b]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	
	[illegible]	[illegible]	
	[illegible]	[illegible]	
	Benzo(k)fluoranthene	[illegible]	—
	[illegible]	—[a]	[illegible]
	[illegible]		
	[illegible]		[illegible]
	[illegible]		[illegible]
	[illegible]	—[a]	[illegible]
	[illegible]		[illegible]
	[illegible]		[illegible]
	[illegible]		[illegible]
	Zinc	—[a]	3.0 x 10[illegible]

[a]Chronic daily intake (CDI) for carcinogenic effects not calculated for chemicals not considered to be potential carcinogens or for chemicals without slope factors.
[b]CDI for noncarcinogenic effects not calculated because RfDs are not available.

Table 6–8. Results of the Exposure Assessment—Inhalation

Potentially Exposed Population	Chemical	Chronic Daily Intake ($mg \cdot kg^{-1} \cdot d^{-1}$)	
		Carcinogenic Effects	Noncarcinogenic Effects
Inhalation of Volatile Organic Compounds During Showering With Groundwater (White Settlement wells in 30 years)			
Residents	1,1-Dichloroethane	—[a]	3.1×10^{-4}
	1,2-Dichloroethene	—[a]	—[b]
	Toluene	—[a]	1.5×10^{-4}
	Trichloroethene	9.2×10^{-5}	—[b]
Inhalation of Chemicals in Air			
Plant 4 Workers	Benzene	6.2×10^{-5}	1.7×10^{-4}
	Chromium	3.0×10^{-7}	8.4×10^{-7}
	Freon 113	—[a]	—[b]
	Lead	—[a]	—[b]
	Methylene Chloride	1.7×10^{-5}	4.8×10^{-5}
	Trichloroethene	8.8×10^{-5}	—[b]
	1,2,4-Trimethylbenzene	—[a]	—[b]
	1,3,5-Trimethylbenzene	—[a]	—[b]
	Zinc	—[a]	5.0×10^{-5}

[a] Chronic daily intake (CDI) for carcinogenic effects not calculated for chemicals not considered to be potential carcinogens.
[b] CDI for noncarcinogenic effects not calculated because RfDs are not available.

Table 6–9. Results of the Exposure Assessment—Dermal

Potentially Exposed Population	Chemical	Chronic Daily Intake ($mg \cdot kg^{-1} \cdot d^{-1}$) Carcinogenic Effects	Noncarcinogenic Effects
Dermal Exposure to Chemicals of Concern During Showering With Groundwater (White Settlement wells in 30 years)			
Residents	[illegible]	—[a]	4.5 x $10^{?}$ [illegible]
	[illegible]	—[a]	[illegible]
	Toluene	—[a]	3.7 x 10^{-4}
	[illegible]	[illegible]	—[b]
	[illegible]	[illegible]	[illegible]

[a]Chronic daily intake (CDI) for carcinogenic effects not calculated for chemicals not considered to be potential carcinogens.
[b]CDI for noncarcinogenic effects not calculated because RfDs are not available.

SF is used to estimate an upper-bound probability of an individual developing cancer as a result of exposure to a potential carcinogen. Carcinogens with EPA-derived SFs are also given an EPA weight-of-evidence classification; this classification groups potential carcinogens according to the quality and quantity of carcinogenic potency data for a given chemical. The footnotes in Table 6–10 present the EPA weight-of-evidence classification system. Table 6–10 also presents available RfDs and SFs for each COPC.

Risk Characterization

In the risk characterization, the results of the toxicity assessment (SFs and RfDs) and the exposure assessment (chemical intakes for potentially exposed populations) are integrated to arrive at quantitative estimates of carcinogenic risks and noncarcinogenic risks. The results of the risk characterization potentially provide a basis for any remedial action that might be needed to protect public health and the environment.

According to the 1990 National Oil and Hazardous Substances Pollution Contingency Plan (NCP) that provides the framework for implementation of the Superfund program, the ILCR (excess) cancer risk should not exceed the 1.0 x 10^{-4} to 1.0 x 10^{-6} range. The Office of Solid Waste and Emergency Response (OSWER) Directive 9355.0–30 (EPA 1991b) states "Where cumulative carcinogenic site risk to an individual based on an RME scenario for the current and future use is less than 1.0 x 10^{-4}, and the noncarcinogenic hazard quotient (index) is less than one, remedial action is generally not warranted. . . ." Noncarcinogenic health hazards are expressed in terms of a Hazard Quotient (HQ) for a single substance or Hazard Index (HI) for multiple substances and/or exposure pathways. The terms HQ and HI are the ratios of particular chemical

Table 6–10. Summary of Toxicity Values[a]

Chemical of Potential Concern	Slope Factor $(mg/kg\text{-}d)^{-1}$			Reference Dose (mg/kg-d)	
	Ingestion[b]	Inhalation	Weight of Evidence[c]	Ingestion[b]	Inhalation
[illegible]					
Benzo[a]anthracene	5.79×10^{-1}		B2		
[illegible]	[illegible]		[illegible]		
[illegible]					
[illegible]					
[illegible]					
cis-1,2-Dichloroethene			D	1.0×10^{-2}	
Copper			D	3.7×10^{-2}	
1,2-Dichlorobenzene			D	9.0×10^{-2}	4.0×10^{-2}
1,4-Dichlorobenzene			C	2.4×10^{-2}	1.4×10^{-2}
[illegible]			[illegible]	[illegible]	[illegible]
[illegible]				[illegible]	
[illegible]					
Zinc				2.0×10^{-1}	

[a] A blank means that it is not applicable or that data do not exist.
[b] Oral toxicity data were used for dermal exposure as necessary
[c] Group A—Human carcinogen (sufficient evidence of carcinogenicity in humans); Group B—Probable human carcinogen (B1—limited evidence of carcinogenicity in humans, B2—sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans); Group C—Possible human carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data); Group D—Not classified as to human carcinogenicity (inadequate or no evidence).
[d] Slope factor is based on a benzo[a]pyrene toxicity equivalency factor of 0.1 (from EPA Region 6 guidance).

exposures to reference doses, as discussed in the following sections. If the value of the HQ is less than 1.0, the hazards are not considered to pose a threat to public health, including sensitive subgroups.

Carcinogenic Risk

Carcinogenic risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. The estimate of ILCR is calculated by multiplying the chronic (lifetime) daily intake (CDI) by the cancer SF.

EPA policy must be considered to interpret the significance of the cancer risk estimates. In the NCP (40 CFR 300.430[e][2][I][A][2]), EPA states that "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper-bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}." The agency further discusses in the preamble to the NCP that the 1.0×10^{-6} risk level be used as a point of departure for establishing remediation goals for the risks from constituents at Superfund sites (*Federal Register*, Vol. 55, No. 46, 8713). EPA guidance indicates that if the estimated total cancer risk based on maximum exposure conditions is 1.0×10^{-4} or less, further action at the site is generally not warranted unless there are adverse environmental impacts, or drinking water standards (MCLs or maximum contaminant level goals [MCLGs]) are exceeded (40 CFR Parts 141 and 143).

Tables 6–11 and 6–12 summarize the potential ILCRs for RME associated with Plant 4 for both the current and future land-use scenarios for the COPCs for each exposure pathway. The only risks that are outside the acceptable risk range, as defined by EPA, are those associated with ingestion and inhalation of TCE-contaminated water in the future land-use scenario (RME assumptions). The total risk associated with exposure to TCE is 3.4×10^{-4}. Remedial alternatives were developed that would address RME.

Noncarcinogenic Risk

The potential for noncarcinogenic health effects, expressed as HQ and HI, is calculated in a manner similar to the carcinogenic risks. HQ applies to individual chemicals, whereas HI applies to the sum of potential noncarcinogenic health effects for all COPCs in a given exposure scenario. HQ is calculated by dividing the daily intake by the reference dose.

Tables 6–13 and 6–14 present summaries of the potential hazard indices for the RMEs that are associated with Plant 4 for both current and future land-use scenarios for the COPCs for each exposure pathway. The only exposure scenario that exceeds the acceptable hazard index of 1.0 is the future land-use exposure pathway involving ingestion of groundwater from White Settlement production wells. This pathway, using RME assumptions, yields an HI of 1.1. Using CT assumptions, the HI is 7.7×10^{-1}, which is below the threshold value. Remedial action alternatives were developed to address the RME.

Table 6–11. Summary of Potential Incremental Lifetime Cancer Risks Associated With Plant 4: Current Land Use

Chemical	Estimated Average Daily Intake[a] (mg/kg-d)	Slope Factor (mg/kg-d)[-1]	Weight of Evidence[b]	Chemical-Specific ILCR	Total Pathway ILCR	Total Exposure ILCR
[illegible]						
[illegible]	[illegible]	[illegible]		[illegible]		
Benzo[a]anthracene	2.9×10^{-7}	0.579	B2	1.7×10^{-7}		
[illegible]						
Benzo[b]fluoranthene	3.3×10^{-7}	0.579	B2	1.9×10^{-7}		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
					2.1×10^{-6}	
[illegible]						
[illegible]						
[illegible]						
Trichloroethene	8.8×10^{-5}	1.7×10^{-2}	B2	1.5×10^{-6}		
					1.5×10^{-6}	
[illegible]						
					2.1 x 10[illegible]	
Current Occupational Exposure: Total Potential ILCR (weight of evidence predominantly A)						1.7×10^{-5}

[a] The parameter values used to calculate the estimated average daily intakes are provided in Table 6–6

[b] Group A—Human carcinogen (sufficient evidence of carcinogenicity in humans); Group B—Probable human carcinogen (B1—limited evidence of carcinogenicity in humans; B2—sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans); Group C—Possible human carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data).

Table 6–12. Summary of Potential Incremental Lifetime Cancer Risks Associated With Plant 4: Future Land Use

Chemical	Estimated Average Daily Intake[a] (mg/kg-d)	Slope Factor (mg/kg-d)$^{-1}$	Weight of Evidence[b]	Chemical-Specific ILCR	Total Pathway ILCRs	Total Exposure ILCR
[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[a] The parameter values used to calculate the estimated average daily intakes are provided in Table 6–6.

[b] Group A—Human carcinogen (sufficient evidence of carcinogenicity in humans); Group B—Probable human carcinogen (B1—limited evidence of carcinogenicity in humans; B2—sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans); Group C—Possible human carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data).

Table 6–13. Summary of Potential Hazard Indices Associated With Plant 4: Current Land Use

Chemical	Estimated Average Daily Intake[a] (mg·kg⁻¹·d⁻¹)	Reference Dose (mg⁻¹·kg·d)	Chemical-Specific HQ	Total Pathway HI	Total Exposure HI
Exposure Pathway: Occupational Ingestion of Soil					
Cadmium	1.9×10^{-6}	1.0×10^{-3}	1.9×10^{-3}		
Chromium	1.0×10^{-8}	5.0×10^{-3}	2.0×10^{-6}		
Copper	1.0×10^{-3}	3.7×10^{-2}	3.0×10^{-2}		
Fluoranthene	1.3×10^{-6}	4.0×10^{-2}	3.3×10^{-5}		
[illegible]	[illegible]	[illegible]	[illegible]		
Pyrene	9.4×10^{-7}	3.0×10^{-2}	3.1×10^{-5}		
[illegible]	[illegible]	[illegible]	[illegible]		
Benzene	[illegible]	[illegible]	[illegible]		
[illegible]					
[illegible]					
				4.2×10^{-2}	
Exposure Pathway: Dermal Exposure While Swimming					
cis-1,2-Dichloroethene	8.2×10^{-6}	1.0×10^{-2}	8.2×10^{-4}		
[illegible]				[illegible]	
[illegible]					[illegible]

[a]The parameter values used to calculate the estimated average daily intakes are provided on Table 6-6.

Table 6–14. Summary of Potential Hazard Indices Associated With Plant 4: Future Land Use

Chemical	Estimated Average Daily Intake[a] ($mg \cdot kg^{-1} \cdot d^{-1}$)	Reference Dose ($mg^{-1} \cdot kg \cdot d$)	Chemical-Specific HQ	Total Pathway HI	Total Exposure HI
Exposure Pathway: Ingestion of Groundwater From White Settlement Production Wells					
Barium	2.7×10^{-3}	7.0×10^{-2}	3.9×10^{-2}		
Chromium	1.8×10^{-4}	5.0×10^{-3}	3.6×10^{-2}		
1,2-Dichloroethene	1.0×10^{-2}	1.0×10^{-2}	1.0		
				1.1	
Exposure Pathway: Inhalation of Volatile Organic Compounds During Showering With Groundwater From White Settlement Production Wells					
Toluene	1.5×10^{-4}	6.0×10^{-1}	2.5×10^{-4}		
				3.4×10^{-3}	
1,1-Dichloroethane	6.3×10^{-7}	1.0×10^{-1}	6.3×10^{-6}		
				3.8×10^{-1}	
Future Residential Exposure: Total Potential HI					1.1

[a] The parameter values used to calculate the Estimated Average Daily Intakes are provided on Table 6–6.

Site-Specific Evaluation

Results of the human-health risk assessment were use to determine threshold values of contaminants that equate to a 1.0×10^{-6} risk level. These values were compared to contaminant concentrations detected at individual sites at Plant 4 to further evaluate the need for remedial action to reduce the overall risks at Plant 4. Table 6–15 shows the results of this evaluation arranged by medium. Groundwater and air contamination do not lend themselves to site boundaries like soil and sediment. Therefore, rather than addressing the groundwater contamination on a site-by-site basis, the groundwater was addressed by individual aquifer and by areas of contamination within each aquifer.

Table 6–15. Summary of Proposed Actions

Site	Finding	Voluntary Action/ Selected Remedy
Soil and Sediments		
Landfill No. 1 (Site LF01)	Concentrations of BAP exceed the human health-risk threshold value. However, the BAP contamination is suspected to be from asphalt paving fragments and not from past waste-disposal practices.	Completed voluntary action to partially remove contaminated soil. Selected remedy is no action.
Landfill No. 2	Contaminants do not pose an excess risk to [illegible]	Selected remedy is no action.
Landfill No. 3 (Site LF03)	Concentrations of copper, lead, and zinc exceed ecological risk thresholds. Contaminants do not pose an excess risk to human health.	Remedial action alternatives for ecological risk developed in Feasibility Study.
Landfill No. 4 (Site LF04)	Concentrations of BAP exceed human health-risk threshold and concentrations of arsenic, cadmium, and copper exceed ecological risk thresholds	Remedial action alternatives developed in Feasibility Study.
[illegible] Training Area (FDTA) [illegible]	[illegible] human health or the environment.	[illegible]
[illegible]	[illegible] human health or the environment	[illegible]
FDTA-4 (Site FT07)	Contaminants do not pose an excess risk to human health or the environment.	Selected remedy is no action.
FDTA-5 (Site FT08)	Contaminants do not pose an excess risk to human health or the environment.	Selected remedy is no action.
FDTA-6 (Site FT09)	Contaminants do not pose an excess risk to human health or the environment.	Completed voluntary action to partially remove contaminated soil. Selected remedy is no action.

Table 6-15 (continued). Summary of Proposed Actions

Site	Finding	Voluntary Action/ Selected Remedy
Soil and Sediments (continued)		
[illegible] (Site DP[illegible])	[illegible]	[illegible]
Chrome Pit No. 2 (Site DP11)	No sampling was done at the site because the site could not be found.	Selected remedy is no action.
[illegible] (Site DP12)	[illegible] contaminants do not pose an excess risk to human health or the environment.	[illegible] remove contaminated soil. Selected remedy is no action.
Die Yard Chemical Pits (Site DP13)	Contaminants do not pose an excess risk to human health or the environment.	Completed voluntary action to remove contaminated soil. Selected remedy is no action.
[illegible] (FSA) No. 1 (Site SS14)	[illegible] contaminants do not pose an excess risk to human health or the environment.	[illegible] system and vadose-zone bioventing system. No further response action planned.
FSA-2 (Site SS15)	Contaminants do not pose an excess risk to human health or the environment.	No response action planned.
[illegible] (Site SS16)	[illegible] contaminants do not pose an excess risk to human health or the environment.	[illegible] system and vadose-zone bioventing system. Selected remedy is no action.
Former Fuel Storage Area (Site SS17)	Contaminants do not pose an excess risk to human health or the environment.	Selected remedy is no action.
Solvent Lines (Site [illegible])	Contaminants do not pose an excess risk to [illegible]	Selected remedy is no action.
[illegible] Research Facility (Site OT19)	[illegible] human health or the environment.	[illegible]
Wastewater Collection Basins (Site WP20)	Contaminants do not pose an excess risk to human health or the environment.	Selected remedy is no action.
West Compass Rose (Site OT21)	Contaminants do not pose an excess risk to human health or the environment.	No response action planned.
[illegible] Line (Site OT22)	[illegible] groundwater.	[illegible] part of this site.
[illegible] and No. 2 (Site OT23)	[illegible]	[illegible] was a voluntary action at Landfill No. 1.
Jet Engine Test Stand (Site OT24)	Contaminants do not pose an excess risk to human health or the environment.	Selected remedy is no action.

Table 6-15 (continued). Summary of Proposed Actions

Site	Finding	Voluntary Action/ Selected Remedy
Soil and Sediments (continued)		
Underground Storage Tank (UST) No. 19 (Site ST25)	Contaminants do not pose an excess risk to human health or the environment.	Completed voluntary action to remove UST. Selected remedy is no action.
(Site ST26)	human health or the environment.	remove UST. Selected remedy is no action.
UST No. 24A (Site ST27)	Contaminants do not pose an excess risk to human health or the environment.	Completed voluntary action to remove UST. Selected remedy is no action.
UST No. 24B (Site ST28)	Contaminants do not pose an excess risk to human health or the environment.	Completed voluntary action to remove UST. Selected remedy is no action.
UST No. 25A (Site ST29)	Contaminants do not pose an excess risk to human health or the environment.	Completed voluntary action to remove UST. Selected remedy is no action.
UST No. 30 (Site ST30)	Contaminants do not pose an excess risk to human health or the environment.	Completed voluntary action to remove UST. Selected remedy is no action.
Assembly Building/Parts Plant Perimeter (Building 181)	Contaminants do not pose an excess risk to human health or the environment, although the presence of TCE in the vadose zone causes groundwater contamination.	Ongoing voluntary action (soil-vapor extraction) to remove TCE contamination in the vadose zone. Remedial action alternatives developed in Feasibility Study.
Meandering Road Creek (includes inlet to Lake Worth)	Concentrations of silver exceed ecological risk thresholds. Contaminants do not pose an excess risk to human health.	Remedial action alternatives developed in the Feasibility Study.
Groundwater		
Paluxy Aquifer	Presence of TCE and 1,2-DCE may cause excess human health risk in the future in two areas: (1) East Plume under the East Parking Lot and (2) West Plume under Landfill No. 3.	Remedial action alternatives developed in Feasibility Study.
Terrace Alluvial Flow System—East Parking Lot Plume	TCE and DCE contamination is the source of contamination in the Paluxy aquifer. Suspected DNAPLs at the Assembly Building and Window Area. Upper Zone flow system is hydraulically connected to the Paluxy aquifer.	Ongoing voluntary action at the East Parking Lot to extract and treat contaminated groundwater in the Window Area. Remedial action alternatives developed in the Feasibility Study.

Table 6-15 (continued). Summary of Proposed Actions

Site	Finding	Voluntary Action/ Selected Remedy
Groundwater (continued)		
[illegible] System—West Plume	[illegible] human health or the environment.	[illegible] include a vacuum-enhanced pumping system at Landfill No. 3, French Drains No. 1 and No. 2. and collection of leachate at Landfill No.1.
[illegible] System—North Plume	[illegible] human health or the environment.	[illegible] light nonaqueous phase liquids and [illegible]
[illegible]		
[illegible] Creek	[illegible] human health or the environment.	
Lake Worth	Contaminants do not pose an excess risk to human health or the environment.	No remedial action planned.
Farmers Branch Creek	Contaminants do not pose an excess risk to human health or the environment.	No remedial action planned.

To estimate the RME risk from exposure to contaminated air and soil, on-site workers were assumed to work at the site 250 days each year for a period of 25 years. The workers were assumed to spend an equal amount of time at all the contaminated sites on Plant 4. For on-site workers exposed to noncarcinogenic contaminants in the soil (considering soil ingestion, skin exposure, and inhalation of particulates), the HI was 0.5. This value indicates that no adverse effects to on-site workers from noncarcinogenic contaminants in the soil are anticipated.

Only one carcinogenic contaminant, benzo[*a*]pyrene, in the soil exceeds the lower limit of the acceptable risk range (1 in 1,000,000 incremental cancer risk). The calculated risk for benzo[*a*]pyrene in Landfill No. 4, using maximum values, was 1.6 in 1,000,000 incremental cancer risk. This risk is within the acceptable risk range, but remedial alternatives were developed because the risk exceeds the lower limit of the range.

The risk to on-site workers exposed to contaminants in the air resulted in a cumulative incremental cancer risk of 1.7 in 100,000 for the maximum-exposure scenario and 6.4 in 1,000,000 for the average-exposure scenario (CT). The primary contaminants in the air that cause risk are chromium, TCE, and benzene.

Even though the incremental cancer risk for contaminants in the air is above the lower limit of the acceptable risk range, remedial alternatives were not developed because (1) chromium and benzene levels measured on site were comparable to levels measured off site, indicating remedial actions at Plant 4 would not reduce the risk to off-site residents, and (2) TCE levels were found to be the result of ongoing operations at the plant and, therefore, should not be considered under the CERCLA process but under a different regulatory authority. TCE is no longer used at Plant 4, but the air sampling was completed before the use of TCE was discontinued.

The TCE concentrations measured in air appear to correlate directly with the wind direction and the location of the on-site sampling location with respect to Building 181. However, concentrations of TCE in air was most likely the result of ongoing Plant 4 operations and not a result of contamination at CERCLA sites on Plant 4. Further, the use of TCE has been discontinued at the plant. Therefore, no remedial action objectives were developed for TCE as an air contaminant.

Most of the sites evaluated have either been addressed by an interim removal action or contain contaminants at levels that do not exceed human-health threshold values. No further action is deemed necessary at these sites. For soil and sediments, only the contaminants present at Landfill No. 3 and Landfill No. 4 required the development of remedial action alternatives from a human health perspective. The main human health concern is from contaminated groundwater under the future land-use scenario. Remedial action alternatives were developed that would address the potential future contamination of the Paluxy aquifer.

6.2 Ecological Risk

The Plant 4 site includes large paved areas and buildings, as well as grassy areas with scattered oak trees, and lake-side and creek-side areas with various types of trees, shrubs, and vines. Most of the site has been altered from its natural state by human activities. The Plant 4 ecological risk assessment focused on the relatively natural areas near Meandering Road Creek, Lake Worth, and Farmers Branch Creek.

Receptors considered for the ecological risk assessment were identified on the basis of several criteria, including ecological or social significance, potential for exposure, and availability of pertinent toxicological data. These receptors include largemouth bass, red-tailed hawk, red fox, raccoon, terrestrial prey species (e.g., mice and squirrels), and aquatic prey species (e.g., aquatic insects and minnows).

The ecological risk assessment determined if there is a potential risk to a receptor from a certain contaminant by estimating HQs. HQ represents a comparison of projected exposure levels to what is considered to be the acceptable limit of exposure. It is based on the ratio of the estimated daily intake to an acceptable daily exposure. An HQ greater than 1.0 indicates there is a potential for excess risk to a receptor.

Two types of assessments were used to quantify ecological risk at Plant 4: (1) food web modeling and (2) direct toxicity assessments. Both types of assessments produce conservative estimations of ecological risk.

The HQs calculated for receptors exposed to contamination in the surface water from Meandering Road Creek, Lake Worth, and Farmers Branch Creek are less than a value of 1.0, which indicates there is not a potential for excess risk from contaminants in the surface water.

The HQs calculated for some receptors exposed to soils and sediments exceed a value of 1.0, specifically at Landfill No. 3 and Landfill No. 4. Table 6–16 summarizes the results of the ecological risk assessment for these areas. Remedial action alternatives were developed for these areas to mitigate the potential ecological risk. Sediments from Meandering Road Creek, including the inlet to Lake Worth, contained silver and Aroclor-1254 (a PCB compound) in concentrations that have the potential to cause excess ecological risk. Remedial action alternatives were also developed to address sediments in this location.

Table 6–16. Summary of Contaminants That Exceed Ecological-Risk Threshold Levels

Contaminant	Exposure Pathway	HQ Based on Average Concentrations	HQ Based on Maximum Values
Arsenic	Mice exposed to soil at Landfill No. 4	2.8	5.8
Cadmium	Mice exposed to soil at Landfill No. 4	1.2	1.2
Copper	Mice exposed to soil at Landfills No. 3 and No. 4	0.63 (Landfill No. 3) 0.31 (Landfill No. 4)	4.9 (Landfill No. 3) 1.0 (Landfill No. 4)
Lead	Mice exposed to soil at Landfill No. 3	0.44	2.8
Zinc	Mice exposed to soil at Landfill No. 3	1.1	8.3
Silver	Aquatic organisms exposed to sediment in Meandering Road Creek	1.9	7.8
Aroclor-1254	Largemouth bass exposed to sediment in Lake Worth	1.2	1.8

6.3 References

U.S. Environmental Protection Agency (EPA), 1989a. *EPA Risk Assessment Guidance for Superfund--Human Health Evaluation Manual (Part A)*, EPA/540/1–89/002, Office of Emergency and Remedial Response, December 1989.

_______________, 1989b. *Exposure as Factors Handbook*, EPA/600/8–89/043.

_______________, 1991a. *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part B)*, Publication 9285.7–01B.

_______________, 1991b. *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions*, Office of Solid Waste and Emergency Response (OSWER) Directive 9355.0–30.

U.S. Environmental Protection Agency (EPA), 1992. *Framework for Ecological Risk Assessment*, Risk Assessment Forum, Washington, DC.

Rauscher, Jon. 1992. Memorandum on "Central Tendency and RME Exposure Parameters."

7.0 Landfill No. 3, Landfill No. 4, and Meandering Road Creek

This section discusses and presents the remediation goals, descriptions of alternatives, and comparative analysis of alternatives for Landfill No. 4, Landfill No. 3, and Meandering Road Creek. Landfill No. 4, Landfill No. 3, and Meandering Road Creek were combined to develop alternatives because they have similar contamination problems. Lake Worth sediments in the inlet where Meandering Road Creek enters Lake Worth also are included in this set of alternatives.

7.1 Remediation Goals

The remediation goals for soil at Landfill No. 4 are

- Prevent human ingestion of BAP at concentrations that cause an excess ILCR.
- Prevent ecological exposure to concentrations of arsenic, cadmium, and copper from causing harm.

The remediation goal for soil at Landfill No. 3 and the sediments in Meandering Road Creek and Lake Worth is

- Prevent ecological exposure to concentrations of copper, lead, and zinc in Landfill No. 3 soil and concentrations of silver and Aroclor-1254 in Meandering Road Creek sediments from causing harm.

These remediation goals are developed to be protective of human health and the environment. The cleanup levels established for this site are based on these remediation goals and on reducing the HI or the HQ to 1.0 and the ILCR to 1.0×10^{-6}.

The soil at Landfill No. 4 has concentrations of BAP that result in an incremental cancer risk of 1.6×10^{-6}, which is within the acceptable risk range. Although the risk to human health is within the acceptable risk range, alternatives were evaluated to determine if any significant risk reduction could be achieved through a reasonable degree of remediation.

Levels of arsenic, cadmium, and copper in the soil at Landfill No. 4 could cause harm to mice. Limiting the exposure of mice to the presence of arsenic, cadmium, and copper at Landfill No. 4 to levels less than 29.1 mg/kg, 132 mg/kg, and 563 mg/kg, respectively, would reduce the respective HQs to 1.0. Limiting the exposure of mice to copper, lead, and zinc contamination at Landfill No. 3 to less than 563 mg/kg, 2,000 mg/kg, and 1,000 mg/kg, respectively, would reduce the respective HQs to 1.0.

Concentrations of silver in the sediments of Meandering Road Creek could cause harm to aquatic insects and minnows. Reducing silver concentrations in the sediments in Meandering Road

Creek (and Lake Worth) to 1.0 mg/kg would reduce the HQ to 1.0. The presence of the chemical Aroclor-1254 causes potential risk to largemouth bass. Reducing the levels of Aroclor-1254 to 0.1 mg/kg would reduce the HQ to 1.0.

7.2 Description of Alternatives

The alternatives developed for Landfill No. 4, Landfill No. 3, and Meandering Road Creek use capping, solidification and disposal in a hazardous-waste landfill, and monitoring. These alternatives are:

- Alternative 1, No Action (selected alternative)
- Alternative 2a, Capping That Addresses Human Health Risk Areas
- Alternative 2b, Capping That Addresses All Risk Areas
- Alternative 3a, Removal and Disposal That Address Human Health Risk Areas
- Alternative 3b, Removal and Disposal That Address All Risk Areas

Alternative 1, No Action (selected alternative)

Present Worth: $73,000
Implementation Time: 0 months

This alternative assumes there would be no additional activities to remediate the contaminated soil but does include monitoring of contaminant levels in the surface water and sediments in Meandering Road Creek and Lake Worth. Monitoring will continue as long as contamination remains in soil at Landfill No. 4 and Landfill No. 3 and in sediments in Meandering Road Creek or until the Air Force, EPA, and State of Texas agree that monitoring is no longer required. The monitoring is described in more detail in Section 7.4, "The Selected Remedy."

If monitoring indicates that the concentrations of contaminants will cause unacceptable risks to the aquatic environment or MCLs to be exceeded in Lake Worth, appropriate remedial actions will be taken. Remedial actions may include removal of the sediments or containment of contaminants in the landfills that are causing the unacceptable risks or contamination levels.

Alternative 2a, Capping That Addresses Human Health Risk Areas

Present Worth: $430,000
Implementation Time: 12 months

Alternative 2a involves capping areas to contain BAP contamination in the soil (areas with contamination that exceeds human health-risk threshold values) to eliminate the exposure pathway to on-site workers. Components of this alternative include

- Place a cap over Landfill No. 4. The cap could be constructed of material such as concrete, clay, or synthetic material.
- Monitor contamination in Meandering Road Creek and Lake Worth to determine if contaminants from Landfill No. 4 and Landfill No. 3 are leaching to the surface water. Monitoring will continue as long as contamination remains in Landfill No. 4, Landfill No. 3, and Meandering Road Creek sediments.

This alternative does not involve excavation of BAP-contaminated soil and does not include areas at Landfill No. 3 and Meandering Road Creek where there is a potential for excess ecological risk.

Alternative 2b, Capping That Addresses All Risk Areas

Present Worth: $473,000
Implementation Time: 12 months

Alternative 2b involves capping areas to contain BAP contamination in the soil (areas with contamination that exceeds human health-risk threshold values) to eliminate the exposure pathway to on-site workers and removal of soil and sediments that have the potential to cause excess ecological risk. Components of this alternative include

- Excavate 185 yd^3 of soil contaminated with copper, lead, and zinc at Landfill No. 3 and place the soil on Landfill No. 4.
- Remove 177 yd^3 of sediments contaminated with silver and Aroclor-1254 from Meandering Road Creek and Lake Worth and place the sediments on Landfill No. 4.
- Place a cap over Landfill No. 4 after soil from Landfill No. 3 and sediments from Meandering Road Creek and Lake Worth have been placed on the landfill.
- Monitor contamination in Meandering Road Creek and Lake Worth to determine if contaminants from Landfill No. 4 and Landfill No. 3 are leaching to the surface water. Monitoring will continue as long as contamination remains in Landfill No. 4, Landfill No. 3, and Meandering Road Creek sediments.

Alternative 3a, Removal and Disposal That Address Human Health Risk Areas

Present Worth: $19,151,000
Implementation Time: 12 months

Alternative 3a involves removing approximately 32,000 yd^3 of BAP-contaminated soil (areas with contamination that exceeds human health-risk threshold values) and transporting the soil to a hazardous-waste landfill. Components of this alternative include

- Excavate 32,000 yd^3 of BAP-contaminated soil at Landfill No. 4.
- Place the soil in suitable containers for transportation.
- Transport the soil to a hazardous-waste landfill.
- Stabilize the soil before disposal.
- Establish site safeguards such as storm-water controls.
- No monitoring is required with this alternative.

This alternative does not include soil areas at Landfill No. 3 and sediment in Meandering Road Creek and Lake Worth where there is a potential for excess ecological risk.

Alternative 3b, Removal and Disposal That Address All Risk Areas

Present Worth:	$19,244,000
Implementation Time:	12 months

Alternative 3b has all the components of Alternative 3a except that this alternative also includes removing contaminated sediments in Meandering Road Creek and contaminated soil from Landfill No. 3. Components of this alternative include

- Excavate 32,000 yd^3 of BAP-contaminated soil at Landfill No. 4.
- Excavate 185 yd^3 of soil contaminated with copper, lead, and zinc at Landfill No. 3 and transport to a solid-waste landfill.
- Remove 177 yd^3 of sediments contaminated with silver and Aroclor-1254 from Meandering Road Creek and Lake Worth and transport to a solid-waste landfill.
- Place the soil from Landfill No. 4, Landfill No. 3, and Meandering Road Creek in suitable containers for transportation.
- Transport the soil to a hazardous-waste landfill.
- Stabilize the soil before disposal.
- No monitoring is required with this alternative.

7.3 Comparative Analysis of Alternatives

Alternatives must be evaluated against the nine criteria specified in the NCP. Figure 7–1 presents these criteria. A comparative analysis of alternatives for Landfill No. 4, Landfill No. 3, and Meandering Road Creek are given in the following text and are summarized in Table 7–1.

Overall Protection of Human Health and the Environment

All the alternatives, including the selected alternative, Alternative 1, No Action, are considered protective of human health and the environment. The No Action Alternative results in a human health risk of 1.6×10^{-6} ILCR from concentrations of BAP left in Landfill No. 4. This risk is within the acceptable risk range for human health. The No Action Alternative was deemed acceptable even though the BRA determined there is the potential for excess ecological risk.

Three factors were considered in determining that no action to mitigate the potential for ecological risk was acceptable. One factor was that the conservative manner in which potential ecological risk was determined likely overestimated the risk. Another factor was that the calculated HQs were relatively close to an HQ of 1.0, the threshold value. The third factor was that the risk was to prey species (i.e., mice and minnows) and not to predators such as hawks or largemouth bass.

Alternatives 2a and 3a both reduce the potential for human exposure to below an ILCR of 1.0×10^{-6}. However, these alternatives do not reduce the potential for excess ecological risk. Only Alternatives 2b and 3b reduce both human health risk and the potential for excess ecological risk.

The selected alternative, Alternative 1, No Action, provides protection within the acceptable range for human health. The selected alternative does not reduce the potential ecological harm (there is a potential for harm to mice and aquatic organisms and largemouth bass from contaminants in sediment). However, the No Action Alternative was deemed to be acceptable by the Air Force, the EPA, and the State of Texas.

Alternatives 2a and 3a are protective of human health but are the same as the No Action Alternative for mitigation of ecological risk. Alternatives 2b and 3b are protective of human health and reduce ecological risk to below threshold values.

Compliance With Applicable or Relevant and Appropriate Requirements

All the alternatives can meet the requirements for compliance with chemical-specific, action-specific, and location-specific applicable or relevant and appropriate requirements (ARARs). Table 7–2 summarizes the ARARs for all the alternatives.

The following nine criteria are used to evaluate alternatives. Overall protection of human health and the environment and compliance with applicable or relevant and appropriate requirements (ARARs) (unless a specific ARAR is waived) are *threshold criteria* [illegible] to be the selected alternative. Long-term effectiveness and [illegible]: reduction of toxicity, mobility, [illegible] d cost are the ***balancing criteria*** that are used to compare and weigh the major [illegible] two criteria. State acceptance and community acceptance [illegible] e based on input from the State of Texas or the public and may be used to modify an alternative or select a different alternative.

Threshold Criteria

Overall protection of human health and the environment addresses if an alternative can adequately protect human health and the environment, in both the short- and long-term, from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the site by eliminating, reducing, or controlling exposures to contamination. Overall protection of human health and the environment draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Compliance with ARARs assesses if the alternatives attain ARARs under Federal environmental laws and State environmental laws or provide a basis for invoking a waiver.

Balancing Criteria

Long-term effectiveness and permanence assesses the ability of an alternative to provide long-term protection after remediation goals have been met, along with the degree of certainty that the alternative will prove successful.

Reduction of toxicity, mobility, or volume through treatment evaluates the degree to which alternatives employ recycling or treatment that reduces toxicity, mobility, or volume, including how treatment is used to address the principal threats posed by the site.

Short-term effectiveness addresses the time it takes for an alternative to be implemented and the potential effect on human health (including the community and workers) and the environment during implementation.

Implementability evaluates the ease or difficulty of implementing the alternatives. Implementability considers technical feasibility (e.g., technical difficulties and unknowns associated with the construction and operation of the technology), administrative feasibility (e.g., activities needed to coordinate with other offices and agencies), and availability of services and materials.

Cost includes capital costs, including both direct and indirect costs, annual operation and maintenance (O&M) costs, and net present value of capital and O&M costs. Cost is considered and compared to the benefit that will result from implementing the alternative.

Modifying Criteria

State acceptance considers the concerns of the State on the alternatives and offers comments. The State may agree with, oppose, or have no comment on the proposed remedy.

Community acceptance allows for a public comment period when interested persons and organizations can comment on the proposed remedy. Evaluating community acceptance includes determining which components of the alternatives interested persons in the community support, have reservations about, or oppose.

Figure 7-1. Evaluation Criteria Specified in the National Contingency Plan

Table 7–1. Comparative Analysis of Alternatives for Landfill No. 4, Landfill No. 3, and Meandering Road Creek

Criteria	Alternative 1, No Action (selected remedy)	Alternative 2a, Capping That Addresses Human Health Risk	Alternative 2b, Capping That Addresses All Risk Areas	Alternative 3a, Removal/Disposal That Addresses Human Health Risk	Alternative 3b, Removal/Disposal That Addresses All Risk Areas
Overall Protection of Human Health and the Environment	Protective of human health. Potential excess ecological risk was considered acceptable because of conservative nature of ecological risk assessment. Rating: Protective	Reduces human health risk. Does not reduce ecological risk, but acceptable because of conservative nature of ecological risk assessment. Rating: Protective	Reduces human health and ecological risk. More protective than no action and Alternative 2a. Rating: Protective'	Reduces human health risk. Does not reduce ecological risk, but acceptable because of conservative nature of ecological risk assessment. More protective of human health than Alternatives 1, 2a, and 2b. Rating: Protective	Reduces human health and ecological risks. Most protective of all alternatives. Rating: Protective
Compliance with ARARs	Complies with ARARs because there are no ARARs requiring action. Rating: Complies	Alternative would comply with ARARs. Rating: Complies	Alternative would comply with ARARs. Rating: Complies	Alternative would comply with ARARs but requires compliance with more ARARs than capping. Rating: Complies	Alternative would comply with ARARs but requires compliance with the most ARARs. Rating: Complies
Long-Term Effectiveness and Permanence	Least effective of all alternatives but still acceptable. Rating: Good	Effective at reducing human health risks but requires maintenance. More effective than Alternative 1. Rating: Good	Effective at reducing health and ecological risks but requires maintenance. More effective than Alternatives 1 and 2a. Rating: Good	Effective at reducing human health risks on site, but long-term liabilities exist at final disposal site. More effective at reducing human health risk than Alternatives 1, 2a, and 2b. Rating: Good	Effective at reducing human health and ecological risks on site, but long-term liabilities exist at final disposal site. Most effective alternative. Rating: Good
Reduction of Toxicity, Mobility, or Volume Through Treatment	Worst alternative at reducing toxicity, mobility, or volume. Rating: Poor	Mobility of BAP is reduced but no change in toxicity or volume. Better than Alternative 1 at reducing mobility. No reduction through treatment. Rating: Poor	Mobility of all contaminants is reduced but no change in toxicity or volume. No reduction through treatment. Better than Alternatives 1 and 2a at reducing mobility. Rating: Poor	Mobility of BAP is reduced but no change in toxicity and volume. No effect on ecological contaminants. Better than Alternatives 1, 2a, and 2b at reducing mobility. Rating: Good	Mobility of all contaminants are reduced, but contaminants would still exist at disposal site. Best alternative at reducing mobility. Rating: Good
Short-Term Effectiveness	No short-term risks to workers or the community during implementation. Best alternative for short-term risks. Rating: Good	Small risk expected during construction activities. Small risk of affecting wetlands. Rating: Good	Small risk expected during construction activities. More short-term risk to Meandering Road Creek and Lake Worth from excavation and dredging than Alterative 2a Rating: Good	Small risk during construction activities. Small risk of affecting wetlands. Transportation-related risks. More short-term risks than Alternatives 1, 2a, and 2b. Rating: Fair	Small risk during construction. Risk to Meandering Road Creek and Lake Worth from excavation and dredging and transportation-related risk. Most short-term risk of all other alternatives. Rating: Fair
Implementability	Easiest to implement because monitoring is the only action. Rating: Good	Easy to implement. Requires acceptance of no action for potential ecological risk. Rating: Good	Easy to implement, but slightly more difficult than Alternatives 1 and 2a. Rating: Good	Transportation issues to be resolved, but services are available. More difficult to implement than Alternatives 1, 2a, and 2b. Rating: Good	Transportation issues to be resolved, but services are available. Readily implemented but most difficult of all alternatives. Rating: Good
Cost	$73,000	$430,000	$473,000	$19,151,000	$19,244,000

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Table 7–2. Summary of ARARs for Landfill No. 4, Landfill No. 3, and Meandering Road Creek

ARAR	Description	Compliance Aspects	Alternatives
Texas Industrial Waste Management Regulations (Texas Administrative Code [TAC], Title 30, Chapter 335)	These regulations establish minimum standards of operation for all aspects of the management and control of hazardous waste generated in the State of Texas. Land disposal restrictions would determine if excavated soil could be placed in a Resource Conservation and Recovery Act landfill.	Sets requirements for storage, [illegible] [illegible] sediments, if it meets the definition of hazardous waste. Excavated soil from Landfill No. 4 was assumed to be hazardous waste and would require treatment before disposal.	2b, 3a, 3b
(CWA) (Section 404)	Act, commonly known as the CWA, governs the control of pollution of the nation's surface water. The objective of the CWA is to restore and maintain the chemical, physical and biological integrity of the nation's surface water. Section 404 of the CWA addresses surface-water dredging and filling.	management and erosion control during construction of a cap or excavation of soil for transportation. Also, controls dredging of the sediments from Meandering Road Creek and Lake Worth.	

No ARARs (chemical-, action-, or location-specific ARARs) are applicable to soil and sediment contamination at Landfill No. 4, Landfill No. 3, and Meandering Road Creek. Therefore, Alternative 1, No Action, would comply with ARARs.

Alternative 2a, Capping That Addresses Human Health Risk Areas, involves the capping of soil contamination at Landfill No. 4. Selection of Alternative 2a requires compliance with Section 404 of the Clean Water Act, a chemical-specific ARAR. This ARAR sets requirements for storm-water management and erosion control during construction of the cap over Landfill No. 4.

ARARs for Alternative 2b consist of the Clean Water Act (Section 404) and Texas Industrial Waste Management Regulations (Texas Administrative Code [TAC], Title 30, Chapter 335), which are chemical-specific ARARs. Section 404 of the Clean Water Act sets requirements for storm-water management and erosion control during construction of the cap on Landfill No. 4 and dredging of sediment from Meandering Road Creek and Lake Worth. The Texas Industrial Waste Management Regulations will determine the storage, treatment, and disposal requirements for soil and sediment excavated from Landfill No. 3 and Meandering Road Creek.

ARARs for Alternative 3a, Removal/Disposal That Addresses Human Health Risk Areas, consist of the Clean Water Act (Section 404) and Texas Industrial Waste Management Regulations (TAC, Title 30, Chapter 335), chemical-specific ARARs. Section 404 of the Clean Water Act sets requirements for storm-water management and erosion control during excavation of soil from Landfill No. 4. The Texas Industrial Waste Management Regulations will determine the storage, treatment, and disposal requirements for the soil excavated from Landfill No. 4. Land disposal restrictions would determine if excavated soil could be place in a Resource Conservation and Recovery Act (RCRA) landfill. ARARs for Alternative 3b, Removal/Disposal That Addresses All Risk Areas, are the same ARARs as for Alternative 3a.

Long-Term Effectiveness and Permanence

The selected alternative, No Action, provides long-term effectiveness because residual risk from existing contamination will be within the acceptable range. The alternative also is permanent, but, compared to the other alternatives, it is the least effective and provides the least permanence. However, monitoring will be conducted to ensure that the selected alternative maintains its required effectiveness and permanence. All the other alternatives provide long-term effectiveness by reducing risk to levels below the threshold criteria. Long-term effectiveness is the highest for Alternatives 3a and 3b because the contaminants in the soil are stabilized before disposal at an off-site location. The selected remedy will ensure the remediation goals are met.

Reduction of Toxicity, Mobility, or Volume Through Treatment

The selected alternative provides no reduction in toxicity, mobility, or volume through treatment. Alternatives 2a and 2b also provide no reduction in toxicity, volume, or mobility through treatment. Although mobility is not reduced through treatment, the mobility of the contaminants is reduced because the cap on Landfill No. 4 will reduce storm-water infiltration into the landfill that could mobilize the contaminants.

Alternatives 3a and 3b are the only alternatives that use treatment (stabilization) to reduce mobility. Treatment of the excavated soil will involve testing to determine if it is hazardous waste. Soil that is hazardous waste will need to comply with land disposal restrictions in 40 CFR 268. No reduction in toxicity or volume of contaminants is achieved with Alternatives 3a and 3b. Alternative 3b provides the greatest reduction in mobility because it considers areas with potential ecological risk.

Short-Term Effectiveness

The selected alternative, No Action, is the best for short-term effectiveness because it has the least risk to workers and the community during implementation of the alternative. It also has the shortest project life for implementation. However, Alternatives 2a, 2b, 3a, and 3b also provide good short-term effectiveness because risk to the community and workers will be minimal and the alternatives will be completed within 1 year.

Alternative 3b involves the greatest short-term risk because of excavation and dredging activities in wetland and stream areas and transportation of contaminated soil and sediments. Alternative 2b involves the same excavation and dredging activities as Alternative 3b. Alternative 3a involves the same transportation activities as Alternative 3b.

Implementability

The selected alternative, No Action, is the easiest to implement, involving only monitoring activities. The other alternatives use established technologies, are relatively easy to implement, and should be successful from a construction standpoint. Comparatively, Alternatives 3a and 3b are the most difficult to implement.

Cost

The No Action Alternative is the best alternative in terms of cost because it requires only monitoring. The estimated present worth cost of the selected alternative is $73,000. Alternatives 3a and 3b have significantly higher present worth costs of $19,151,000 and $19,244,000, respectively. These higher costs are because the excavated soil is assumed to be classified as hazardous waste for disposal, requiring stabilization and expensive disposal fees. The present worth costs for Alternatives 2a and 2b are $430,000 and $473,000, respectively, and involve capping and monitoring for Alternative 2a and capping, monitoring, and dredging for Alternative 2b.

State Acceptance

TNRCC concurs with Alternative 1, No Action, as the selected remedy for Landfill No. 4, Landfill No. 3, and Meandering Road Creek.

Community Acceptance

The Air Force solicited input from the community and from members of the Restoration Advisory Board on the remediation alternatives proposed for Landfill No. 4, Landfill No. 3, and Meandering Road Creek. The comments received from the public and Restoration Advisory Board members indicate that the community will accept the selected remedy with monitoring of contamination levels in Lake Worth and Meandering Road Creek.

There is some concern by members of the public about leaving the contamination in the landfills and the resulting effect on contamination levels in Lake Worth. The city of Fort Worth, which obtains drinking water from Lake Worth, was especially concerned about contamination leaching from the landfills and entering Lake Worth. All comments received during the public comment period and the Air Force responses are in Appendix A, "Responsiveness Summary."

7.4 The Selected Remedy

The Air Force, with the concurrence of the EPA and the State of Texas, has determined that Alternative 1, No Action, meets the threshold criteria while providing the best balance of long-term effectiveness and permanence; reduction in toxicity, mobility, and volume; short-term effectiveness; implementability; and costs while being acceptable to the State and community. As presented in Section 7.1, the remediation goals for Landfill No. 4 are

- Prevent human ingestion of BAP at concentrations that cause an excess ILCR.

- Prevent ecological exposure to concentrations of arsenic, cadmium, and copper from causing harm.

The remediation goal for soil at Landfill No. 3 and the sediments in Meandering Road Creek is

- Prevent ecological exposure to concentrations of copper, lead, and zinc in Landfill No. 3 soil and concentrations of silver and Aroclor-1254 in Meandering Road Creek sediments from causing harm.

Alternative 1, No Action, meets these remediation goals because the current risk to human health from BAP is 1.6×10^{-6} ILCR, which is within the acceptable risk range. Existing levels of contamination show a potential for excess ecological risk; however, a risk management decision was made that no action is acceptable because of the conservative manner in which ecological risk was calculated, the lack of risk for predator species, and the calculated risk was not significantly higher than threshold levels.

The selected remedy will ensure the remediation goals are met by

- Monitoring the contaminant levels in the surface water of Meandering Road Creek. Monitoring will be conducted semiannually and samples will be analyzed for VOCs and metals. The frequency of monitoring may be reduced if contaminant levels continue to decline and the Air Force, EPA, and State of Texas agree to the reduced monitoring. During the remedial design phase, the Air Force will submit to EPA and the State of Texas for their concurrence a detailed monitoring plan defining the frequency of sampling, sampling points, and an analyte list. The detailed monitoring plan may differ slightly from the assumptions stated here.

- Implementing corrective measures if monitoring indicates the concentration of contaminants in Meandering Road Creek are increasing to levels that may cause excess risk or MCLs are being exceeded in Lake Worth. A TCE concentration of approximately 5,000 ug/L is the level that may cause excess risk in Meandering Road Creek surface water, based on ecological risk. The primary MCLs of concern for Lake Worth are TCE with an MCL of 5 ug/L, *cis*-1,2-DCE with and MCL of 70 µg/L, *trans*-1,2-DCE with an MCL of 100 µg/L, and vinyl chloride with an MCL of 2 ug/L. Corrective measures that may be taken include capping or enhancements to the vacuum-enhanced extraction system at Landfill No. 3. Exceedance of MCLs will be determined on a statistical basis.

- Implementing contingency measures if monitoring indicates an increase in the concentrations of contaminants. Contingency measures will include removal or containment of the source material that is causing the increase in surface-water contamination. One contingency measure the Air Force has voluntarily installed, and is operating, is the vacuum-enhanced extraction system at Landfill No. 3, as described in Section 2.2, "Interim Remedial Actions."

The primary factors for selecting Alternative 1, No Action, was that it met the threshold criteria (protection of human health and the environment and compliance with ARARs) and was the most cost effective of all the alternatives. Because the remediation goals are already being met, the long-term effectiveness and permanence for the selected remedy is good. Short-term risks are minimal for the selected remedy, the least short-term risk of all the alternatives, because this alternative only involves monitoring and is readily implemented. The selected remedy does not satisfy the statutory preference for treatment as a principal element.

7.5 Statutory Determinations

The most important aspect of the selected remedial action is to be protective of human health and the environment. Section 121 of CERCLA also requires that the selected remedial action comply with ARARs established under Federal or State laws, unless a waiver is granted. In addition, the selected remedy must be cost effective and use permanent solutions or resource-recovery technologies to the maximum extent practicable. Section 121 also contains a preference for remedial actions that use treatment as a primary element. The following text discusses how selected remedy, Alternative 1, No Action, meets these statutory requirements.

Protection of Human Health and the Environment

The selected remedy, Alternative 1, No Action, is protective of human health and the environment because existing contamination levels do not cause excess risk or are considered acceptable. The most significant human health risk is caused by concentrations of BAP in the soil at Landfill No. 4. Concentrations of BAP in the soil at Landfill No. 4 cause a human health risk of 1.0×10^{-6} ILCR, which is within the acceptable range of 1.0×10^{-6} to 1.0×10^{-4} ILCR.

Concentrations of metals in the soil at Landfill No. 4, soil at Landfill No. 3, sediment in Meandering Road Creek, and sediment in Lake Worth were determined to have the potential to cause excess ecological risk. The potential excess ecological risk is primarily to prey species (e.g., mice, minnows, and aquatic organisms) and not to predator species such as hawks or largemouth bass. One sediment sample from Lake Worth has a concentration of Aroclor-1254, a PCB compound, high enough to potentially cause excess risk to largemouth bass.

Three primary factors were considered in determining that no action to mitigate the potential for ecological risk was acceptable. One factor was that the conservative manner in which potential ecological risk was determined likely overestimated the risk. The ecological risk assessment assumed that the prey species or a largemouth bass would live its entire life only in the area with the contamination. Figure 5-2 shows the sample locations that had concentrations high enough to potentially cause excess risk. The sample locations are isolated, indicating an animal or a fish probably would not spend its entire life in the areas of contamination. The second factor was that the calculated HQs were relatively close to an HQ of 1.0, the threshold value. The third factor was that the risk was primarily to prey species and not to predators.

Compliance With Applicable or Relevant and Appropriate Requirements

No ARARs are applicable to soil and sediment contamination at Landfill No. 4, Landfill No. 3, and Meandering Road Creek. Therefore, Alternative 1, No Action, would comply with ARARs and no waiver of ARARs is required to implement this alternative.

Cost Effectiveness

The No Action Alternative is the most cost effective at managing risk to human health and the environment to within acceptable limits. It is the least expensive alternative, only involving the cost of monitoring.

Use of Permanent Solutions and Treatment or Resource-Recovery Technologies to the Maximum Extent Practicable

The selected remedy, No Action, uses permanent solutions to the maximum extent practicable, considering cost effectiveness and the existing risk to human health and the environment from contamination remaining at sites.

Of the alternatives that are protective of human health and the environment and comply with ARARs, the selected alternative provides the best balance of long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; short-term effectiveness; implementability; costs; and the statutory preference for treatment, while considering State and community acceptance.

Preference for Treatment as a Principal Element

Treatment of the contamination at Landfill No. 4, Landfill No. 3, and Meandering Road Creek is not required because the existing risk to human health and the environment is within acceptable limits. However, because contamination will remain on site, a review will be conducted 5 years after the start of the remedial action. The only activity involved in the remedial action is monitoring. Monitoring has been an ongoing activity at the site and, therefore, the remedial action will begin immediately after the ROD becomes effective.

Documentation of Significant Changes

The Proposed Plan was released for public comment in November 1995. The Proposed Plan identified Alternative 1, No Action, as the selected alternative. The Air Force reviewed all written and oral comments submitted during the public comment period. Comments by members of the Restoration Advisory Board, made before and during the public comment period, also were reviewed. After review of these comments, no significant changes to the selected remedy, as originally identified in the Proposed Plan, were made.

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8.0 Paluxy Aquifer and Upper Sand Groundwater

8.1 Remediation Goals

The remediation goals for the Paluxy aquifer are to prevent future human exposure by ingestion, inhalation during showering, and dermal exposure during showering to TCE concentrations exceeding 5.0 µg/L and to concentrations of 1,2-DCE isomers exceeding 70 µg/L for *cis*-1,2-DCE and 100 µg/L for *trans*-1,2-DCE.

The remediation goals for TCE and 1,2-DCE concentrations in the Paluxy aquifer are based on the MCLs set in the Safe Drinking Water Act. A TCE level of 5.0 µg/L results in a cumulative future risk of 1.7×10^{-6} ILCR, which is within the acceptable risk range of 1.0×10^{-6} to 1.0×10^{-4} ILCR. The risk for exposure to levels of 70 µg/L for *cis*-1,2-DCE and 100 µg/L for *trans*-1,2-DCE results in an HQ that is less than 1.0. Current TCE levels in the Paluxy aquifer are as high as 100 µg/L.

The remedial action objective for groundwater in the Upper Sand is to prevent contamination in the Upper Sand from causing TCE contaminant levels in the Paluxy aquifer to exceed 5.0 µg/L. The Upper Sand groundwater is only found in the area of the East Parking Lot. A TCE level of 400 µg/L in the Upper Sand groundwater was determined adequate to prevent contaminant levels in the Paluxy aquifer from exceeding 5.0 µg/L. The TCE level of 400 µg/L is based on a mixing calculation that estimates a volume and concentration of Upper Sand groundwater that would mix with a volume of clean Paluxy aquifer groundwater. Current contamination levels in the Upper Sand groundwater range from ND to approximately 10,000 µg/L.

8.2 Documentation of Significant Changes

The Proposed Plan was released for public comment in November 1995. A draft of the Proposed Plan was released to members of the Restoration Advisory Board before the public comment period. The Draft Proposed Plan identified Alternative 3a, Groundwater Extraction With Air Stripping, as the selected alternative. Members of the Restoration Advisory Board expressed considerable concern about the use of air stripping because contaminants would be released to the atmosphere. Considering the concern expressed by members of the Restoration Advisory Board, the Air Force chose Alternative 3b, Groundwater Extraction With Ultraviolet Oxidation, as the selected alternative.

The Final Proposed Plan dated November 1995 identified Alternative 3b, Groundwater Extraction With Ultraviolet Oxidation, as the selected alternative. Alternative 3b was presented as the selected alternative at the public meeting on the Proposed Plan. The Air Force reviewed all written and oral comments submitted during the public comment period.

After review of these comments, the Air Force changed the name of the selected alternative, Alternative 3b, from "Groundwater Extraction and Treatment With Ultraviolet Oxidation" to "Groundwater Extraction and Treatment With Near-Zero Off-Gas Emissions." The name of the alternative was changed to allow use of other technologies that would result in near-zero off-gas emissions. The alternative is still based on using ultraviolet oxidation (a technology with near-zero off-gas emissions) but accommodates the use of other technologies such as air stripping with off-gas treatment if that technology is deemed more appropriate during remedial design. The selected alternative still meets the public's concern of minimizing contaminants released to the atmosphere.

8.3 Description of Alternatives

Three alternatives were developed to address contamination in the Paluxy aquifer and Upper Sand groundwater in the Paluxy Formation. Alternative 3 is presented as Alternative 3a and Alternative 3b because two different approaches to treatment of the extracted groundwater were considered. Several treatment processes were screened in the Feasibility Study. Treatment by air stripping with no control of off-gas emissions and ultraviolet oxidation (a technology that limits off-gas emissions to a minimum) were identified as the best processes for contaminated Paluxy groundwater. The alternatives make use of treatment, containment, and institutional controls.

- Alternative 1, No Action
- Alternative 2, Alternate Water Supply
- Alternative 3a, Groundwater Extraction and Treatment With Air Stripping
- Alternative 3b, Groundwater Extraction and Treatment With Near-Zero Off-Gas Emissions (selected remedy)

Alternative 1, No Action

Present Worth:	$274,000
Implementation Time:	0 years

Alternative 1, No Action, assumes that no additional activities would be conducted to remediate TCE and 1,2-DCE contamination in the Paluxy aquifer and the Upper Sand groundwater. The only activity in the alternative is monitoring to track the movement and contaminant levels in the aquifer. Monitoring will continue as long as contamination exceeds remediation goals in the Paluxy aquifer and Terrace Alluvial flow system. The implementation time of 0 years does not include the length of time that monitoring will be required. Monitoring will continue as long as contaminant levels exceed remediation goals in the Paluxy aquifer and Terrace Alluvial flow system.

Alternative 2, Alternate Water Supply

Present Worth:	$937,000
Implementation Time:	1 year

Alternative 2 supplies a source of water for the city of White Settlement that would not be jeopardized by TCE and 1,2-DCE contamination. New water supply wells will be drilled into the Travis Peak/Twin Mountain aquifer, the aquifer below the Paluxy aquifer. The Travis Peak/Twin Mountain aquifer has proven production rates and water quality and currently is being used by the cities of Fort Worth and White Settlement.

This alternative also includes monitoring the TCE plume in the Paluxy aquifer and Upper Sand groundwater to track its movement and concentration levels but does not include any extraction or treatment of contaminated groundwater. Monitoring will continue as long as contamination exceeds remediation goals for the Paluxy aquifer and Terrace Alluvial flow system. The implementation time of 1 year does not include the length of time that monitoring will be required.

Alternative 3a, Groundwater Extraction and Treatment With Air Stripping

Present Worth:	$2,541,000
Implementation Time:	3 years for Paluxy aquifer
	15 years for Upper Sand groundwater

Alternative 3a uses extraction and treatment with air stripping to remove contaminants from the Paluxy aquifer and Upper Sand groundwater. Two areas of the Paluxy aquifer are included in this alternative, an area under Landfill No. 3 and an area under the East Parking Lot. Components of the alternative include

- Extraction of contaminated Paluxy aquifer groundwater from under Landfill No. 3.
- Extraction of contaminated Paluxy aquifer groundwater from beneath the Window Area of the East Parking Lot Plume. Contamination in this area currently is below MCLs but extraction of groundwater will be initiated if MCLs are exceeded.
- Extraction of contaminated Upper Sand groundwater to minimize contamination that moves vertically from groundwater in the Terrace Alluvial flow system to the Paluxy aquifer.
- Treatment of the extracted groundwater with air stripping and discharge of the treated water to surface water or a sewage treatment plant.
- Installation of additional monitoring wells in the Upper Sand groundwater and in the Paluxy aquifer.
- Monitoring of contaminant movement and concentrations in both the Paluxy aquifer and Upper Sand groundwater. Monitoring will continue as long as contamination exceeds remediation goals in the Paluxy aquifer and Terrace Alluvial flow system, estimated at 15 years for the Terrace Alluvial flow system.

Air stripping will be used to treat the contaminants in the extracted groundwater, primarily TCE and 1,2-DCE. The air-stripping system for this alternative will be a modification to the system being used for the interim action currently operating in the East Parking Lot. The air stripper will comply with all Federal, State, and local clean air requirements, including those specific to Tarrant County, Texas. Based on anticipated concentration levels in the groundwater, off-gas treatment would not be required to meet air-quality requirements. If the air stripper does not meet air quality requirements, catalytic oxidation or carbon adsorption will be added to help the system meet requirements. The cost of catalytic oxidation or carbon adsorption is not included in the cost estimate.

Remediation of contamination in the Paluxy aquifer (i.e., the plume located under Landfill No. 3) is estimated to take 3 years. This alternative assumes one extraction well in the vicinity of Landfill No. 3 to extract groundwater from the Paluxy aquifer. Extraction of groundwater from the Upper Sand portion of the Paluxy Formation will continue until remediation of the East Parking Lot Plume is completed, estimated at 15 years.

Alternative 3b, Groundwater Extraction and Treatment With Near-Zero Off-Gas Emissions (selected remedy)

Present Worth:	$3,101,000
Implementation Time:	3 years for Paluxy aquifer
	15 years for Upper Sand groundwater

Alternative 3b is the selected alternative for remediation of contamination in the Paluxy aquifer and Upper Sand groundwater. This alternative has all the components of Alternative 3a except that extracted groundwater is treated with ultraviolet oxidation (or another technology that would result in near-zero off-gas emissions) instead of air stripping. Other technologies may be air stripping with an off-gas treatment system that uses vapor-phase carbon adsorption or catalytic oxidation. Ultraviolet oxidation is the representative technology used for evaluation in this alternative. Ultraviolet oxidation treatment is a fully developed technology that uses ultraviolet light and oxidation to destroy contaminants in the groundwater and minimizes contaminants released to the air. No treatability tests have been conducted using ultraviolet oxidation at Plant 4.

Remediation of contamination in the Paluxy aquifer is estimated to take 3 years. Extraction of groundwater from the Upper Sand portion of the Paluxy Formation will continue until remediation of the East Parking Lot Plume is completed, estimated at 15 years for this alternative.

8.4 Comparative Analysis of Alternatives

The selected remedy for the Paluxy aquifer and the Upper Sand groundwater is Alternative 3b, Groundwater Extraction and Treatment With Near-Zero Off-Gas Emissions. Table 8-1 presents a comparative analysis of the four alternatives.

Table 8-1. Comparative Analysis of Alternatives for the Paluxy Aquifer and Upper Sand Groundwater

Criteria	Alternative 1, No Action	Alternative 2, Alternate Water Supply	Alternative 3a, Extraction With Air-Stripping and Treatment	Alternative 3b Extraction and Treatment With Near-Zero Off-Gas Emissions (selected remedy)
Overall Protection of Human Health and the Environment	Contaminants unmitigated; may affect White Settlement production wells in time. Rating: Not Protective	Contaminants unmitigated; safe alternate water supply provided for White Settlement. Rating: Protective	Protects human health and the environment by removing contaminated groundwater and treating with air stripping. Rating: Protective	Protects human health and the environment by removing contaminated groundwater and treating with ultraviolet oxidation. Rating: Protective
Compliance with ARARs	Would not comply with any ARARs. Rating: Does Not Comply	Complies with some but not all ARARs. Rating: Does Not Comply	Would comply with all ARARs. Rating: Complies	Would comply with all ARARs. Rating: Complies
Long-Term Effectiveness and Permanence	Provides the worst long-term effectiveness or permanence of all alternatives. Rating: Poor	Provides permanent, long-term, and safe drinking water for White Settlement but has no effect on the contaminant plumes. Rating: Poor	Effective at removing TCE and 1,2-DCE from the groundwater; permanent solution [illegible] contaminants. Rating: Good	Effective at removing TCE and 1,2-DCE from the groundwater; permanent solution for extracted contaminants. Rating: Good
Reduction of Toxicity, Mobility, or Volume Through Treatment	Reduction in toxicity and volume over time through natural attenuation. No change to mobility. No reduction through treatment. Rating: Poor	Reduction in toxicity and volume over time through natural attenuation. No change to mobility. No reduction through treatment. Rating: Poor	Reduces mobility [illegible] contaminants in the groundwater. Rating: Good	Reduces mobility and volume of contaminants in the groundwater. Reduces toxicity by destroying contaminants with ultraviolet oxidation. Best of all alternatives. Rating: Good
Short-Term Effectiveness	No effects on the community or the workers. Best of all alternatives. Rating: Good	No expected effects on the community or the workers. Rating: Good	Safety requirements [illegible] installation but no [illegible] effects on the community [illegible] workers. Rating: Good	Safety requirements for system installation but no expected effects on the community or the workers. Rating: Good
Implementability	Requires no action to implement. Easiest to implement of all alternatives. Rating: Good	Services, vendor, and equipment readily available. Requires coordination with the city of White Settlement. Rating: Good	Straightforward construction and operation. Services, vendors, and technology are readily available. Rating: Good	Straightforward construction and operation. Services, vendors, and technology available. Most difficult of all alternatives to implement but still readily implemented. Rating: Good
Cost	$274,000	$937,000	$2,541,000	$3,101,000

Overall Protection of Human Health and the Environment

The selected alternative, Alternative 3b, is protective of human health and the environment. Alternatives 2 and 3a also are protective of human health and the environment. Alternative 2, Alternate Water Supply, protects human health by providing a source of drinking water in the Travis Peak/Twin Mountain aquifer. Alternative 3a and Alternative 3b provide protection by removing the contamination in the Paluxy aquifer. Alternative 1, the No Action Alternative, is not protective of human health and the environment because contamination exceeding MCLs in the Paluxy aquifer is allowed to migrate to drinking-water wells.

Compliance With Applicable or Relevant and Appropriate Requirements

Table 8–2 summarizes the ARARs applicable to all the alternatives.

Table 8–2. Summary of ARARs for the Paluxy Aquifer and Upper Sand Groundwater

ARAR	Description	Compliance	Alternatives
[illegible] Water Standards (TAC, Title 31, Part IX, Chapter 290)	[illegible] Drinking Water Standards. These standards are written to comply with the requirements of the Safe Drinking Water Act and Federal Primary Drinking Water Regulations. The purpose of these standards is to ensure the safety of public water supplies.	[illegible] standards for contaminant levels in the water supply of White Settlement.	[illegible]
Water Quality Standards (TAC, Title 30, Part II, Chapter 307)	quality of surface water in the State consistent with public health and enjoyment, protection of the environment, and operation of existing industries and economic development. Quality standards for surface water are established in this chapter.	treatment systems would need to be in compliance with State surface-water quality standards.	
National Pollutant Discharge Elimination System (NPDES) (40 CFR Part 403)	The NPDES was designed to regulate and reduce pollution discharges to navigable waters of the United States.	Discharges from the treatment systems would need to meet the requirements established in this ARAR.	3a, 3b
Texas Regulation V: Control of Pollution from Volatile Organic Compounds (TAC, Title 31, Chapter 115)	This chapter requires the control of VOCs and sets standards for VOC emissions and controls.	Releases of VOCs to the air, caused by treatment of groundwater, would need to comply with these State regulations.	3a, 3b

Table 8-2 (continued). Summary of ARARs for the Paluxy Aquifer and Upper Sand Groundwater

ARAR	Description	Compliance	Alternatives
TAC Guidance Document, *Exemption 68*	This document provides guidance for the air emissions from various treatment systems to be used on remediation projects.	The chosen air stripping and ultraviolet oxidation treatment systems would comply with the levels set in this document.	3a, 3b

Alternative 1, No Action, fails to ensure safe drinking water for the population of White Settlement in the future and does not provide for remediation of contaminated groundwater. This alternative would not comply with the following ARARs:

- Texas Drinking Water Standards (Texas Administrative Code [TAC], Title 31, Part IX, Chapter 290)

Alternative 2, Institutional Controls, involves procuring a new water supply for White Settlement. This procurement would ensure that the White Settlement population is not adversely affected by the presumed contamination of its potable production wells. By providing a safe potable water supply to the population of White Settlement, this alternative would comply with the following ARAR:

- Texas Drinking Water Standards (TAC, Title 31, Part IX, Chapter 290)

However, the NCP requires that drinking water aquifers be remediated to MCLs or nonzero MCLGs, as specified in the Safe Drinking Water Act. The Texas Drinking Water Standards is the State standard that incorporates the requirements of the Safe Drinking Water Act. Alternative 2 does not meet the requirement of remediating the Paluxy aquifer (a drinking water aquifer) to levels set in the Texas Drinking Water Standards.

Alternative 3a involves installation of a groundwater extraction and treatment system to protect the White Settlement drinking water supply and provide remediation for existing groundwater contamination. The effluent water from the treatment system would be discharged to the surface water requiring compliance with the National Pollutant Discharge Elimination System (NPDES).

The treatment system for Alternative 3a uses air stripping to remove dissolved volatile contaminants. Air emissions from the air stripper are regulated under TAC Guidance Document, *Exemption 68*. Removal of contaminants from the groundwater would result in compliance with Federal and State contaminant-level standards. Alternative 3a would comply with the following ARARs:

- Texas Drinking Water Standards (TAC, Title 31, Part IX, Chapter 290)

- Texas Surface Water Quality Standards (TAC, Title 30, Part II, Chapter 307)

- National Pollutant Discharge Elimination System (40 CFR Part 403)

- Texas Regulation V: Control of Pollution from Volatile Organic Compounds (TAC, Title 31, Chapter 115)

- TAC Guidance Document *Exemption 68*

Alternative 3b also involves installation of a groundwater extraction and treatment system to protect the White Settlement drinking water supply and provide remediation for existing groundwater contamination. The effluent water from the treatment system would be discharged to the surface water and would require compliance with NPDES and State of Texas criteria.

The treatment system for Alternative 3b uses ultraviolet oxidation to destroy dissolved volatile contaminants. Air emissions from the air stripper are regulated under TAC Guidance Document *Exemption 68*. Removal of contaminants from the groundwater would result in compliance with Federal and State contaminant-level standards. Alternative 3b would comply with the following ARARs:

- Texas Drinking Water Standards (TAC, Title 31, Part IX, Chapter 290)

- Texas Surface Water Quality Standards (TAC, Title 30, Part II, Chapter 307)

- National Pollutant Discharge Elimination System (40 CFR Part 403)

- Texas Regulation V: Control of Pollution from Volatile Organic Compounds (TAC, Title 31, Chapter 115)

- TAC Guidance Document *Exemption 68*

Long-Term Effectiveness and Permanence

The selected alternative, Alternative 3b, provides good long-term effectiveness because contaminants are permanently removed from the aquifer. Alternative 3a provides the same degree of permanence as the selected alternative. Alternative 2 provides less long-term effectiveness and permanence because contamination is left in the aquifer. The No Action Alternative provides the least long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 1 and 2 provide no reduction in toxicity, mobility, or volume of contaminants. Only Alternatives 3a and 3b provide a reduction in mobility and volume of contaminants through treatment. Alternative 3b provides more reduction in toxicity than the other alternatives because contaminants are destroyed when treating the extracted groundwater. The contaminants are transferred from the groundwater to the air with Alternative 3a, Groundwater Extraction and Treatment With Air Stripping.

Short-Term Effectiveness

Alternatives 3a and 3b involve the most activities to complete and provide the highest potential for short-term risk to the community and workers. The short-term risk is highest for Alternatives 3a and 3b because of the activities (construction and operation of remediation equipment) that are not included in the other alternatives. These alternatives also require the longest time to complete: 3 years to remediate contamination in the Paluxy aquifer and 15 years for groundwater remediation activities in the Upper Sand. Even though the short-term risk is highest for Alternatives 3a and 3b, the risk is expected to be minimal.

There are no expected short-term risks to the community from activities required for Alternative 2. Short-term risks to workers for Alternative 2 would be minimal because the only activities are drilling new production wells. The No Action Alternative provides the least short-term risk to the community and workers and the shortest time to implement because there are no activities, other than monitoring, that could endanger workers or the community.

Implementability

Alternative 3b is relatively easy to implement because readily available technology is used. However, when compared with the other alternatives, it is the most difficult to implement because it involves more activities. Alternative 3a is also relatively easy to implement because readily available technology is used. However, Alternative 3a and Alternative 3b will be more difficult to implement than Alternative 1 and Alternative 2. The No Action Alternative is the easiest to implement because it involves only monitoring.

Cost

The present worth cost of Alternative 3b is $3,101,000, the highest of the alternatives. Alternative 3b has a higher present worth cost than Alternative 3a ($2,541,000) because ultraviolet oxidation treatment is more expensive than treatment with air stripping. Alternative 2, Alternate Water Supply, has a present value of $937,000. The No Action Alternative is the least expensive because it involves only monitoring. It has a present worth cost of $274,000.

State Acceptance

The Texas Natural Resource Conservation Commission concurs with selection of Alternative 3b, Groundwater Extraction and Treatment With Near-Zero Off-Gas Emissions, as the preferred remedy for contamination in the Paluxy aquifer and Upper Sand groundwater.

Community Acceptance

The Air Force solicited input from the community and from members of the Restoration Advisory Board on the remediation alternatives proposed for the Paluxy aquifer and Upper Sand groundwater. The comments received from the public and Restoration Advisory Board members indicate that the community is supportive of the selected remedy, Alternative 3b, Groundwater Extraction and Treatment With Near-Zero Off-Gas Emissions.

A draft of the Proposed Plan presented to members of the Restoration Advisory Board had Alternative 3a, Groundwater Extraction and Treatment With Air Stripping, as the preferred alternative. Members of the Restoration Advisory Board expressed concern over the use of air stripping for treatment because contaminants would be released to the atmosphere. Tarrant County, Texas, is a nonattainment zone for ozone, and air stripping would release VOCs to the atmosphere. This release of VOCs could contribute to ozone formation. However, the levels of VOCs released to the atmosphere would be within the allowable limits established by State of Texas regulations.

On the basis of comments received from the public, the Air Force, with the concurrence of EPA and the State of Texas, agreed to select Alternative 3b, Groundwater Extraction and Treatment With Near-Zero Off-Gas Emissions, as the selected alternative. Alternative 3b was the preferred alternative in the final Proposed Plan that was presented at the public meeting in December 1995. All comments received during the public comment period and the Air Force responses are in Appendix A, "Responsiveness Summary."

8.5 The Selected Remedy

The Air Force, with the concurrence of the EPA and the State of Texas, has determined that Alternative 3b, Groundwater Extraction and Treatment With Near-Zero Off-Gas Emissions, is the best remedy for achieving the remediation goals and meeting public acceptance. As presented in Section 8.1, the remediation goals for the Paluxy aquifer and Upper Sand groundwater are

- Prevent future human exposure by ingestion, inhalation during showering, and dermal exposure during showering to TCE concentrations exceeding 5.0 µg/L and to concentrations of 1,2-DCE isomers exceeding 70 µg/L for *cis*-1,2-DCE and 100 µg/L for *trans*-1,2-DCE.

- Prevent contamination in the Upper Sand groundwater from causing allowable TCE contaminant levels (i.e., 5.0 µg/L) in the Paluxy aquifer to be exceeded. TCE concentrations that are less than 400 µg/L in the Upper Sand groundwater were determined adequate to prevent contamination in the Paluxy aquifer from exceeding 5.0 µg/L.

These goals are based on the MCLs for TCE, *cis*-1,2-DCE, and *trans*-1,2-DCE. The cumulative ILCR for TCE for three exposure pathways (ingestion, dermal exposure during showering, and inhalation during showering) is 1.7×10^{6} ILCR. The chemical 1,2-DCE is a noncarcinogen and the risk from exposure to levels of *cis*-1,2-DCE at 70 µg/L and *trans*-1,2-DCE at 100 µg/L results in a HQ of less than 1.0.

The allowable TCE concentration in the Upper Sand groundwater of 400 µg/L is based on a mixing calculation. The mixing calculation used estimated horizontal flow in the Paluxy aquifer, an allowable TCE concentration in the Paluxy aquifer of 5.0 µg/L, and estimated vertical flow from the Terrace Alluvial flow system to the Upper Sand groundwater to determine an allowable TCE concentration in the Window Area of the Terrace Alluvial flow system. The allowable TCE concentration of 400 µg/L determined for the Window Area of the Terrace Alluvial flow system was also the allowable level assumed for the Upper Sand groundwater because all the flow in the Upper Sand groundwater is from the Terrace Alluvial flow system. The remediation goal for the Upper Sand groundwater may be lowered if the calculated level of 400 µg/L is shown not to be protective of the Paluxy aquifer.

On the basis of information obtained during the remedial investigation and the analysis of remedial alternatives, the Air Force, the EPA, and the State of Texas believe that the selected groundwater remedy will attain these goals. The selected alternative meets the remediation goals by

- Extracting contaminated Paluxy aquifer groundwater from under Landfill No. 3.

- Extracting contaminated Paluxy aquifer groundwater from beneath the Window Area of the East Parking Lot. Contamination in this area currently is below MCLs but extraction of groundwater will be initiated if MCLs are exceeded. Exceedance of MCLs will be determined on a statistical basis.

- Extracting contaminated Upper Sand groundwater to minimize contamination that moves vertically from groundwater in the Terrace Alluvial flow system to the Paluxy aquifer.

- Treating the extracted groundwater with ultraviolet oxidation and discharging the treated water to surface water or a sewage treatment plant.

- Installing additional monitoring wells in the Upper Sand groundwater and in the Paluxy aquifer to monitor contaminant movement and concentrations in both the Paluxy aquifer and Upper Sand groundwater. Monitoring will continue as long as contamination exceeds remediation goals in the Paluxy aquifer and Terrace Alluvial flow system, estimated at 15 years for the Terrace Alluvial flow system.

A more detailed description of the selected remedy follows. It should be noted that certain aspects of the selected remedy may change during remedial design. The costs of the selected remedy are

Capital Cost (extraction system with air stripping)	$2,091,000
Present Worth of Operation and Maintenance (O&M) Costs	451,000
Present Worth of Monitoring	559,000
Worth of Selected Remedy	$3,101,000

Capital costs are assumed to occur within the first year and include installation of groundwater extraction wells, installation of an ultraviolet oxidation treatment system, piping from the treatment system to the discharge point, electrical connections, and installation of monitoring wells. O&M costs would include electrical requirements, water sampling for compliance, and equipment maintenance and replacement. Monitoring costs include obtaining samples from monitoring wells and laboratory analysis of those samples to monitor contaminant concentrations and movement.

Extraction of groundwater from the Paluxy aquifer under Landfill No. 3 will be performed with one extraction well estimated to pump at 45 gallons per minute (gal/min). Groundwater will be extracted from the Upper Sand groundwater to contain contamination that has migrated from the Terrace Alluvial flow system. Extraction from the Upper Sand groundwater will be from eight wells, five existing monitoring wells and three new wells. Pumping rates are expected to vary from 1 to 19 gal/min. One ultraviolet oxidation unit will be located near Landfill No. 3 to treat water extracted from the Paluxy in this area and another ultraviolet oxidation unit will be located near the East Parking Lot to treat water extracted from the Upper Sand groundwater.

Monitoring will be conducted to track contaminant levels in the Paluxy aquifer and Upper Sand groundwater, especially near the downgradient edge of the plume. The locations of monitoring wells, number of monitoring wells, and frequency of sampling will be established to provide early detection of contamination before it migrates off site and to monitor performance of the remedial action. If the contamination appears to be moving off site at concentrations that exceed MCLs (i.e., 5.0 μg/L for TCE) in either the Paluxy aquifer or Upper Sand groundwater, the remedial action will be modified to capture the contamination before it moves off Federal property.

The following assumptions for monitoring are based on a preliminary plan. The final monitoring plan, to be developed during remedial design, will be more detailed and may be slightly different.

- Contamination levels in the Paluxy aquifer near Landfill No. 3 will be monitored with samples obtained from two wells located near the downgradient extent of the plume.

- Contamination levels in the Paluxy aquifer near the East Parking Lot will be monitored with samples obtained from wells located near the downgradient extent of contamination in the Upper Sand groundwater.

- Contamination levels in the Upper Sand groundwater will be monitored with samples obtained from wells near the downgradient extent of contamination and near the Window Area. The downgradient (eastern) extent of contamination in the Upper Sand groundwater is not well defined and new monitoring wells are anticipated in this area to better define the contamination.

- Sampling will be conducted semiannually during remediation and then annually after remediation is completed. Monitoring will be discontinued when contaminant levels have been shown to remain below remediation goals. The remediation goal for the Upper Sand (400 µg/L) is an estimate based on a calculated TCE concentration in the Upper Sand groundwater that is protective of groundwater in the Paluxy aquifer (i.e., will not cause TCE concentrations in the Paluxy aquifer to exceed 5.0 µg/L). The remediation goal for the Upper Sand groundwater may be lowered if the calculated level of 400 µg/L is shown not to be protective of the Paluxy aquifer.

- Sampling will be discontinued in the Paluxy aquifer near Landfill No. 3 if contamination levels remain below remediation goals. Sampling in the Paluxy aquifer near the East Parking Lot will be discontinued if contamination levels remain below remediation goals after remediation of the Upper Sand groundwater is completed. Sampling of the Upper Sand groundwater will be discontinued if contamination remains below remediation goals after remediation of the Upper Sand groundwater and the Window Area of the East Parking Lot are completed.

- All samples will be analyzed for VOC and metal concentrations.

Groundwater contamination may be especially persistent in the immediate vicinity of a source (e.g., the area under Building 181 in the Terrace Alluvial flow system). The ability to achieve cleanup goals at all points throughout the area of attainment, or plume, cannot be determined until the extraction system is implemented and modified, as necessary, and the plume response is monitored over time. If the selected remedy cannot meet remediation goals, at any or all of the monitoring points during implementation, contingency measures and goals may replace the selected remedy.

If implementation of the selected remedy clearly demonstrates, in corroboration with strong hydrogeological and chemical evidence, that it will be technically impracticable to achieve and maintain remediation goals, contingency measures will be implemented. At a minimum, and as a necessary condition for invoking any contingency, the Air Force will demonstrate that contaminant levels have ceased to substantially decline over time and are remaining relatively constant at some statistically significant level above remediation goals in a discrete portion of the plume, as verified by samples obtained from multiple monitoring wells.

If it is determined, on the basis of the preceding criteria and system performance data, that certain portions of the aquifer cannot be restored to the remediation goals, all or some of the following measures involving long-term management may occur for an indefinite period of time:

- Source containment involving either a physical barrier system or a hydraulic barrier system.
- Low-level pumping as a long-term control of groundwater flow and containment measure.
- Institutional controls, such as deed notifications on water-supply well construction and use.
- Waiver of chemical-specific ARARs for the cleanup of those portions of the aquifer on the technical basis of the impracticability of achieving further contaminant reduction.

The decision to implement any or all of these measures may be made during a periodic review of the remedial action that will occur at 1-year intervals. A ROD amendment or an Explanation of Significant Differences will be issued to inform the public of the details of these actions when they occur.

8.6 Statutory Determinations

The most important aspect of the selected remedial action is to be protective of human health and the environment. Section 121 of CERCLA also requires that the selected remedial action comply with ARARs established under Federal or State laws, unless a waiver is granted. In addition, the selected remedy must be cost effective and use permanent solutions or resource-recovery technologies to the maximum extent practicable. Section 121 of CERCLA also contains a preference for remedial actions that use treatment as a primary element. The following sections discuss how the selected remedy, Alternative 3b, Groundwater Extraction and Treatment With Near-Zero Off-Gas Emissions, meets the statutory requirements.

Protection of Human Health and the Environment

The selected remedy protects human health and the environment by reducing concentrations of TCE and 1,2-DCE in the Paluxy aquifer to MCLs. Of all the alternatives, the selected remedy provides the best protection of human health and the environment and addresses the public's concern regarding releasing contaminants to the atmosphere.

The selected remedy will eliminate the potential for excess future risk to human health by reducing concentrations of TCE and 1,2-DCE in the Paluxy aquifer. Future human health risk may be caused by exposure from contaminated groundwater through ingestion, inhalation during showering, and dermal exposure during showering. The cumulative carcinogenic risk from exposure to groundwater with TCE concentrations of 5.0 µg/L is 1.7×10^{-6} ILCR. The HQ for exposure to *cis*-1,2-DCE concentrations of 70 µg/L and *trans*-1,2-DCE concentrations of 100 µg/L is less than 1.0.

Compliance With Applicable or Relevant and Appropriate Requirements

The selected remedy will comply with all ARARs and an ARAR waiver will not be required for implementation. The Paluxy aquifer is a drinking water aquifer and remediation to MCLs is required. The treated groundwater will be discharged to surface waters so the requirements of State of Texas water quality standards and NPDES must be met. ARARs governing the release of VOCs to the atmosphere are applicable, but the selected remedy will use ultraviolet oxidation, a technology that destroys the contaminants, or a technology that uses off-gas treatment to minimize contaminants that are released to the atmosphere.

Cost Effectiveness

The Air Force, with the concurrence of the EPA and the State of Texas, believe the selected remedy, Alternative 3b, Groundwater Extraction and Treatment With Near-Zero Off-Gas Emissions, is cost effective at meeting the remediation goals and protecting human health and the environment. The selected remedy has the highest net present worth of all the alternatives ($3,101,000) but is the only alternative that meets the remediation goals, complies with all ARARs, and does not release contaminants to the atmosphere. Alternative 3a, Groundwater Extraction and Treatment With Air Stripping, has a lower net present worth ($2,541,000), meets remediation goals, and complies with ARARs but uses a treatment technology that releases contaminants to the atmosphere. Alternative 3b was chosen as the selected remedy because it does not release contaminants to the atmosphere and has a net present worth that is not significantly higher than Alternative 3a.

Use of Permanent Solutions and Treatment or Resource-Recovery Technologies to the Maximum Extent Practicable

The selected remedy uses permanent solutions and treatment technologies to the maximum extent practicable. Of the alternatives that meet the threshold criteria, the selected remedy provides the best balance of trade-offs in terms of the balancing criteria. The selected remedy provides the best long-term effectiveness and permanence and the best reduction in toxicity, mobility, and volume. Short-term risks for the selected remedy are reasonable and do not endanger the community or workers during implementation of the remedy. The cost of the selected remedy is the highest of all the alternatives, but it is considered cost effective because it meets the remediation goals, complies with ARARs, and addresses the public's concern about releasing contaminants to the atmosphere.

Preference for Treatment as a Principal Element

The selected remedy meets the statutory preference for treatment as a principal element. The principal threat to human health is TCE and 1,2-DCE contamination in the Paluxy aquifer that exceeds MCLs. The selected remedy addresses the principal threat by extracting and treating contaminated groundwater until contamination levels in the Paluxy aquifer are below MCLs. Extracted groundwater is treated with ultraviolet oxidation before being discharged to surface waters.

The selected remedy also uses treatment to address contamination in the Upper Sand groundwater that is a cause of contamination in the Paluxy aquifer under the East Parking Lot. The same treatment technology, ultraviolet oxidation, will be used for contaminated groundwater extracted from the Upper Sand groundwater as will be used for contaminated groundwater in the Paluxy aquifer.

9.0 East Parking Lot Groundwater Plume and Terrace Alluvial Flow System

9.1 Remediation Goals

The following remediation goals for groundwater in the East Parking Lot Groundwater Plume and Terrace Alluvial flow system are based on preventing further contamination of the Paluxy aquifer and migration of contamination off site:

- Prevent TCE concentrations in the Window Area of the East Parking Lot Groundwater Plume from exceeding 400 µg/L.

- Remove DNAPL from the groundwater in the area under Building 181 and under the southern portion of the Assembly Building/Parts Plant.

- Prevent groundwater in the East Parking Lot Plume and Terrace Alluvial flow system with contamination above MCLs from migrating off Air Force Plant 4 or Naval Air Station Fort Worth and prevent groundwater contamination from causing excess risk in surface water. Exceedance of MCLs will be determined on a statistical basis.

The first remedial action objective is based on a calculated maximum concentration in the Window Area of the East Parking Lot Plume that will not cause TCE levels in the Paluxy aquifer to exceed 5.0 µg/L. DNAPL may be present in the Window Area and, if present, would have to be removed before TCE concentrations of 400 µg/L could be met.

For purposes of compliance with the TCE concentration of 400 µg/L, the Window Area is defined as the area beneath the East Parking Lot where the aquitard is less than 2 ft thick (see Figure 5–1). The Window Area is approximated by an area 500-ft in diameter centered around monitoring well W–149. During remedial activities, other areas could be identified that meet the definition of the Window Area (i.e., an area where the aquitard is less than 2 ft thick). If other areas do meet the definition of the Window Area, the allowable TCE concentrations for those areas also will be 400 µg/L.

The second remedial action objective of removing DNAPL from the groundwater will be demonstrated by reducing TCE concentrations to levels below 10,000 µg/L. The TCE level of 10,000 µg/L is approximately 1 percent of TCE's solubility in water (1,100,000 µg/L). This value was chosen on the basis of technical information suggesting that DNAPL may be present when TCE concentrations are as low as 1 percent of its solubility in water.

Groundwater in the Terrace Alluvial flow system is not used as a drinking water source by Air Force Plant 4 or Naval Air Station Fort Worth because of low yield and poor quality of water and because the Paluxy aquifer is a readily available source of good quality water. However, the potential exists that an individual off site could use this groundwater as drinking water. Because of this potential, the third remedial action objective was established to prevent groundwater that has contamination above MCLs from migrating beyond Federal property boundaries. Exceedance of MCLs also applies to the West Fork of the Trinity River and will be the target for determining if corrective action is needed. A TCE concentration of 5,000 µg/L in Farmers Branch Creek, based on ecological risk, will be another target for determining if corrective action is needed.

9.2 Description of Alternatives

Three alternatives were developed to address contamination in the East Parking Lot Groundwater Plume of the Terrace Alluvial flow system. Alternative 2 is presented as Alternative 2a and Alternative 2b because two different types of treatment for the extracted groundwater were considered. Treatment, containment, and institutional controls are used in Alternatives 2a, 2b, and 3. Alternative 3 uses an innovative technology.

- Alternative 1, No Action
- Alternative 2a, DNAPL/Groundwater Extraction and Treatment With Air Stripping
- Alternative 2b, DNAPL/Groundwater Extraction and Treatment With Ultraviolet Oxidation
- Alternative 3, Enhanced DNAPL/Groundwater Extraction and Treatment With Air Stripping and Destruction of Contaminants (selected remedy)

Alternative 1, No Action

Alternative 1 assumes that no additional activities would occur to impede or remediate the DNAPL or the dissolved TCE concentration in the East Parking Lot Plume. The only activity included in this alternative is monitoring to track the movement and the concentrations of contaminants in the East Parking Lot Plume and Terrace Alluvial groundwater.

In addition to the East Parking Lot Plume, monitoring would include the North Plume and West Plume in the Terrace Alluvial flow system, Meandering Road Creek, Lake Worth, and Farmers Branch Creek. The present worth cost of Alternative 1 is $822,000.

Alternative 2a, DNAPL/Groundwater Extraction and Treatment With Air Stripping

Alternative 2a involves removal of DNAPL, remediation of dissolved TCE, and treatment of extracted groundwater. Components of this alternative include

- Remove DNAPL by dissolution into the groundwater and then extract the groundwater. Removal of DNAPL would be expedited by injection of clean water to help increase dissolution of the DNAPL.

- Treat the extracted groundwater with air stripping as the primary treatment after the extracted groundwater passes through an oil/water separator. Treated groundwater would be discharged to surface water or to a sewage treatment plant.

- Potential use of a barrier to separate the Window Area from high TCE concentrations in the area of Building 181. The barrier could be a slurry wall, a system of interceptor wells, or a horizontal well. The barrier may be installed at the beginning of the project or following efforts to remove the DNAPL (whether or not the DNAPL is successfully removed). The remedial design will determine if a barrier is needed at the beginning of the project.

- Initiate institutional controls to restrict future use of the Terrace Alluvial groundwater at Air Force Plant 4 and Naval Air Station Fort Worth.

- Monitor to track plume movement and determine if the plume is likely to move off site. Monitoring also would include the North Plume and West Plume in the Terrace Alluvial flow system, Meandering Road Creek, Lake Worth, and Farmers Branch Creek. Monitoring will be conducted to ensure that remediation goals are being met and to determine if contaminated groundwater is moving off site.

- Install additional monitoring wells.

If migration of contamination in the groundwater appears to be moving off site at concentrations above MCLs, remedial measures will be taken to stop movement of the plume. Remedial measures could involve various containment measures, such as interceptor wells, an interceptor trench, a combination of wells and a trench, or a slurry wall, and operation of the pump-and-treat system at Naval Air Station Fort Worth Landfills No. 4 and No. 5.

DNAPL contamination removal would be by natural dissolution into the groundwater and extraction from wells. A TCE concentration of 10,000 µg/L will be used to determine if the DNAPL has been removed to acceptable levels. When TCE concentrations drop below 10,000 µg/L, the assumption will be that DNAPL has been removed. However, recognizing that TCE concentrations will increase after extraction has stopped, remediation will continue until concentrations drop below 7,500 µg/L (75 percent of 10,000 µg/L). If concentrations then increase to levels above 10,000 µg/L, remediation will begin immediately and continue until the TCE concentration drops below 7,500 µg/L again. This level would apply to the groundwater under Building 181.

The allowable TCE concentration for the Window Area is 400 µg/L, which is based on meeting the MCL for TCE in the Paluxy aquifer. Although the Window Area is not directly downgradient from Building 181, it will be affected by TCE concentrations under Building 181. If the higher TCE concentrations under Building 181 affect the TCE concentrations in the Window Area so that the 400-µg/L concentration goal cannot be attained, a barrier will be used to isolate the Window Area from higher upgradient TCE concentrations.

Air stripping will be used to treat the contaminants in the extracted groundwater, primarily TCE and 1,2-DCE. The current groundwater extraction and air-stripping system in the East Parking Lot will be expanded and used for this alternative. The air stripper will comply with all Federal, State, and local clean air requirements, including those specific to Tarrant County, Texas. If the air stripper does not meet air quality requirements, catalytic oxidation or carbon adsorption will be added to help the system meet requirements.

The present worth cost of this alternative is $6,882,000. Remediation of contamination in the East Parking Lot Plume with this alternative is estimated to take more than 100 years. This alternative requires extraction of groundwater from the Upper Sand portion of the Paluxy Formation to continue for the entire life (more than 100 years) of this alternative to keep contamination from reaching the Paluxy aquifer.

Alternative 2b, DNAPL/Groundwater Extraction and Treatment With Ultraviolet Oxidation

Alternative 2b has all the components of Alternative 2a except that treatment is by ultraviolet oxidation rather than air stripping. Ultraviolet oxidation treatment uses ultraviolet light and oxidation to destroy contaminants in the groundwater. Use of the current air-stripping system in the East Parking Lot will be discontinued.

The present worth cost of this alternative is $7,334,000. Remediation of contamination in the East Parking Lot Plume is estimated to take more than 100 years. This alternative requires that extraction of groundwater from the Upper Sand portion of the Paluxy Formation continue for the entire life of this alternative (more than 100 years) to keep contamination from reaching the Paluxy aquifer.

Alternative 3, Enhanced DNAPL/Groundwater Extraction and Treatment With Air Stripping and Destruction of Contaminants (selected remedy)

Alternative 3 is the selected alternative for the East Parking Lot Groundwater Plume. This alternative is similar to Alternatives 2a and 2b except that removal of DNAPL would be enhanced with the use of surfactants. Surfactants are chemicals that can be injected into the groundwater to increase the dissolution of DNAPL and, therefore, reduce the remediation time. The use of surfactants is considered an innovative technology.

The existing groundwater extraction and air-stripping system in the East Parking Lot will be expanded and modified to allow surfactant recovery and reuse. Also, destruction of contaminants in the effluent from the air stripper will be done with catalytic oxidation or vapor-phase carbon adsorption. The present worth cost of this alternative is $10,118,000. Remediation of contamination in the East Parking Lot Plume with this alternative is estimated to take 15 years. This alternative requires that extraction of groundwater from the Upper Sand portion of the Paluxy Formation continue for the entire life (15 years) of this alternative to keep contamination from reaching the Paluxy aquifer.

9.3 Comparative Analysis of Alternatives

The selected alternative for the East Parking Lot Groundwater Plume is Alternative 3, Enhanced DNAPL/Groundwater Extraction and Treatment With Air Stripping and Destruction of Contaminants. Table 9–1 presents a comparative analysis of the four alternatives.

Overall Protection of Human Health and the Environment

Alternative 3, Enhanced DNAPL/Groundwater Extraction and Treatment With Air Stripping and Destruction of Contaminants, provides the best protection of human health and the environment because it has the highest potential of removing DNAPL from the groundwater within a reasonable time period and thereby meet the remediation goals. Alternatives 2a and 2b are protective of human health and the environment because the traditional groundwater extraction techniques used in these alternatives eventually will remove the DNAPL, but it will take more than 100 years to complete. Alternative 1, No Action, is not protective of human health and the environment because contamination from the Terrace Alluvial flow system would continue to migrate to the Paluxy aquifer.

Overall Compliance With Applicable or Relevant and Appropriate Requirements

This section describes the ARARs that each alternative will be required to meet and if the alternatives will be able to meet those ARARs. Table 9–2 presents a summary of the ARARs for the East Parking Lot Groundwater Plume.

The No Action Alternative, Alternative 1, would result in a decrease in TCE concentrations measured across the site because of natural attenuation, decomposition, and dispersion from the plume as it migrates with the groundwater. This process is slow and would not occur in time to prevent risk to human health and the environment. TCE would continue to diffuse through the Window Area into the Paluxy aquifer and could affect the potable wells in White Settlement. This alternative does not adequately provide any control or prevention of this exposure risk. This alternative fails to ensure safe drinking water for the population of White Settlement and does not provide environmental remediation of contaminated groundwater and would not comply with the following ARAR:

- Texas Drinking Water Standards (TAC, Title 31, Part IX, Chapter 290)

Alternative 2a uses air stripping to remove dissolved volatile contaminants and an oil/water separator to remove emulsified DNAPL. Air emissions from the air stripper are regulated under TAC Guidance Document *Exemption 68*. Removal of contaminants from the groundwater would

Table 9–1. Comparative Analysis of Alternatives for the East Parking Lot Plume

Criteria	Alternative 1, No Action	Alternative 2a, Extraction and Treatment With Air Stripping	Alternative 2b, Extraction With Ultraviolet Oxidation	Alternative 3, Enhanced Extraction With Destruction of Contaminants (selected remedy)
Overall Protectiveness	Contaminants may affect the White Settlement production wells in time. Least protective alternative. Rating: Not Protective	Treatment method is protective because dissolved contaminants are removed. Rating: Protective	Treatment method is protective because dissolved contaminants are destroyed. Protection is not provided until extraction of groundwater has continued for more than 100 years. Rating: Protective	Treatment method is protective because dissolved contaminants are removed. Extraction method may provide protection within a reasonable time. Most protective alternative. Rating: Protective
Compliance with ARARs	Would not comply with ARARs. Rating: Does Not Comply	Would comply with ARARs. Rating: Complies	Would comply with ARARs. Rating: Complies	Would comply with ARARs. Rating: Complies
Long-Term Effectiveness and Permanence	Alternative provides the least long-term effectiveness, and is not a permanent solution. Rating: Poor	Effective at removing VOCs from extracted groundwater, a permanent solution. Extraction method not effective at removing DNAPL from the aquifer. Less effective than Alternative 3. Rating: Fair	Effective at destroying VOCs in extracted groundwater; a permanent solution. Extraction method not effective at removing DNAPL from the aquifer. Less effective than Alternative 3. Rating: Fair	Air stripping is effective at removing VOCs from extracted groundwater. Enhanced extraction would help remove DNAPL. Potentially the most effective alternative but considerable uncertainty with performance of the technology. Rating: Good
Reduction of Toxicity, Mobility, or Volume Through Treatment	Reduction in toxicity and volume over time; no change in mobility. Rating: Poor	Reduces mobility and volume through groundwater pumping; reduces toxicity through treatment with air stripping. Rating: Fair	Reduces mobility and volume through groundwater well pumping; reduces toxicity by destroying dissolved organic contamination through ultraviolet oxidation. Rating: Fair	Reduces mobility and volume by removing DNAPL source areas; reduce toxicity through treatment with air stripping. Rating: Good
Short-Term Effectiveness	No risks to the community or workers, but natural attenuation would take the longest time of all alternatives to reach remediation goals. Rating: Poor	Safety requirements for system installation. No expected impacts to workers or nearby communities. Expected project life is more than 100 years. Rating: Poor	Safety requirements for system installation. No expected effect on workers or community. Expected project life is more than 100 years. Rating: Poor	Safety requirements for system installation. No expected effect on workers or nearby communities. Project life is 15 years. Rating: Good
Implementability	Easiest alternative to implement. Rating: Good	Services, vendors, and technology are readily available. Easy to implement. Rating: Good	Services, vendors, and technology are readily available. Pretreatment of water may be required. Treatability testing may be required. Easier to implement than Alternative 3. Rating: Good	Innovative technology; has not been proven at full scale. Pilot testing required. Most difficult alternative to implement but still implementable. Rating: Good
Cost	$822,000	$6,882,000	$7,334,000	$10,118,000

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Table 9–2. Summary of ARARs for the East Parking Lot Plume

Standards (TAC, Title 31, Part IX, Chapter 290)	Texas Drinking Water Standards. These standards are written so as to comply with the requirements of the Safe Drinking Water Act and Federal Primary Drinking Water Regulations. The purpose of these standards is to ensure the safety of public water supplies.	contamination migrating to the Paluxy Upper Sand and then to the Paluxy aquifer must be controlled to comply with this alternative.	
Texas Surface Water Quality Standards (TAC, Title 30, Part II, Chapter 307)	The goal of this chapter is to maintain the quality of surface water in the State consistent with public health and enjoyment, protection of the environment, and operation of existing industries and economic development. Quality standards for surface water are established in this chapter.	Discharges from the treatment systems would need to be in compliance with State surface water quality standards.	2a, 2b, 3
National Pollutant Discharge Elimination System (NPDES) (40 CFR Part 403)	NPDES was designed to regulate and reduce pollution discharges to navigable waters of the United States.	Discharges from the treatment systems would need to meet the requirements established in this ARAR.	2a, 2b, 3
Control of Pollution from Volatile Organic Compounds (TAC, Title 31, Chapter 115)	VOCs and sets standards for VOC emissions and controls.	air, caused by treatment of groundwater, would need to comply with these State regulations.	
Document *Exemption 68*	for the air emissions from various treatment systems to be used on remediation projects.	system would comply with the levels set in this document.	

result in compliance with Federal and State contaminant level standards. Alternative 2a would comply with the following ARARs:

- Texas Drinking Water Standards (TAC, Title 31, Part IX, Chapter 290)
- Texas Surface Water Quality Standards (TAC, Title 30, Part II, Chapter 307)
- National Pollutant Discharge Elimination System (40 CFR Part 403)

- Texas Regulation V: Control of Pollution from Volatile Organic Compounds (TAC, Title 31, Chapter 115

- TAC Guidance Document *Exemption 68*

Alternative 2b also involves installing a groundwater extraction/remediation system to pump groundwater and remove dissolved TCE. The major treatment method to be used in Alternative 2b is an ultraviolet oxidation process with an oil/water separator to remove emulsified DNAPL. This method oxidizes the molecules of the contaminants into components that are nontoxic and is an irreversible treatment process. It does not involve changing the state of the contaminants as does air stripping. ARARs controlling releases of VOCs are not included for Alternative 2b because the treatment process destroys the contaminants and does not release them to the atmosphere. Alternative 2b would comply with the following ARARs:

- Texas Drinking Water Standards (TAC, Title 31, Part IX, Chapter 290)

- Texas Surface Water Quality Standards (TAC, Title 30, Part II, Chapter 307)

- National Pollutant Discharge Elimination System (40 CFR Part 403)

Alternative 3 involves locating and removing the DNAPL and installing a groundwater extraction/remediation system. By first locating the DNAPL through tracers, then targeting the DNAPL with surfactants designed for the Terrace Alluvial flow system, the DNAPL may be removed. After the source is removed or if it is determined necessary before the source is removed, a slurry wall may be installed upgradient of the Window Area. This installation would alter the direction and amount of contaminated water flowing to the Window Area. The construction of the slurry wall with DNAPL-resistant materials should not pose a regulatory problem as such materials are already in use. The addition of surfactants into the groundwater must be approved by TNRCC.

Alternative 3 uses air stripping with vapor-phase carbon adsorption or catalytic oxidation to remove dissolved volatile contaminants and then destroy the contaminants before they are released to the atmosphere. Air emissions from the air stripper would be directed to the vapor-phase carbon adsorption or catalytic oxidation units. Releases from the vapor-phase carbon adsorption or catalytic oxidation units are regulated under TAC Guidance Document *Exemption 68*. Alternative 3 would comply with the following ARARs:

- Texas Drinking Water Standards (TAC, Title 31, Part IX, Chapter 290)

- Texas Surface Water Quality Standards (TAC, Title 30, Part II, Chapter 307)

- National Pollutant Discharge Elimination System (40 CFR Part 403)

- Texas Regulation V: Control of Pollution from Volatile Organic Compounds (TAC, Title 31, Chapter 115
- TAC Guidance Document *Exemption 68*

Long-Term Effectiveness and Permanence

No reliable and proven techniques are available for effectively removing DNAPL from groundwater. Alternative 3, the selected alternative, is an innovative technology that increases the dissolution of TCE contamination into the groundwater and, therefore, has the highest potential of removing the DNAPL. However, because Alternative 3 is an innovative technology, there is considerable uncertainty with its performance. If it is successful, it would provide the most-effective and permanent solution within a reasonable time period.

Alternatives 2a and 2b use groundwater pumping to extract DNAPL from groundwater. This method is not effective because it relies on natural dissolution of TCE contamination into groundwater to remove the concentration of TCE. Groundwater extraction is an effective method of removing dissolved contamination but dissolution of TCE DNAPL into the groundwater is a slow process that makes Alternatives 2a and 2b ineffective. No Action, Alternative 1, provides the least long-term effectiveness and permanence because it relies entirely on natural dissolution of the TCE DNAPL into the dissolved phase and then natural attenuation of the dissolved TCE.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 2a and 2b and the selected alternative, Alternative 3, all reduce mobility and volume through treatment by removing TCE contamination from the groundwater. Alternatives 2b and 3 provide reduction in toxicity because contaminants are destroyed in the ultraviolet oxidation, catalytic oxidation, or carbon adsorption process. It should be noted that contaminants are only destroyed with the carbon adsorption process when the carbon is regenerated. Contaminants are only transferred from groundwater to air with the air-stripping treatment used in Alternative 2a. Alternatives 2a and 2b provide a much slower reduction in toxicity, mobility, and volume than Alternative 3 because removal of contaminants from the groundwater is dependent on natural dissolution.

Alterative 1, No Action, provides the least reduction in toxicity, mobility, or volume through treatment because it relies on natural attenuation.

Short-Term Effectiveness

The No Action Alternative would have the least short-term risk to workers and the community from a remedial action but would take the longest time to reach cleanup levels. Alternatives 2a and 2b will have minimal short-term risks to workers and the community but have long remediation times, more than 100 years. Alternative 3 also will have minimal short-term risk to workers and the community but will be the most intensive remedial action and, therefore, have the highest short-term risks to workers and the community during its project life of 15 years. Because Alternatives 2a and 2b have such long project lives, they have higher overall short-term risks to the community and workers than the selected alternative.

Alternatives 2a and 2b rely on the natural dissolution of DNAPL into the groundwater for removal. Because TCE has a low solubility, the estimated time for the DNAPL to dissolve and allow cleanup levels to be reached is more than 100 years. The No Action Alternative would take longer to dissolve the DNAPL than Alternatives 2a and 2b.

Implementability

The No Action Alternative is the easiest to implement, requiring only monitoring. Alternatives 2a and 2b are relatively easy to implement because established technologies are used. Alternative 2b is more difficult to implement than Alternative 2a because treatment with ultraviolet oxidation is more complex than treatment with air stripping. The selected alternative, Alternative 3, is the most difficult to implement because it uses new technology.

Cost

The selected alternative is the most expensive with a present worth cost of $10,118,000. The No Action Alternative is the least expensive, involving only monitoring, with a present worth cost of $822,000. Alternatives 2a and 2b have present worth costs of $6,882,000 and $7,334,000, respectively.

If either Alternative 2a or 2b were the selected alternative, the selected alternative for the Paluxy aquifer and Upper Sand groundwater will be required to operate for the entire project life of more than 100 years. This extended period of operation would result in an increase of the present worth cost of the selected alternative for the Paluxy aquifer and Upper Sand groundwater.

State Acceptance

The Texas Natural Resource Conservation Commission concurs with the selected alternative.

Community Acceptance

The Air Force solicited input from the community and from members of the Restoration Advisory Board on the remediation alternatives proposed for the East Parking Lot Plume. The comments received from the public and Restoration Advisory Board members indicate that the community is supportive of the selected remedy, Alternative 3, Enhanced DNAPL/Groundwater Extraction and Treatment With Air Stripping and Destruction of Contaminants.

The draft Proposed Plan was presented to members of the Restoration Advisory Board. The preferred alternative in the draft Proposed Plan was Alternative 3, but it did not include destruction of contaminants from the air stripper. Members of the Restoration Advisory Board expressed concern over the use of air stripping for treatment because contaminants would be released to the atmosphere. Tarrant County, Texas, is a nonattainment zone for ozone; air stripping would release VOCs to the atmosphere and could contribute to ozone formation. However, the levels of VOCs released to the atmosphere would be within the allowable limits established by State of Texas regulations.

On the basis of comments received from the public, the Air Force, with the concurrence of the EPA and the State of Texas, agreed to modify Alternative 3 to include destruction of contaminants. Air discharged from the air stripper will pass through a catalytic oxidation unit or vapor-phase carbon adsorption units to remove contamination before being released to the atmosphere. Alternative 3, as modified to include destruction of contaminants, was the preferred alternative in the final Proposed Plan that was presented at the public meeting in December 1995. All comments received during the public comment period and the Air Force responses are in Appendix A, "Responsiveness Summary."

9.4 The Selected Remedy

The Air Force, with the concurrence of the EPA and the State of Texas, has determined that Alternative 3, Enhanced DNAPL/Groundwater Extraction and Treatment With Destruction of Contaminants, is the best remedy for achieving the remediation goals. As presented in Section 9.1, the remediation goals for the East Parking Lot Groundwater Plume are

- Prevent TCE concentrations in the Window Area of the East Parking Lot Groundwater Plume from exceeding 400 µg/L.
- Remove DNAPL from the groundwater in the soil under Building 181 and under the southern portion of the Assembly Building/Parts Plant.
- Prevent groundwater in the East Parking Lot Plume and Terrace Alluvial flow system with contamination above MCLs from migrating off Air Force Plant 4 or Naval Air Station Fort Worth and prevent groundwater contamination from causing excess risk in surface water. Exceedance of MCLs will be determined on a statistical basis.

The first remedial action objective is based on a calculated concentration in the East Parking Lot Plume that will not cause TCE levels in the Paluxy aquifer to exceed 5.0 µg/L. DNAPL may be present in the Window Area and, if present, would have to be removed before TCE concentrations of 400 µg/L could be met. For purposes of compliance with the TCE concentration of 400 µg/L, the Window Area is defined as the area where the aquitard is less than 2 ft thick. This area is approximately 500 ft in diameter and is centered around monitoring well W-149. During remedial activities, other areas could be identified that meet the definition of the Window Area. If other areas do meet the definition of the Window Area, the allowable TCE concentrations for those areas also will be 400 µg/L.

The second remedial action objective is to remove DNAPL from the groundwater. This remedial action objective will be demonstrated by reducing TCE concentrations to levels below 10,000 µg/L. The TCE level of 10,000 µg/L is approximately 1 percent of TCE's solubility in water (1,100,000 µg/L). This value was chosen on the basis of technical information suggesting that DNAPL may be present when TCE concentrations are as low as 1 percent of its solubility in water.

Groundwater in the Terrace Alluvial flow system is not used as a drinking water source by Air Force Plant 4 or Naval Air Station Fort Worth because of low yield and poor quality of water and because the Paluxy aquifer is a readily available source of good quality water. Therefore, no risk is associated with contamination in the Terrace Alluvial flow system within the boundaries of Plant 4 and Naval Air Station Fort Worth. However, the potential exists that an individual off site could use this groundwater as drinking water. Because of this potential, the third remedial action objective was established to prevent groundwater that has contamination above MCLs from leaving Federal property boundaries.

Exceedance of MCLs also applies to the West Fork of the Trinity River and will be the target for determining if corrective action is needed. A TCE concentration of 5,000 µg/L in Farmers Branch Creek, based on ecological risk, will be another target for determining if corrective action is needed.

On the basis of information obtained during the remedial investigation and the analysis of remedial alternatives, the Air Force, the EPA, and the State of Texas believe that the selected groundwater remedy will attain these goals. The selected remedy meets the remediation goals by

- Removing DNAPL by enhanced dissolution into the groundwater and then extracting the groundwater.

- Treating the extracted groundwater with air stripping as the primary treatment after the extracted groundwater passes through an oil/water separator. Treated groundwater would be discharged to surface water or to a sewage treatment plant. Air discharged from the air stripper will pass through a catalytic oxidation unit or vapor-phase carbon adsorption units before being discharged to the atmosphere.

- Potential use of a barrier to separate the Window Area from high TCE concentrations in the area of Building 181. The barrier could be a slurry wall, a system of interceptor wells, or a horizontal well. The barrier may be installed at the beginning of the project or following efforts to remove the DNAPL (whether or not the DNAPL is successfully removed). The remedial design will determine if a barrier is needed at the beginning of the project.

- Initiating institutional controls to restrict future use of the Terrace Alluvial groundwater at Air Force Plant 4 and Naval Air Station Fort Worth.

- Monitoring to track the areal extent and movement of contamination, the contaminant levels within and around the DNAPL remediation area, and the changes in contaminant concentrations within the plume. Monitoring also would include the North Plume and West Plume in the Terrace Alluvial flow system, Meandering Road Creek, Lake Worth, and

Farmers Branch Creek. Monitoring will be conducted to ensure that remediation goals are being met and to determine if contaminated groundwater is moving off site.

- Installing additional monitoring wells.

- If migration of contamination in the groundwater appears to be moving off site at concentrations above MCLs, corrective actions will be taken to stop the plume. Corrective actions could involve various containment measures, such as interceptor wells, an interceptor trench, a combination of wells and a trench, or a slurry wall, and operation of the pump-and-treat system at Naval Air Station Fort Worth Landfills No. 4 and No. 5.

A more detailed description of the selected remedy follows. It should be noted that certain aspects of the selected remedy may change during remedial design. The costs of the selected remedy are

Capital Cost	$ 7,753,000
Present Worth of O&M Costs	1,166,000
Present Worth of Monitoring Costs	1,199,000
Total Present Worth of Alternative 3	$10,118,000

Capital costs are assumed to occur within the first year and include installation of groundwater extraction wells, purchase of surfactants, installation of an air-stripping treatment system and a catalytic oxidation unit to treat the air discharged from the air stripper, piping from the treatment system to the discharge point, electrical connections, and installation of additional monitoring wells. O&M costs include electrical requirements, water sampling for compliance, and equipment maintenance and replacement. Monitoring costs are annual costs that include obtaining samples from monitoring wells and laboratory analysis of those samples.

Extraction of groundwater from the East Parking Lot Plume will be from approximately 10 extraction wells operating at one time with each well estimated to pump 5 gal/min. Only a small area of the East Parking Lot Plume will be remediated at a time to ensure better control of the surfactant injection and extraction processes. The initial assumption is that an area being remediated would have 10 injection and 10 extraction wells.

Monitoring will be conducted to track contaminant levels in the Terrace Alluvial flow system (includes the East Parking Lot Plume, North Plume, and West Plume) and potentially affected surface waters. The location of monitoring wells, number of monitoring wells, and frequency of sampling in the North Plume and the West Plume will be established to provide early detection of contamination before it migrates off site at levels that exceed MCLs of the contaminants.

The locations of monitoring wells, number of monitoring wells, and frequency of sampling in the East Parking Lot Plume will be established to monitor remedial action in the Window Area (remediation goal of 400 µg/L), to monitor remedial action in the DNAPL area (remediation goal of 10,000 µg/L), and to provide early detection of contamination along the perimeter of the plume before it migrates off site at levels that exceed the MCLs of the contaminants.

If monitoring indicates that contamination in the East Parking Lot Plume, the North Plume, or the West Plume may migrate off Federal property at levels that exceed MCLs, remedial actions or additional monitoring wells will be considered. Remedial actions may include an interceptor-well system similar to the system at Landfill No. 3. The existing system at Naval Air Station Fort Worth Landfills No. 4 and No. 5 could also be reactivated if remediation goals are not being met. Also, the Air Force, with the concurrence of the EPA and the State of Texas, may use other technologies such as permeable treatment walls to mitigate contamination moving off Federal boundaries.

The following assumptions for monitoring are based on a preliminary plan. The final monitoring plan, to be developed during remedial design, will be more detailed and may be slightly different.

- Contamination levels in the DNAPL remediation area of the East Parking Lot Plume will be monitored with analysis of samples from wells located near the edge of the suspected DNAPL area and within the Window Area. Monitoring will be performed as needed during DNAPL remediation (estimated at 15 years), semiannually at a minimum, and then annually after the remediation is completed.

- Contamination levels along the perimeter of the East Parking Lot Plume and the boundaries of Plant 4 and Naval Air Station Fort Worth will be monitored with analysis of samples from wells located to allow detection of contamination before it can migrate off Federal boundaries. Samples will be taken semiannually during remediation of the DNAPL area and then may be taken annually if contamination levels remain relatively steady and are not increasing.

- Contamination levels in the West Plume will be monitored with analysis of samples from wells near the boundary of Plant 4. Sampling will be conducted semiannually for at least 5 years and then may be performed annually if contamination levels remain relatively steady and are not increasing.

- Contamination levels in the North Plume will be monitored with analysis of samples from wells near the boundary of Plant 4. Sampling will be conducted semiannually for at least 5 years and then may be performed annually if contamination levels remain relatively steady and are not increasing.

- Contamination levels in the surface waters of Lake Worth, Farmers Branch Creek, and the West Fork of the Trinity River will be monitored with analysis of samples from several locations. Sampling points will be located where the surface water is most likely to be affected by contaminated groundwater discharge. Sampling will be conducted semiannually, except for annual sampling of the West Fork of the Trinity River.

- Sampling of the North Plume, the West Plume, and the perimeter areas of the East Parking Lot Plume will be discontinued when it can be demonstrated that the concentrations of contaminants in the plumes will not exceed MCLs at the Federal property boundaries. Sampling of Lake Worth will be discontinued when sampling of the North Plume is discontinued. Sampling of Farmers Branch Creek and the West Fork of the Trinity River will be discontinued when sampling of the East Parking Lot Plume perimeter is discontinued.

- Additional monitoring wells will be installed where needed.
- All samples will be analyzed for VOC and metal concentrations.

Surfactant-enhanced extraction of DNAPL is the most promising of all technologies and approaches considered to meet the remediation goals that are applicable to the East Parking Lot Plume. However, the use of surfactants to remove DNAPL is an innovative technology and there is considerable uncertainty about its performance.

The contingency measures described in Section 8.5, "The Selected Remedy," for the Paluxy aquifer and Upper Sand groundwater are also applicable to the selected remedy for the East Parking Lot Plume.

9.5 Statutory Determinations

The most important aspect of the selected remedy is to be protective of human health and the environment. Section 121 of CERCLA also requires that the selected remedial action comply with ARARs established under Federal or State laws, unless a waiver is granted. In addition, the selected remedy must be cost effective and use permanent solutions or resource-recovery technologies to the maximum extent practicable. Section 121 also contains a preference for remedial actions that use treatment as a primary element. The following text discusses how the selected remedy, Alternative 3, Enhanced DNAPL/Groundwater Extraction and Treatment With Air Stripping and Destruction of Contaminants, meets the statutory requirements.

Protection of Human Health and the Environment

The selected remedy protects human health and the environment by reducing concentrations of TCE in the Window Area of the East Parking Lot Plume to 400 µg/L. The selected remedy has the best potential of restoring the groundwater in the East Parking Lot Plume to required levels. A TCE concentration of 400 µg/L was determined as the maximum allowable concentration in the Window Area that would not cause TCE concentrations in the Paluxy aquifer to exceed 5.0 µg/L, the MCL for TCE.

Contamination in the East Parking Lot Plume has migrated onto Naval Air Station Fort Worth where TCE-contaminated groundwater discharges to Farmers Branch Creek. Present levels of TCE contamination do not cause excess human health or ecological risk in Farmers Branch Creek. Contamination levels in Farmers Branch Creek will be monitored to ensure allowable levels are not exceeded.

Farmers Branch Creek flows into the West Fork of the Trinity River, which is used as a drinking water supply. Monitoring of contamination in the West Fork of the Trinity River also will be conducted to ensure MCLs are not exceeded.

Compliance With Applicable or Relevant and Appropriate Requirements

The selected remedy will comply with all ARARs, and an ARAR waiver will not be required for implementation. The groundwater in the East Parking Lot Plume and Terrace Alluvial flow system is not used as drinking water on Air Force Plant 4 or Naval Air Station Fort Worth so remediation to MCLs is required. The treated groundwater will be discharged to surface waters so the requirements of State of Texas water quality standards and NPDES must be met. ARARs governing the release of VOCs to the atmosphere are applicable, but the selected remedy will use air stripping with off-gas treatment to minimize contaminants that are released to the atmosphere.

Cost Effectiveness

The Air Force, with the concurrence of the EPA and the State of Texas, believes the selected remedy, Alternative 3, Enhanced DNAPL/Groundwater Extraction and Treatment With Air Stripping and Destruction of Contaminants, is cost effective at meeting the remediation goals and protecting human health and the environment. The selected remedy has the highest net present worth of all the alternatives ($10,118,000) but is the only alternative that has the potential to meet the remediation goals within a reasonable time period (i.e., 15 years), complies with all ARARs, and does not release contaminants to the atmosphere.

Alternatives 2a and 2b have a lower net present worth ($6,882,000 and $7,334,000, respectively) but cannot meet the remediation goals within a reasonable time period. Traditional groundwater extraction techniques have been shown to be ineffective at removing DNAPL and, therefore, it would take more than 100 years for Alternative 2a or 2b to meet remediation goals.

Use of Permanent Solutions and Treatment or Resource-Recovery Technologies to the Maximum Extent Practicable

The selected remedy uses permanent solutions and treatment technologies to the maximum extent practicable. Of the alternatives that meet the threshold criteria (protection of human health and environment and compliance with ARARs), the selected remedy provides the best balance of trade-offs in terms of the balancing criteria. The selected remedy provides the best long-term effectiveness and permanence and the best reduction in toxicity, mobility, and volume and is best in terms of short-term risks to workers and the community.

The cost of the selected remedy is the highest of all the alternatives, but it is considered cost effective because it has the best chance of all the alternatives of meeting remediation goals. The selected remedy also is the most difficult of all the alternatives to implement because it uses an innovative technology. However, the selected remedy is still readily implemented.

Preference for Treatment as a Principal Element

The selected remedy meets the statutory preference for treatment as a principal element. The principal threat to human health is TCE and 1,2-DCE contamination in the Paluxy aquifer that exceeds MCLs. The selected remedy addresses the principal threat by removing DNAPL and reducing contamination levels in the Window Area of the East Parking Lot Plume to levels that will not cause MCLs to be exceeded in the Paluxy aquifer. Extracted groundwater is treated with air stripping before being discharged to surface waters. Also, air discharged from the air stripper will be treated with an off-gas treatment system before being released to the atmosphere.

9.6 Documentation of Significant Changes

The Proposed Plan was released for public comment in November 1995. A draft of the Proposed Plan was released to members of the Restoration Advisory Board before the public comment period. The Draft Proposed Plan identified Alternative 3, Enhanced DNAPL/Groundwater Extraction and Treatment With Air Stripping and Destruction of Contaminants, as the selected alternative. There was considerable concern by members of the Restoration Advisory Board about the use of air stripping because contaminants would be released to the atmosphere. Considering the concern expressed by members of the Restoration Advisory Board, the Air Force revised the selected alternative to include vapor-phase carbon adsorption or catalytic oxidation to remove TCE from the effluent of the air stripper.

The final Proposed Plan, dated November 1995, included the revised Alternative 3, Enhanced DNAPL/Groundwater Extraction and Treatment With Air Stripping and Destruction of Contaminants, as the selected remedy. The revised Alternative 3 was presented as the selected remedy at the public meeting on the Proposed Plan. The Air Force reviewed all written and oral comments submitted during the public comment period. After review of these comments, no significant changes to the selected remedy, as identified in the Proposed Plan dated November 1995, were made.

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10.0 Building 181

10.1 Remediation Goals

The remedial action objective for the soil under Building 181 is to prevent TCE concentrations in the soil from causing unacceptable groundwater contamination in the Paluxy aquifer.

The soil cleanup level was based on a concentration of TCE in the soil that would not allow leachate from the soil to exceed Terrace Alluvial groundwater cleanup levels. A TCE soil contamination level of 11.5 mg/kg was established on the basis of an allowable leachate concentration that would migrate from the soil to the Terrace Alluvial groundwater. The allowable TCE concentration in the leachate was assumed to be 5,000 µg/L. A level one-half the remedial action objective for TCE in groundwater (10,000 µg/L) was used to add conservatism and to ensure that peak concentrations in the groundwater would not result from TCE contamination in soil.

10.2 Description of Alternatives

Two alternatives were developed for TCE contamination in the soil under Building 181, No Action and Soil-Vapor Extraction. Soil-vapor extraction was the only treatment alternative developed because EPA has designated this method as a presumptive remedy for VOC contamination in soil, where the technology is applicable on the basis of site conditions. Pilot tests conducted at Plant 4 to test the applicability of soil-vapor extraction show it to be effective.

- Alternative 1, No Action
- Alternative 2, Soil-Vapor Extraction (selected remedy)

Alternative 1, No Action

Present Worth: $0
Implementation Time: 0 years

Alternative 1 assumes that no activities will occur to remediate the contaminated soil. Monitoring is not included in this alternative. TCE concentrations in the groundwater will be monitored as part of the selected alternative for the East Parking Lot Groundwater Plume. No costs are associated with the No Action Alternative because the only monitoring would be of the Terrace Alluvial groundwater and costs for monitoring the Terrace Alluvial groundwater are included in the alternatives for the East Parking Lot Plume.

Alternative 2, Soil-Vapor Extraction (selected remedy)

Present Worth: $612,000
Implementation Time: 5 years

Alternative 2 is the selected alternative for this site. It will be used to remove TCE contamination from the soil under Building 181. Alternative 2 is essentially an expansion of the pilot-scale system currently in operation. Components of this alternative include

- Vapor-recovery wells. An initial estimate of 18 vapor-recovery wells has been determined, but this number could change depending on the subsurface conditions encountered.
- A blower to create a vacuum in the wells and extract the TCE contamination.
- Removal of contaminants from the extracted air before release to the atmoshpere. Contaminants may be removed with vapor-phase carbon adsorption, catalytic oxidation, or another technology that removes the contamination in the air before it is released to the atmosphere.
- Vacuum-enhanced recovery wells to remove groundwater within the vadose zone (groundwater on top of clay layers in the soil above the Terrace Alluvial groundwater).
- Treatment of the extracted groundwater with air stripping and near-zero off-gas emissions. Contaminants in the off gas may be destroyed with with vapor-phase carbon adsorption, catalytic oxidation, or other technologies that remove the contamination in the air before it is released to the atmosphere. The treated groundwater will be discharged to surface water or a sewage treatment plant.
- Soil-gas probes to monitor performance. Monitoring will continue as long as remedial action activities are ongoing.

Soil-vapor extraction works by creating a vacuum in recovery wells; the vacuum volatilizes the TCE and causes it to be drawn into the wells. The vapor is then conveyed by piping to vapor-phase carbon adsorption units where the TCE adheres to the carbon. The air that is free of TCE is then vented to the atmosphere.

Vapor-phase carbon adsorption units were selected for pilot-scale testing to remove TCE. Another method of removing the TCE contamination is to destroy the TCE with catalytic oxidation. Both carbon adsorption and catalytic oxidation are equally effective at removing TCE contamination and will be considered for the final design. The present worth of the alternative is $612,000. Remediation will continue until cleanup levels of 11.5 mg/kg of TCE in the soil are met, which is expected to take approximately 5 years.

10.3 Comparative Analysis of Alternatives

The selected alternative for Building 181 is Alternative 2, Soil-Vapor Extraction. Table 10–1 presents a comparative analysis of the two alternatives.

Table 10–1. Comparative Analysis of Soil Alternatives for Building 181

Criteria	Alternative 1, No Action	Alternative 2, Soil Vapor Extraction (selected remedy)
Overall Protection of Human Health and the Environment	Protective of human health and the environment only for exposure to soil in the vadose zone; not protective of groundwater. Rating: Not Protective	Protective of human health and the environment for both the soil in the vadose zone and the groundwater. Rating: Protective
Compliance with ARARs	Complies with ARARs related to TCE in the soil because there are no ARARs requiring action. Rating: Complies	Release of TCE to the atmosphere needs to comply with ARARs. Alternative would comply with ARARs. Rating: Complies
Long-Term Effectiveness and Permanence	Allows continued migration of TCE to the groundwater. No change over baseline condition. Rating: Poor	Residual risks are significantly reduced because TCE is permanently removed. Pilot tests have shown soil-vapor extraction to be effective at this site. Rating: Good
Reduction of Toxicity, Mobility, or Volume Through Treatment	No reductions in toxicity, mobility, or volume over baseline condition. Rating: Poor	Reduces toxicity, mobility, and volume through treatment. TCE removed from the vadose zone is destroyed by off-gas treatment or during regeneration of the carbon adsorption canisters. Rating: Good
Short-Term Effectiveness	Least short-term risks to the community, workers, or the environment. Rating: Good	Small risk potential to workers in the plant from TCE vapor but controls for the TCE vapor are effective. Estimated cleanup time is 5 years. Rating: Good
Implementability	Easiest to implement. There are no administrative or technical difficulties. Rating: Good	Relatively easy to implement. Technology is available from many sources and it uses material that is readily available. Rating: Good
Cost	No cost[a]	$612,000

[a]No cost is assigned to this alternative because monitoring costs are included in the alternatives for the East Parking Lot Plume.

Overall Protection of Human Health and the Environment

The selected alternative, Alternative 2, is protective of human health and the environment because it stops contamination from reaching the groundwater at unacceptable levels. The No Action Alternative is not protective of human health and the environment because contamination in the soil under Building 181 causes groundwater contamination that ultimately contaminates the Paluxy aquifer.

Compliance With Applicable or Relevant and Appropriate Requirements

No chemical-, action-, or location-specific ARARs are applicable to the TCE contamination in the vadose zone under Building 181. Therefore, Alternative 1, No Action, would not violate any ARARs for the vadose zone. However, selection of this alternative would result in continued contamination of the groundwater and subsequent contamination of the Paluxy aquifer at levels above regulatory levels.

Alternative 2 involves using soil-vapor extraction to extract vapor-phase TCE from the vadose zone under Building 181 and then remove TCE concentrations from the air stream before discharging the air to the atmosphere. Alternative 2 must comply with ARARs governing the release of TCE and other VOCs. Specific requirements are established for releases of VOCs in Tarrant County, Texas, because it is a nonattainment area for ozone. Releases from the vapor extraction system will be controlled to allowable levels with vapor-phase carbon adsorption or catalytic oxidation. The following ARARs are applicable to Alternative 2:

- Texas Regulation V: Control of Pollution from Volatile Organic Compounds (TAC, Title 30, Chapter 115) — This chapter requires the control of VOCs and sets standards for VOC emissions and controls. Release of VOCs to the air, caused by treatment of groundwater, requires compliance with these State regulations.

- TAC Guidance Document *Exemption 68* — This document provides guidance for the air emissions from various treatment systems to be used on remediation projects. The chosen treatment system would comply with this document.

Long-Term Effectiveness and Permanence

The selected alternative, Alternative 2, provides the best long-term effectiveness by permanently removing TCE contamination from the soil under Building 181. However, because of limitations of the technology, complete removal of all TCE in the vadose zone will not be achieved. TCE will remain in varying amounts in some areas. Alternative 1, No Action, provides minimal long-term effectiveness through natural biodegradation of the TCE contamination in the soil.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 2, Soil-Vapor Extraction, provides reduction in toxicity, mobility, and volume through active treatment by removing contaminants from the soil and destroying the contaminants. The toxicity and volume of the contaminants are reduced when the carbon adsorption units that extract the TCE contamination from the air are regenerated or when the TCE is destroyed by a catalytic oxidation unit. Alternative 1, No Action, does not provide any reduction in toxicity, mobility, or volume through treatment.

Short-Term Effectiveness

Alternative 1, No Action, is the best for short-term effectiveness because it involves the least risk to workers and the community during implementation of the alternative. However, the short-term risks of the selected alternative, Alternative 2, are minimal and there will be no noticeable increase in risk to the community and workers from the selected alternative. Also, the selected alternative will be completed within a reasonable time period, estimated at 5 years. There is considerable uncertainty in the time-to-cleanup estimate because no information is available on the quantity of TCE that has been spilled and how much TCE remains in the vadose zone. The estimate of 5 years to meet the remediation goal is based on an assumption that 61,000 pounds (5,000 gallons) of TCE are present in the vadose zone and the soil-vapor extraction system will be able to remove 12,200 pounds (1,000 gallons) per year.

Implementability

The selected alternative will be relatively easy to implement because established technologies are used, equipment is readily available from several vendors, and pilot-scale tests have been performed to help work out any difficulties with operating the equipment. However, Alternative 1, No Action, is easier to implement because it does not require any construction or operation of equipment.

Cost

The No Action Alternative does not have any costs but would result in higher groundwater treatment costs for the East Parking Lot Groundwater Plume. The higher groundwater treatment costs have not been estimated. The present worth cost of the selected alternative, Alternative 2, is estimated at $612,000. This is based on a 5-year project life and a discount rate of 5 percent applied to O&M costs.

State Acceptance

The Texas Natural Resource Conservation Commission concurs with Alternative 2, Soil Vapor-Extraction, as the preferred remedy for TCE contamination in the vadose zone under Building 181.

Community Acceptance

The Air Force solicited input from the community and from members of the Restoration Advisory Board on the remediation alternatives proposed for Building 181. The comments received from the public and Restoration Advisory Board members indicate that the community is supportive of the selected remedy for Building 181. All comments received during the public comment period and the Air Force responses are in Appendix A, "Responsiveness Summary."

10.4 The Selected Remedy

The Air Force, with the concurrence of the EPA and the State of Texas, has determined that Alternative 2, Soil-Vapor Extraction, is the best remedy for achieving the remediation goal. As presented in Section 10.1, the remediation goal for Building 181 is to prevent TCE concentrations in the soil from causing unacceptable groundwater contamination in the Paluxy aquifer.

An allowable TCE soil contamination level of 11.5 mg/kg was established to meet the remediation goal. The TCE soil contamination level is not based on risk but on an allowable leachate concentration that would migrate from the soil to the Terrace Alluvial groundwater. The allowable TCE concentration in the leachate was assumed to be 5,000 μg/L. A level that is one-half the remedial action objective for TCE in groundwater (one half of 10,000 μg/L) was used to ensure that peak concentrations in the Terrace Alluvial groundwater under Building 181 would not result from TCE contamination in soil.

On the basis of information obtained during the remedial investigation and the analysis of remedial alternatives, the Air Force, the EPA, and the State of Texas believe that the selected remedy for Building 181 will attain this goal. The selected remedy will meet this goal by

- Using vapor-recovery wells to extract volatilized TCE. An initial estimate of 18 vapor-recovery wells has been determined, but this number could change depending on the subsurface conditions encountered.
- Installing a blower to create a vacuum in the wells and extract the TCE contamination.
- Removal of contaminants from the extracted air before release to the atmosphere. Contaminants may be removed with vapor-phase carbon adsorption, catalytic oxidation, or other technologies that remove the contamination in the air before it is released to the atmosphere.
- Vacuum-enhanced recovery wells to remove groundwater within the vadose zone (groundwater on top of clay layers in the soil above the Terrace Alluvial groundwater).
- Treatment of the extracted groundwater with air stripping and near-zero off-gas emissions. Contaminants in the off gas may be destroyed with vapor-phase carbon adsorption, catalytic oxidation, or other technologies that remove the contamination in the air before it is released to the atmosphere. The treated groundwater will be discharged to surface water or a sewage treatment plant.
- Installing soil-gas probes to monitor performance. Monitoring will continue as long as remedial action activities are ongoing.

A more detailed description of the selected remedy follows. It should be noted that certain aspects of the selected remedy may change during remedial design. The costs of the selected remedy are

Capital Cost	$259,000
Present Worth of O&M Costs	353,000
Total Present Worth of Alternative 2	$612,000

Capital costs are assumed to occur within the first year and include installation of additional vapor extraction wells (e.g., perched zone wells and upper zone wells), a blower, installation of an air-stripping treatment system and carbon adsorption units to treat the air discharged from the air stripper and from the vapor recovery wells, piping from the extraction wells to the carbon adsorption units, and electrical connections. O&M costs include electrical requirements, equipment maintenance and replacement, replacement of carbon adsorption canisters, and sampling with the soil-gas probes. O&M costs include carbon adsorption canisters but other off-gas treatment technologies may be used. The cost of the completed pilot tests is not included in this estimate.

Extraction of volatilized TCE will be from 18 extraction wells. Eleven of the extraction wells are assumed to be perched wells (screened at approximately 5 ft below ground surface), and 7 of the extraction wells are assumed to be upper zone wells (screened at approximately 25 ft below ground surface). Extraction wells that encounter groundwater will be made into dual-phase extraction wells that allow both groundwater and air to be extracted and treated. Extracted groundwater will be treated with air stripping. Air discharged from the air stripper will be sent through the carbon adsorption units before being released to the atmosphere. Approximately 30 to 40 soil-gas probes will be installed to monitor the concentrations of TCE in the vadose zone.

Soil-vapor extraction is an effective technology at removing TCE from the vadose zone. However, because of limitations of the technology and conditions that are inherent to the subsurface, removal of TCE to the levels specified by the remediation goal (11.5 mg/kg) from all areas under Building 181 may not be possible. If implementation of the selected remedy demonstrates that it is technically impracticable to meet the remediation goal for the area of attainment (the area under Building 181), operation of the soil-vapor extraction system may be discontinued, with concurrence of EPA and the State of Texas. For example, if TCE levels in the extraction wells are minimal and measures such as the placement of additional extraction wells does not increase removal rates, operation of the system may be discountinued.

No other actions are currently planned if it is deemed technically impracticable to meet remediation goals. Measures such as containment of the groundwater under Building 181 may be considered. The result of discontinuing operation of the soil-vapor extraction system before remediation goals are met is not known because the remediation goal is based on assumed subsurface conditions that may not represent actual conditions. Discontinuing operation of the extraction system may result in a longer remediation time for the Terrace Alluvial groundwater under Building 181 or it may have no noticable effect.

An assumption for remediation of the vadose zone under Building 181 is that the Terrace Alluvial groundwater under Building 181 will be remediated to levels below 10,000 µg/L. Remediation of the Terrace Alluvial groundwater under Building 181 requires removal of DNAPL and may not be technically practicable. If it is determined that remediation of the Terrace Alluvial groundwater under Building 181 is technically impracticable and adequate containment measures are implemented, the operation of the soil-vapor extraction system may be discontinued.

10.5 Statutory Determinations

The most important aspect of the selected remedy is to be protective of human health and the environment. Section 121 of CERCLA also requires that the selected remedial action comply with ARARs established under Federal or State laws, unless a waiver is granted. In addition, the selected remedy must be cost effective and use permanent solutions or resource-recovery technologies to the maximum extent practicable. Section 121 also contains a preference for remedial actions that use treatment as a primary element. The following text discusses how the selected remedy, Alternative 2, Soil-Vapor Extraction, meets the statutory requirements.

Protection of Human Health and the Environment

The selected remedy protects human health and the environment by reducing concentrations of TCE in the vadose zone to concentrations that will not exceed the allowable levels for the Terrace Alluvial groundwater under Building 181 (10,000 µg/L). Maintaining an allowable TCE concentration in the Terrace Alluvial groundwater is an important aspect of protecting the groundwater in the Paluxy aquifer, which is the exposure route for human health risk.

Compliance With Applicable or Relevant and Appropriate Requirements

The selected remedy will comply with all ARARs and an ARAR waiver will not be required for implementation. The selected remedy will comply with State ARARs governing the release of TCE and other VOCs to the atmosphere. There also are specific ARARs for releases of VOCs in Tarrant County, Texas, because it is a nonattainment area for ozone. Releases from the vapor extraction system will be controlled to allowable levels with vapor-phase carbon adsorption or catalytic oxidation. The discharge of treated groundwater will comply with NPDES and Texas Surface Water Quality Standards.

Cost Effectiveness

The Air Force, with the concurrence of the EPA and the State of Texas, believes the selected remedy, Alternative 2, Soil-Vapor Extraction, is cost effective at meeting the remediation goals and protecting human health and the environment. The selected remedy has the highest net present worth of the two alternatives ($612,000) but is the only alternative that has the potential to meet the remediation goal. Alternative 1 has a lower net present worth ($0) but cannot meet the remediation goal.

Use of Permanent Solutions and Treatment or Resource-Recovery Technologies to the Maximum Extent Practicable

The selected remedy, Alternative 2, uses permanent solutions and treatment technologies to the maximum extent practicable. It meets the threshold criteria (protection of human health and environment and compliance with ARARs) and provides the best balance of trade-offs in terms of the balancing criteria. The selected remedy provides the best long-term effectiveness and permanence and the best reduction in toxicity, mobility, and volume.

The cost of the selected remedy is higher than Alternative 1, No Action, but it is considered cost effective because it has the best chance of meeting the remediation goal. The selected remedy is more difficult to implement than Alternative 1, No Action, because it requires an action involving treatment, whereas Alternative 1 does not require any action. However, the selected remedy can be readily implemented.

Preference for Treatment as a Principal Element

The selected remedy meets the statutory preference for treatment as a principal element. The principal threat to human health is TCE contamination in the Paluxy aquifer that exceeds MCLs. The selected remedy addresses the principal threat by removing TCE from the vadose zone under Building 181 that would eventually result in TCE contamination levels in the Window Area exceeding MCLs in the Paluxy aquifer. The treatment processes use carbon adsorption or catalytic oxidation for extracted air that is contaminated with TCE and air stripping with carbon adsorption or catalytic oxidation for extracted groundwater.

10.6 Documentation of Significant Changes

A draft of the Proposed Plan was released to members of the Restoration Advisory Board before the public comment period. The Draft Proposed Plan identified Alternative 2, Soil-Vapor Extraction, as the selected alternative. Members of the Restoration Advisory Board did not have any significant comments on the preferred alternative for Building 181. The final Proposed Plan, dated November 1995, also listed Alternative 2 as the preferred alternative.

Alternative 2 was presented as the selected remedy at the public meeting on the Proposed Plan. The Air Force reviewed all written and verbal comments submitted during the public comment period. After review of these comments, no significant changes to the selected remedy were made, as identified in the Proposed Plan dated November 1995.

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11.0 No Further Action Sites

11.1 Selected Remedy

No action is the selected remedy for soil in the No Further Action Sites based on the findings of the BRA. The selected remedy applies only to soil at the No Further Action Sites. The BRA determined that [illegible] in the soil at these sites do not pose an unacceptable risk to human health [illegible] Figure 11-1 shows the locations of the No Further Action sites; this figure is the same as Figure 2-1 in Section 2.0 but is included here for the convenience of the reader. Removal of soil has been completed at several of the areas. These actions were taken as voluntary actions before Air Force Plant 4 was listed on the NPL. The BRA was performed after those voluntary actions were completed.

The Terrace Alluvial flow system, which includes the East Parking Lot Plume, the West Plume, and the North Plume, is the affected groundwater under these sites. Information on contamination in the Terrace Alluvial flow system is presented in Section 5.0, "Summary of Site Characteristics." The selected remedy for contamination in the Terrace Alluvial flow system is addressed separately in Section 9.0, "East Parking Lot Groundwater Plume."

11.2 Basis of No Action as the Selected Remedy

The basis for the selected remedy, No Action, for soil at each of the No Further Action Sites is presented in the following sections.

Landfills No. 1 and No. 2

Landfill No. 1—Landfill No. 1 (LF-1) is a 6-acre site that was used from 1942 to approximately 1966 for disposal of general refuse, construction rubble, solvents, thinners, paint sludges, oil, fuels, and unspecified liquid wastes. In 1966, the landfill was closed and the area was graded and paved for employee parking. Before grading and paving, two 6-in. perforated pipes were laid in trenches on bedrock just east of Bomber Road to channel leachate to a storm sewer outfall.

In 1982, a French drain (No. 1), was constructed in the center of LF-1 to prevent leachate from entering the storm sewer. The two drain pipes installed in 1966 were rerouted to the French drain system, and a 90-ft section of 4-in. perforated drain pipe was placed on bedrock on the western edge of the storm sewer outfall.

In 1983, the storm sewer was lined to prevent infiltration of leachate into the storm-water collection system. Liquids and approximately 11,000 cubic yards (yd^3) of contaminated soil in the landfill were excavated and removed as part of an interim remedial action. A second French drain (No. 2) was constructed within the excavation to intercept leachate. This excavation was backfilled and the site was repaved.

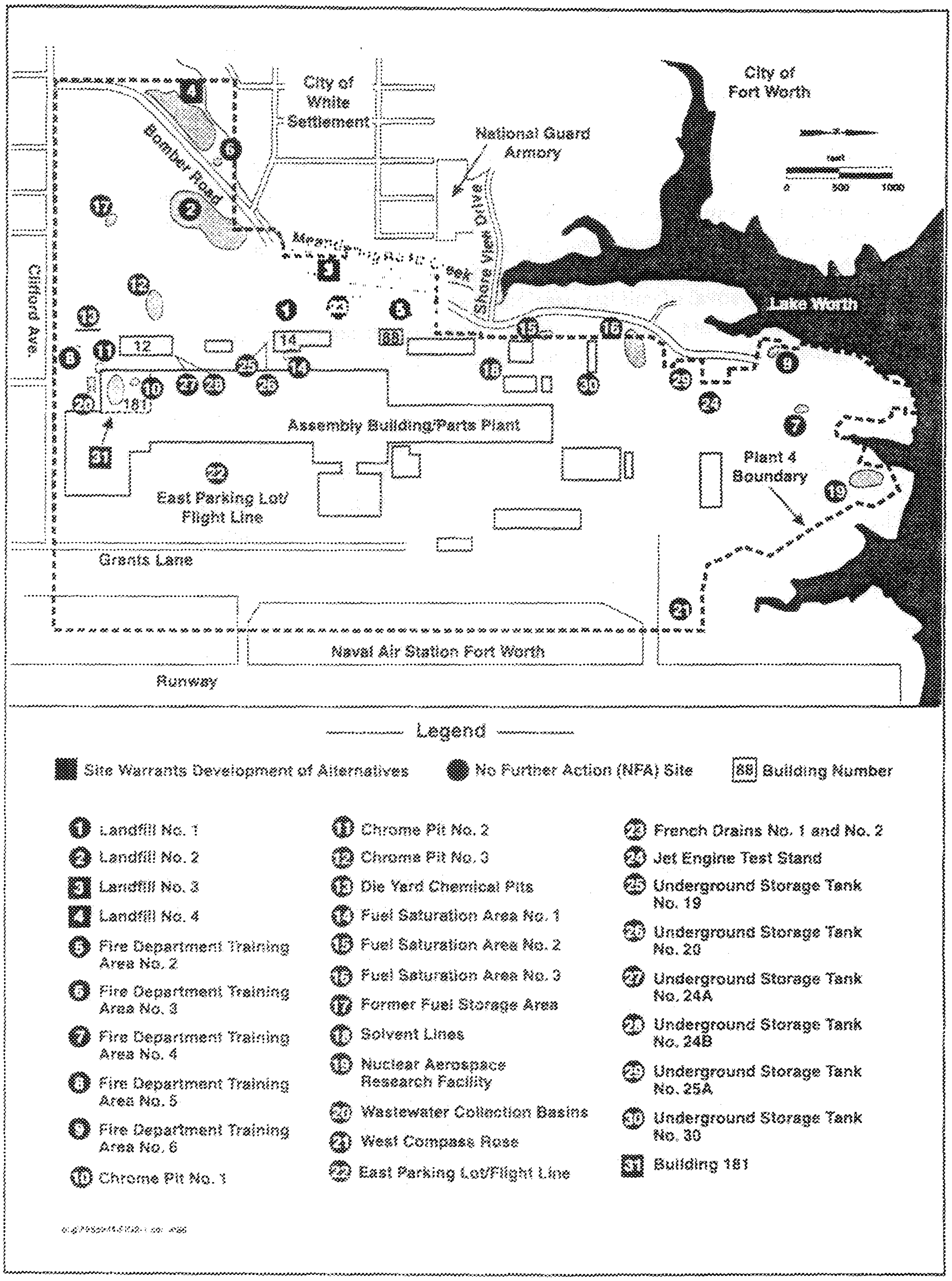

Figure 11-1. Air Force Plant 4 Sites and Areas of Concern

During the remedial investigation, COPCs for soil, as identified in the BRA, that were detected at LF-1 include TCE (ND to 0.11 mg/kg) and toluene (ND to 350 mg/kg). One SVOC, benzo[*a*]pyrene (BAP), was detected at concentrations between 1.1 and 62 mg/kg. These concentrations exceed the human health risk-based concentration of 1.0 mg/kg for BAP. However, BAP was only present in soil samples collected directly below the asphalt cover. Therefore, the presence of this compound is attributed to the overlying asphalt, not to past waste disposal practices.

On the basis of the BRA, and because BAP appears to be derived from the overlying asphalt cover, the soil at this site does not pose an unacceptable excess risk to human health or the environment. Therefore, the selected remedy for Landfill No. 1 is no action.

Landfill No. 2—Landfill No. 2 (LF-2) is an 8-acre site that was used from the early 1940s to the early 1960s for the disposal of construction rubble, plaster, lumber, and tires. No information exists indicating that hazardous materials were disposed of in this landfill. The site is now covered with grass.

Soil in LF-2 was sampled in 1982 and again in 1989. In 1982, three volatile organic COPCs were detected in soil samples obtained during the installation of a monitoring well. Benzene, toluene, and TCE were detected at low concentrations (less than 1.0 mg/kg). In 1989, 39 samples were collected from 7 borings at LF-2. Toluene contamination was detected in only one sample at a concentration less than 1.0 mg/kg. On the basis of these analytical results and detected metal concentrations, the soil at Landfill No. 2 does not pose an unacceptable excess risk to human health or the environment. Therefore, the selected remedy for this area is no action.

Fire Department Training Areas

Fire Department Training Area Nos. 2 through 6 (FDTA-2 through FDTA-6) are the sites discussed in this section. Waste oils, fuels, and other unspecified chemicals were burned at FDTA-2, FDTA-3, FDTA-5, and FDTA-6 during fire-training exercises. FDTA-4 received clean fill material from a nearby foundation excavation.

FDTA-2—FDTA-2 is a 50-ft-diameter earthen ring located north of Landfill No. 1. This area was used for semiannual fire-training exercises between 1955 and 1965. It currently is overlain by the asphalt of the West Parking Lot. No detectable concentrations of VOCs were reported for four samples collected from two borings drilled in 1986. Twenty-three samples were collected from four borings in 1991. TCE and 1,2-DCE were detected at concentrations of less than 1.0 mg/kg. The sitewide BRA determined that those concentrations and the detected metal concentrations do not pose an unacceptable excess risk to human health or the environment. On the basis of available information, the selected remedy for this area is no action.

FDTA-3—FDTA-3, reportedly located near the western edge of Plant 4 and northeast of Landfill No. 4, was used for fire-training exercises in the 1960s. It is now covered with grass. The exact location of FDTA-3 could not be determined from a review of historical aerial photographs. Soil samples were not collected during the installation of one monitoring well reportedly installed near FDTA-3; laboratory analyses of groundwater samples indicate no elevated concentrations of VOCs or metals. On the basis of available information, the selected remedy for this area is no action.

FDTA-4—FDTA-4 was reported to be located near the northern tip of Plant 4. However, Plant 4 fire department personnel report that no fire-training exercises were ever conducted in that immediate area. Personnel reported that the site received clean fill from a foundation excavation. The exact location of FDTA-4 could not be determined from historical aerial photographs. On the basis of available information, no soil samples were required from FDTA-4 and the selected remedy for this area is no action.

FDTA-5—FDTA-5, located at the south-central boundary of Plant 4, was a shallow pit about 35 ft wide by 45 ft long. It was used for fire training exercises in the mid-1960s. Two soil samples were collected near the FDTA-5 area in 1986; 19 soil samples were collected from five borings in 1991 near the approximate location of FDTA-5. No VOCs were detected in two soil samples collected in 1986. Low concentrations (less than 2.0 mg/kg) of VOCs and SVOCs were detected in the 1991 samples. The sitewide BRA determined that those concentrations and the detected metal concentrations do not pose an excess risk to human health or the environment. On the basis of available information, the selected remedy for this area is no action.

FDTA-6—FDTA-6, the primary fire department training area from the late 1960s to 1982, was located in the northwest portion of Plant 4 adjacent to Bomber Road. FDTA-6 was a 50-square-foot gravel-lined area approximately 2 ft deep, surrounded by an earthen berm. Interim remedial action was performed at FDTA-6 in 1983 when oil- and fuel-contaminated soil was removed and hauled to an approved hazardous-waste landfill. Since that time, 17 soil samples were collected in three separate investigations at FDTA-6. Detected concentrations of VOCs and SVOCs were less than 1.0 mg/kg, with the exception of two SVOCs detected at approximately 3.0 mg/kg. The sitewide BRA determined that those concentrations and the detected metal concentrations do not pose an excess risk to human health or the environment. On the basis of available information, the selected remedy for this area is no action.

Chrome Pits

This section describes site investigations at Chrome Pit No. 1, No. 2, and No. 3.

Chrome Pit No. 1—Chrome Pit No. 1 (CP-1) was an unlined earthen pit that received liquid wastes during the early 1940s. Building 181 was constructed on the site of CP-1. The exact location of CP-1 could not be determined from interviews or a review of historical aerial photographs. Analytical results indicate the presence of chromium in the soils around Building 181; however, the concentrations are below the upper background limit for the Western United States. Given the limited usage of the pit and its present location under a building, the selected remedy for this area is no action.

Chrome Pit No. 2—Chrome Pit No. 2 (CP–2), an unlined earthen pit, was located near the southwest corner of the Assembly Building/Parts Plant. CP–2 received liquid chrome wastes during the mid-1940s. The actual location of CP–2 could not be determined from interviews or reviews of historical aerial photographs. Given that the site could not be located, the selected remedy for this area is no action.

Chrome Pit No. 3—Chrome Pit No. 3 (CP–3) was a large earthen pit (approximately 55 ft wide by 165 ft long by 15 ft deep) located in the southern portion of Plant 4 west of Building 12. It was operational from 1957 to 1973 and received chromate sludge, dilute metal solutions, and other unidentified liquids. An interim remedial action was conducted in December 1983 and January 1984 to excavate and remove approximately 8,900 yd^3 of contaminated soil from CP–3. The excavated soil was disposed of at an approved hazardous-waste landfill off the Air Force Plant 4 facility. Soil was excavated to a depth of approximately 20 ft below grade.

Following excavation of the soil, confirmatory soil sampling at CP–3 detected the presence of TCE in one sample at a concentration of 4.8 mg/kg. In 1989, soil samples were collected from 11 shallow (10-ft-deep or less) soil borings around the perimeter of CP–3. These samples were analyzed for VOCs and total extractable chlorinated organics. The maximum concentration of total extractable chlorinated organics in one sample was 72.5 mg/kg. On the basis of the low concentrations of organic compounds detected following the removal of soil, the soil at CP–3 does not pose an excess risk to human health or the environment and the selected remedy for this area is no action.

Die Yard Chemical Pits

The Die Yard Chemical Pits site is located in the southern portion of Plant 4, south of Building 12. Three pits (approximate dimensions of 20 ft wide by 90 ft long and 10 ft deep) were constructed in 1956 and used for the disposal of chromate sludges, metal solutions, and other chemical wastes. In 1962, the site was graded and the entire area was paved for parking. In 1983 and 1984, the original die pits were excavated and 1,100 yd^3 of contaminated soil was removed and transported to an approved hazardous-waste landfill for disposal. Confirmatory soil sampling conducted following soil removal reported ethylbenzene, naphthalene, toluene, and TCE at concentrations between ND and 5.6 mg/kg. In 1991, 4 soil samples were collected from 4 soil borings drilled within the excavated pits, and 17 soil samples were collected from 6 soil borings drilled around the former pits. Four volatile organic COPCs were detected at low concentrations (i.e., less than 0.5 mg/kg). No SVOC contamination was detected. On the basis of those data and detected metal concentrations, the soil in this area does not pose an excess risk to human health or the environment and the selected remedy for this area is no action.

Fuel Saturation Areas

Fuel Saturation Areas No. 1, No. 2, and No. 3 reportedly were saturated by fuel from leaking pipelines in the mid-1970s to early 1980s.

Fuel Saturation Area No. 1—Fuel Saturation Area No. 1 (FSA–1) is located immediately west of the Assembly Building/Parts Plant, partially beneath Building 14. Soil at this site reportedly became saturated with JP–4 jet fuel leaking from underground piping during the 1970s and early 1980s.

In 1987, one soil sample was collected in the area east of Building 14. No VOC contamination was detected in that sample. In 1991, 45 soil samples were collected from 10 soil borings drilled in the vicinity of FSA–1. Two volatile organic COPCs, ethylbenzene and benzene, were detected in three samples, all at concentrations less than 1.0 mg/kg. Only one sample, collected from 5 to 10 ft below grade to the east of Building 14, contained semivolatile organic COPCs. Semivolatile compounds were detected in one sample at concentrations ranging from 0.9 to 2.7 mg/kg, but no semivolatile COPCs were identified in the other soil samples.

The BRA determined that the soil contamination at FSA–1 does not cause an excess risk to human health or the environment and the selected remedy for this area is no action. Groundwater contamination in this area is addressed in Section 5.5 of this Record of Decision.

Fuel Saturation Area No. 2—Fuel Saturation Area No. 2 (FSA–2) was originally designated as a site requiring environmental investigation because of reports of saturated soil along an underground pipeline in the northwest portion of Plant 4. However, no COPCs were detected in the reported vicinity of FSA–2 in (1) a gridded soil-gas survey, (2) samples from six soil borings, and (3) samples from two monitoring wells. On that basis, no COPCs that pose an excess risk to human health and the environment are present at FSA–2, and the selected remedy for this area is no action.

Fuel Saturation Area No. 3—Fuel Saturation Area No. 3 (FSA–3) is located east of Bomber Road in the northwest portion of Plant 4. This site also was investigated because of reports of leaking underground fuel lines in the area. In 1991, approximately 60 soil samples were collected from 13 borings in the vicinity of FSA–3. Three volatile organic COPCs (acetone, benzene, and ethylbenzene) were detected at concentrations below 1.0 mg/kg in soil samples. Low levels of two semivolatile organic COPCs, naphthalene and 2-methylnaphthalene, were detected at concentrations between 0.85 and 5.9 mg/kg.

The baseline risk assessment determined that soil contamination at FSA–3 does not cause excess risk to human health or the environment and the selected remedy for this area is no action.

Former Fuel Storage Area

The Former Fuel Storage Area (FFSA) is the site of a former 100,000-gallon aboveground JP–4 fuel storage tank located in the southwest portion of Plant 4. The storage tank was used from the early 1940s to 1962, when it was removed from the site and relocated. Soil beneath the tank reportedly contained jet fuel at the time the tank was removed.

In 1982, five soil samples were collected from a test hole and a monitoring well was installed at FFSA. Low levels of VOCs and SVOCs were reported in those samples. In 1991, soil samples were collected from four borings that were drilled around the monitoring well. No volatile or semivolatile COPCs were identified in those samples. On the basis of these data and detected metal concentrations, the soil at this area does not pose an excess risk to human health or the environment and the selected remedy for this area is no action.

Solvent Lines

The Solvent Lines site was designated for No Further Action by the Plant 4 Technical Review Committee before the start of remedial investigation; therefore, no samples were collected during the remedial investigation.

The Solvent Lines area is located in the north-central portion of Plant 4. It was identified as an area requiring investigation on the basis of personnel accounts of reported leaks in the early 1940s. The underground lines were used to transport xylene, 2-butanone, and kerosene from 1942 until 1944, when they were drained, capped, and abandoned in place because of the reported leaks. In 1985, two soil samples collected during installation of a monitoring well were analyzed for xylene and 2-butanone. The presence of neither compound was detected. Therefore, the selected remedy for this area is no action. Also in 1985, 10 groundwater samples were collected from 4 monitoring wells. VOC concentrations in these groundwater samples did not exceed their respective MCLs.

Nuclear Aerospace Research Facility

The Nuclear Aerospace Research Facility (NARF) was located on approximately 120 acres at the northern tip of Plant 4. It was the site of three atomic reactors used between 1953 and 1974 for research and development activities. In 1974, NARF was decontaminated and dismantled.

High-level and low-level radioactive components were segregated and shipped to regulated off-site disposal areas. A total of more than 2 million pounds of miscellaneous parts and 15 million pounds of concrete rubble were removed for off-site disposal.

During the decontamination and decommissioning activities, radiological surveys were performed on a regular basis. Soil and vegetation samples were analyzed from the area around NARF and core samples of structures and subsurface soil in the vicinity were collected for analyses. The results of these analyses were not available; however, soil excavation and removal was documented in the decommissioning records. Following decommissioning activities, radiological surveys were performed and verified to confirm that areas and facilities were available for unrestricted use. The final postclosure report indicates that no radiological contamination remained at the site.

To confirm that all contaminated soil had been removed, nine soil samples were collected in 1989 adjacent to NARF and submitted for laboratory analyses for total alpha and total beta. Alpha radiation in the soil samples ranged from 6.7 to 12.4 picocuries per gram (pCi/g). Beta radiation ranged from 10.0 to 23.1 pCi/g. Gamma radiation was not measured directly, but samples were analyzed for cesium-137, a fission by-product and gamma emitter. The presence of cesium-137 was not detected at the instrument detection limit. The alpha and beta activities are typical of natural background levels encountered in most undisturbed soil.

In 1991, six sediment samples were collected from Lake Worth to confirm that NARF activities had not adversely affected lake sediments. One background sediment sample was collected approximately 1 mile west of NARF activities, on the west side of the inlet from Lake Worth. This sample was collected for comparison purposes from a location that likely was not affected by NARF. Sediment samples were analyzed for the presence of cobalt-60, cesium-137, radium-226, thorium-230, and uranium. The presence of cobalt-60 was not detected in any samples. Cesium-137 was detected in two samples at concentrations of 0.10 and 0.53 pCi/g; radium-226 was detected in all six samples at concentrations between 0.45 and 1.19 pCi/g (the maximum concentrations for cesium-137 and radium-226 were from the background sample). Thorium-230 was detected in all samples at concentrations of 0.6 to 2.0 pCi/g, and uranium was detected in four samples at concentrations between 1.1 and 2.7 mg/kg. These concentrations are typical of background levels encountered in most undisturbed soil. On the basis of these data, the NARF site does not pose an unacceptable excess risk to human health or the environment and the selected remedy for this area is no action.

Wastewater Collection Basins

The Wastewater Collection Basins, located south of Building 181, are two lined, concrete waste basins, each with an approximate capacity of 85,000 gallons. They are designed to collect and settle suspended solids from plant wastewater. Several known spills of TCE from vapor degreasers in Building 181 have flowed to the basins via floor drains. Other chemical spills also may have entered the basins via the floor drains.

In 1991, the basins were drained and the concrete walls, floors, and liners were examined. The plastic liners were no longer present over much of the floors and walls; however, the concrete appeared to be in good condition, with no visible cracks. Also in 1991, two soil borings were drilled near the basins, one near the northeast corner and one to the west of the basins. One sample from one of the borings had a reported concentration of less than 1.0 mg/kg of TCE; no other organic COPCs were detected in these samples. On the basis of these data, this area does not pose an excess risk to human health or the environment and the selected remedy for this area is no action.

West Compass Rose

The West Compass Rose site was included as an environmental investigation site at Plant 4 chiefly on the basis of indirect evidence (i.e., personnel recollections of past surface spills). This approximately 150-square-foot area is located in the northern portion of Plant 4. It was reported that fuel spills may have occurred during aircraft refueling operations at the site.

Twenty-four shallow soil borings were drilled in the area in 1985 as part of a foundation soil study for several buildings planned for the area. Organic vapors were detected in samples from only 3 of the 24 borings. One sample was submitted for VOC analyses but no contaminants were detected. In 1991, an additional boring was drilled at the site and no fuel hydrocarbons were present in soil samples from this boring. On the basis of these data, soil at the West Compass Rose does not pose an excess risk to human health or the environment and the selected remedy for this area is no action.

Jet Engine Test Stand

The Jet Engine Test Stand (JETS) site is located in the northern portion of Plant 4, east of Bomber Road. It was included as an environmental site on the basis of employee reports of jet fuel and gasoline in a sump near the site.

In 1986, five soil samples were collected from six soil borings drilled around the periphery of JETS. Fuel hydrocarbon analysis revealed that two of the samples contained concentrations of 1,700 and 1,300 mg/kg of fuel hydrocarbons. In 1991, seven soil samples were collected from three soil borings drilled around the periphery of JETS. Two of these soil samples contained low concentrations (between 1.1 and 5.1 mg/kg) of semivolatile COPCs. On the basis of the analytical data collected for JETS, this area does not pose an excess risk to human health or the environment and the selected remedy for this area is no action.

Underground Storage Tanks No. 19 and No. 20

Underground Storage Tanks No. 19 and No. 20 (UST–19 and UST–20) were two 12,000-gallon-capacity tanks, formerly located in the south-central portion of Plant 4. UST–19 was used for storage of 2-butanone; UST–20 stored 2-butanone, ethylbenzene, and xylene. Both tanks and a related pumping station were removed in 1988. Following excavation and tank removal, four soil samples were collected from the excavations. Xylene, ethylbenzene, and 2-butanone were detected at the following concentrations: xylene at 0.14 to 46 mg/kg, ethylbenzene at 0.051 to 22 mg/kg, and 2-butanone at 2.7 to 43 mg/kg. In 1991, 27 soil samples were collected from 5 borings drilled at the tank excavation sites. Detected concentrations of 2-butanone, xylene, and ethylbenzene in the soil samples were less than 1.0 mg/kg. Analyses of groundwater samples from wells in the vicinity of UST–19 and UST–20 did not detect any contamination. These wells were sampled in September and October 1991 and in May and June 1993. On the basis of the analytical data collected for UST–19 and UST–20, these areas do not pose an excess risk to human health or the environment and the selected remedy is no action.

Underground Storage Tanks No. 24A and No. 24B

Underground Storage Tanks No. 24A and No. 24B (UST–24A and UST–24B) were located side by side in the south-central portion of Plant 4. These tanks each had a capacity of 8,000 gallons and were used to store gasoline. The two tanks were excavated and removed in 1988. Low concentrations (less than 1.0 mg/kg) of three organic COPCs were detected in confirmatory soil samples obtained from the excavation. In 1991, nine soil samples were collected from four soil borings drilled at the site. No organic COPCs were detected in any of these samples. On the basis of analytical data collected for UST–24A and UST–24B, these areas do not pose an excess risk to human health or the environment and the selected remedy for this area is no action.

Underground Storage Tank No. 25A

Underground Storage Tank No. 25A (UST–25A) was located adjacent to JETS in the northern part of Plant 4. UST–25A formerly was the site of two vertical underground tanks used to store JP–4 jet fuel. The tanks were removed in 1988. Nine confirmatory soil samples collected from the excavation were submitted for fuel hydrocarbon analyses. One soil sample contained low concentrations of benzene (2.2 mg/kg), ethylbenzene (3.6 mg/kg), and toluene (8.3 mg/kg).

In 1991, four soil borings were drilled at the site of the UST–25A tank excavation. Eleven soil samples were submitted for SVOC and VOC analyses. Ethylbenzene was detected at less than 1.0 mg/kg and 2-methylnaphthalene was detected at 3.9 mg/kg. No groundwater samples were collected at UST–25A. Groundwater contamination in this area is discussed in Section 5.5 under the subheading "Terrace Alluvial Flow System." On the basis of these data, soil remaining at UST–25A does not pose an excess risk to human health or the environment and the selected remedy for this area is no action.

Underground Storage Tank No. 30

Underground Storage Tank No. 30 (UST–30), formerly located in the northern portion of Plant 4, was a 2,000-gallon steel tank used to store JP–4 fuel. This tank was installed in 1956 and removed in 1988. Following excavation and removal, one soil sample was collected from the excavation. It contained benzene, ethylbenzene, and toluene concentrations between 1.0 and 3.1 mg/kg.

In 1991, eight samples were collected from four soil borings drilled at the site of the former UST–30. No volatile organic or semivolatile organic COPCs were detected in these samples. No groundwater samples were collected at UST–30. Groundwater contamination in this area is discussed in Section 5.5, "Terrace Alluvial Flow System." On the basis of the analytical data collected for UST–30, this area does not pose an excess risk to human health or the environment and the selected remedy for this area is no action.

11.3 Documentation of Significant Changes

A draft of the Proposed Plan was released to members of the RAB before the public comment period. The Draft Proposed Plan identified no action as the preferred alternative for soil at the No Further Action Sites. Members of the RAB did not have any significant comments on the preferred alternative for the No Further Action Sites. The final Proposed Plan, dated November 1995, also identified no action as the preferred alternative.

No action was presented as the selected remedy at the public meeting on the Proposed Plan. The Air Force reviewed all written and oral comments submitted during the public comment period. After review of these comments, no significant changes to the selected remedy were made, as identified in the Proposed Plan dated November 1995.

Appendix A

Responsiveness Summary

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Overview

This Responsiveness Summary was prepared to provide written responses to comments regarding the Proposed Plan of Action that were submitted during the public meeting on December 14, 1995, and during the public comment period, November 22, 1995, to January 22, 1996. The section "Background of Community Involvement" provides a brief history of community interest and concerns raised during the remedial planning activities at Air Force Plant 4. The section "Summary of Public Comments Received and Air Force Responses" contains a summary of the comments made during the public meeting and the comments received in writing during the public comment period.

Background of Community Involvement

Overall public interest in the remedial planning activities at the site has been light, with the exception of local citizens who volunteered to serve on the Air Force Plant 4 Restoration Advisory Board. The Restoration Advisory Board was established to inform interested citizens of the remedial planning and restoration activities at Air Force Plant 4. The Restoration Advisory Board meets monthly at the White Settlement Senior Services Center and is open to the public. In addition to members of the public, Restoration Advisory Board meetings also were attended by regulatory agency representatives, Plant 4 personnel, Air Force representatives, contractors, and sometimes representatives of the news media.

The Remedial Investigation Report and the Feasibility Study Report were released to the public in September 1995. A draft version of the Proposed Plan was presented for review to members of the Restoration Advisory Board in October 1995. Comments received from the Restoration Advisory Board expressed concern about the preferred alternatives for the Paluxy aquifer, the Upper Sand groundwater, and the East Parking Lot Groundwater Plume because the preferred alternatives for these sites would use air stripping that releases contaminants to the atmosphere. There was also concern by Restoration Advisory Board members and the City of Fort Worth Water Department about the preferred alternative for Landfill No. 4, Landfill No. 3, and Meandering Road Creek. The preferred alternative for Landfill No. 4, Landfill No. 3, and Meandering Road Creek was No Action with monitoring. Restoration Advisory Board members and the City of Fort Worth Water Department were concerned that contamination from the landfills could migrate to Lake Worth.

On the basis of the comments received from the Restoration Advisory Board, the Air Force, with the concurrence of the U.S. Environmental Protection Agency (EPA) and the State of Texas, selected a different alternative for the Paluxy aquifer and the Upper Sand groundwater and modified the alternative for the East Parking Lot Groundwater Plume. For the Paluxy aquifer and Upper Sand groundwater, the Air Force selected the alternative that includes destruction of contaminants. The technology evaluated for the alternative was ultraviolet oxidation, but other technologies that meet the criteria of near-zero off-gas emissions may be used.

The alternative for the East Parking Lot Plume was modified to include destruction of the contaminants before release from the air stripper. The Air Force did not select a different alternative or modify the alternative of No Action for Landfill No. 4, Landfill No. 3, and Meandering Road Creek but addressed the concerns of the Restoration Advisory Board members with the explanation that this alternative includes monitoring. Monitoring will detect any increase in contamination levels. If the contamination levels increase to levels that cause excess risk, corrective action would be taken.

The Air Force held a public comment period regarding the remedial investigation, feasibility study, Proposed Plan, and Administrative Record from November 22, 1995, to January 22, 1996. The Proposed Plan presented at the public meeting included the modifications that were based on comments from the Restoration Advisory Board members. Originally scheduled to end December 22, 1995, the public comment period was extended to January 22, 1996, at the request of a member of the local community. During the public comment period, a formal public meeting was held on December 14, 1995, at the White Settlement Senior Services Center.

Most of those who attended the public meeting were supportive of the proposed actions for Plant 4. However, one member of the public was concerned that the remedial investigation did not adequately characterize contamination that may be in residential areas near Plant 4 and was not satisfied that contamination from Plant 4 was being contained on Federal property and prevented from migrating to residential areas. All the written comments received during the public comment period were submitted by this individual.

Summary of Public Comments Received and Air Force Responses

Comments and questions made during the formal public meeting held on December 14, 1995, along with the Air Force responses, are presented in "Comments and Questions Received During the Public Meeting." Comments and questions received in writing during the public comment period held from November 22, 1995, to January 22, 1995, along with the Air Force responses, are presented in "Comments and Questions Received During the Public Comment Period."

Many of the responses use the term "excess risk." Excess risk, as used in the responses, is risk that exceeds 1.0×10^{-4} incremental lifetime cancer risk (ILCR) for carcinogenic risk or has a hazard quotient or hazard index greater than 1.0 for noncarcinogenic risk.

Comments and Questions Received During the Public Meeting

Comment 1:

An individual requested that the 30-day comment public period, which ended December 22, 1995, be extended 30 days. The individual also asked what the end of the public comment period represented.

Air Force Response: The Air Force agreed to extend the public comment period 30 days to January 22, 1995, and explained that the end of the public comment period is when written comments about the content of the Proposed Plan are no longer accepted.

Comment 2:

An individual with the City of Fort Worth Water Department had a comment on the preferred alternative for Landfill No. 4, Landfill No. 3, and Meandering Road Creek. The individual suggested that language be added to the preferred alternative stating remedial action conducted to reduce harm to aquatic life or to continue use of Lake Worth as a drinking water source should be based on trigger concentrations. The trigger concentrations should be low enough so that remedial action can be performed before there is harm to aquatic life or use of Lake Worth for drinking water is endangered. There was also a related question from another individual if bass from the lake are safe to eat.

Air Force Response: The Air Force agrees with the idea of using trigger concentrations to indicate if corrective action is needed. The Record of Decision is being written to require that appropriate corrective measures will be taken if concentrations in Lake Worth exceed maximum contaminant levels (MCLs).

In response to the question if the bass in Lake Worth are safe to eat, the Air Force's response is that bass from Lake Worth are safe to eat and consumers are not at excess risk, according to the baseline risk assessment.

Comment 3:

An individual questioned the results of the risk assessment that indicated there is not an excess risk from heavy metals, such as mercury, radioactive materials, and other contaminants in the soil. The individual feels that even though the sampling done to date has not shown high levels of contamination, the contamination in the soil will eventually leach to surface water, especially Lake Worth, causing harm to humans and the environment. To prevent this from happening, he suggested that a subsurface concrete wall should be built around the site as an inexpensive way to prevent contamination from getting into the surface water. The individual stated that a concrete subsurface wall would be preferable to a hydraulic containment system, like the one installed at Landfill No. 3, because a subsurface wall would not require continual operation to be effective. The individual also suggested that heavy metals present in the soil could be stabilized with sulfur.

The individual submitted written comments about these same issues. The written comments and the corresponding Air Force responses, along with a rough cost estimate for a subsurface wall, are in "Comments and Questions Received During the Public Comment Period," comments 3 and 4.

Air Force Response: Because the risk assessment did not show that contamination in the soil poses an excess risk, the suggested subsurface wall is not needed. However, it is possible that some contamination in the soil was not detected during the remedial investigation and that this contamination could cause excess risk in the future. Because of this possibility, the Air Force will monitor surface water and groundwater on Plant 4 and at areas adjacent to Plant 4. If monitoring indicates that contamination levels are increasing to levels that cause excess risk, corrective actions will be taken.

Because of the length of time that the contamination has been in the soil, it is likely that contamination levels will not increase in the future but will decrease. Until contamination levels increase to levels that cause excess risk, the Air Force, with the concurrence of the EPA and the State of Texas, does not plan to install a subsurface wall or initiate other remedial actions, other than those specified in the ROD.

If a subsurface wall or barrier is considered in the future, this wall could be a physical barrier, as suggested by the individual, or a hydraulic barrier. Construction material for such a physical barrier is usually a concrete/bentonite mixture or a bentonite/soil mixture; effective subsurface walls have been constructed of both materials. Bentonite is more commonly used for subsurface walls. When concrete is used, bentonite is usually added to the concrete to make it more flexible.

Comment 4:

An individual expressed concern about radioactive materials at the Nuclear Aerospace Research Facility (NARF). The individual stated that even though radioactive materials were not detected in the surveys and sampling conducted during the remedial investigation, there will eventually be a release of these materials. Because the contamination will eventually be released, a subsurface wall should be installed around the site.

The individual also submitted a written comment about this same issue. The written comment and the more detailed Air Force response is in "Comments and Questions Received During the Public Comment Period," comment 5.

Air Force Response: The Air Force removed approximately 26 tons of material from this area. Sampling conducted for the remedial investigation did not show radiation levels to be different than normal background levels. The records search of activities at the site indicates that all radioactive materials were removed from the site. The Air Force reasoning for not installing a subsurface wall is provided in comment 3.

Comment 5:

An individual expressed concern that carbon fibers had been dumped at Landfill No. 3 and that carbon fibers can be hazardous to an individual's health if inhaled or the fibers come into contact with the skin.

Air Force Response: Carbon fibers were never dumped or stored at Landfill No. 3. This area was fenced as a precautionary measure to keep individuals out of the area because there is a potential for exposure to TCE contamination.

Comment 6:

A question was asked if untreated sewage from Plant 4 was discharged to Lake Worth during a period around 1990 to 1991, a period when employment at the plant was as high as 30,000 employees. The question was raised because the individual said he could smell raw sewage near some storm drains and Lake Worth had a high bacteria count at that time.

Air Force Response: Sewage from Plant 4 has been sent to the city of Fort Worth sewage treatment plant since the 1940s. Process water at the plant is treated in the process water treatment facility. Raw sewage was not discharged to Lake Worth in 1990, 1991, or at any time. The smell the individual noticed could have been due to a sewer backing up, but it was not because raw sewage was being discharged to Lake Worth.

Comment 7:

An individual expressed concern about contamination from Plant 4 migrating to the residential areas near the plant. He wanted the Air Force to do an analysis of contamination levels in the residential areas.

The individual also submitted a written comment about this same issue. The written comment with a more detailed Air Force response is in "Comments and Questions Received During the Public Comment Period," comment 1, parts 1a, 1b, and 1d.

Air Force Response: In addition to extensive sampling conducted at Plant 4, the Air Force installed two nested wells (three wells that are screened in the upper, middle, and lower portions of the Paluxy aquifer) at off-site locations. One nested well was located near the National Guard Armory and the other was located north of the National Guard Armory along Shore View Drive. The Air Force may do additional monitoring of groundwater directly south of Plant 4 during the remedial design phase to further define the plume in that area.

Comment 8:

An individual stated that General Dynamics (the operator of Plant 4 at that time) supplied fill material for an area of the football field located south of Brewer High School. Also, other sites may have possible contamination and are not known but should be sampled. The Air Force should sample the residential areas to ensure there is no contamination.

The individual also submitted a written comment about this same issue. The written comment with a more detailed Air Force response is in "Comments and Questions Received During the Public Comment Period," comment 1, part 1c.

Air Force Response: The Air Force does not plan to do any additional soil sampling in off-site residential areas. The records search conducted for the remedial investigation does not indicate removal or off-site disposal of material from Plant 4 during the construction period for Brewer High School. The high school was constructed in 1953. No other evidence is available that landfill material was transported to other locations in the Fort Worth area. Without any indication of where the contamination caused by Plant 4 could be, it is futile to sample to determine if there is contamination.

The Air Force did sample existing residential wells located near Plant 4 and no contamination was detected in any samples from these wells. Additional groundwater sampling directly south of the site, off Plant 4 property, may be performed to better define the extent of contamination in the Terrace Alluvial groundwater that is from a known source. However, the Air Force will not install monitoring wells at random locations in residential areas unless there is a source suspected to be caused by Plant 4.

Comment 9:

An individual asked about "asphalt contamination" and benzo[*a*]pyrene. Another individual stated that benzo[*a*]pyrene is a powerful carcinogen and is used to induce cancer in animals for experiments. He described benzo[*a*]pyrene as an indicator of other contaminants, just as trichloroethene (TCE) is an indicator of organic contamination because TCE carries other contaminants with it as it is washed down.

Air Force Response: "Asphalt contamination" refers to the chemical benzo[*a*]pyrene, which is a derivative of tar and is found in asphalt. The levels of benzo[*a*]pyrene in the landfills are within acceptable limits. The Air Force analyzed samples for hundreds of different chemicals and did not use the analysis of benzo[*a*]pyrene or TCE for an indication of other contamination or focus on either of these contaminants.

Several other contaminants that are similar to benzo[*a*]pyrene or TCE were detected but the levels were not high enough to cause excess risk. Measured TCE and benzo[*a*]pyrene concentrations were at levels that either cause excess risk, as is the case with TCE, or exceed the lower threshold of the acceptable risk range but are within acceptable limits, as is the case with benzo[*a*]pyrene. The presence of TCE does not indicate that there are more contaminants in the groundwater.

Comment 10:

An individual from the city of White Settlement commented that the city of White Settlement has more wells than what is shown on the figures in the Proposed Plan. Also, the Air Force should check with the city of White Settlement about possibly monitoring wells owned by the city and drilling new wells on city property, if the Air Force has the funding available. There may be information available about contamination levels in the groundwater that does not require additional monitoring.

Air Force Response: The Air Force agrees that using existing wells is a cost-effective way of obtaining information about groundwater contamination levels in the residential areas. To date, no contamination has been detected in samples from residential wells that could be attributed to contamination from Plant 4.

Comments and Questions Received During the Public Comment Period

All comments received during the public comment period where from one individual who lives near Plant 4.

Comment 1:

The commentor expressed concern that contamination from Plant 4 has been transported by various means to the residential areas near the plant. Also, because only limited sampling has been conducted in residential areas, a comprehensive sampling program should be performed to determine contamination levels within the residential areas. Four additional parts to the comment (part 1a, 1b, 1c, and 1d) address specific contamination concerns.

Air Force Response: A small amount of contamination could have been transported by various means to areas adjacent to Plant 4, including residential areas. However, the relevant issue is not if small amounts of contamination has been transported off-site, but if the levels of contamination at an off-site location are high enough to cause excess risk (i.e., an incremental lifetime cancer risk greater than 1 in 10,000 and a hazard quotient greater than 1.0).

The most significant ways contamination can be transported off site at levels high enough to cause excess risk are (1) by groundwater discharging to surface water and then individuals being exposed to contamination in the surface water and (2) by groundwater migrating off site and individuals using the groundwater. Transportation of contamination by these methods is addressed in the ROD. Current contamination levels in surface water adjacent to Plant 4 are not high enough to cause excess risk but surface water will continue to be monitored to determine if contamination levels increase to levels that can cause excess risk.

The ROD also requires that contamination levels in the groundwater be monitored to determine if contamination is moving off site. The monitoring will determine if contamination is likely to move off site before it actually reaches Federal boundaries so that corrective action can be taken before any groundwater contamination migrates off site at levels that will cause excess risk.

Transport of contamination to off-site locations at levels that will cause excess risk by other methods, such a volatilization to the atmosphere or dumping of contaminated soil, are not supported by any records or sampling data. Therefore, the Air Force, with the concurrence of the EPA and the State of Texas, does not plan any additional sampling at off-site locations, other than what is specified in the ROD. Concerns about specific contaminants are addressed in parts 1a, 1b, 1c, and 1d of this comment.

Comment 1a:

The commentor expressed concern that a significant amount of TCE has evaporated to the atmosphere and that, once in the atmosphere, the TCE is carried by the wind to eventually be deposited off site by rain and condensation where it can collect on the ground. Also, the commentor stated that because TCE is a "heavy" chemical, with a boiling point higher than water, it stays low to the ground when it evaporates, even while being carried off site by the wind. This route represents a path by which volatile chemicals such as TCE are carried to the community. Because of the long time period that TCE was used at Plant 4, there could be high levels of TCE in the community.

Air Force Response: The commentor is correct with the statement that TCE is likely to have evaporated from Plant 4 and that, once in the atmosphere, TCE can be carried off site by the wind. However, because of the nature of TCE, it will not have accumulated in the community at levels that will cause excess risk. Other statements made by the commentor concerning the fate and transport of TCE are incorrect.

TCE has a relatively high vapor pressure and a boiling point lower than water (86.7 °C). Because of its high vapor pressure, TCE evaporates rapidly to the atmosphere. Once in the atmosphere, TCE exists entirely in the vapor phase and has a half-life of approximately 7 days before it is degraded. A half-life of 7 days means that half the TCE that has evaporated to the atmosphere will degrade within 7 days.

TCE can be removed from the atmosphere by rainfall and dew, called wet deposition. Once it has been removed from the atmosphere by wet deposition, it will be in surface water. TCE in surface water will rapidly partition from the water, as evidenced by its Henry's law constant of 2.0×10^{-2} atmosphere-cubic meters per mole at 20 °C, and revolatilize back to the atmosphere. This principle also applies to TCE in surface water found in streams or lakes, such as Meandering Road Creek or Lake Worth. Experimental studies have shown that the volatilization half-life of TCE in a rapidly moving river is approximately 3.4 hours. Other studies have calculated a volatilization half-life of TCE in a typical pond, lake, and river of 11 days, 4 to 12 days, and 1 to 12 days, respectively. Reevaporation of TCE from dry surfaces also will occur rapidly because of its high vapor pressure.

TCE has evaporated from Plant 4 and has then been carried by the wind to off-site locations. However, considering the characteristics of TCE (i.e., its high vapor pressure and rapid partitioning from surface water to the atmosphere), significant accumulations of TCE within the community that could cause excess risk, as determined by a risk assessment, are unlikely. This conclusion is supported by air sampling conducted as part of the remedial investigation while TCE was still used at Plant 4 (TCE is no longer used at the plant) to determine if TCE evaporating from Plant 4 was being carried off site at levels that would cause excess risk. The off-site air sampling was conducted at a location approximately 0.75 mile west of Plant 4. Analysis of the air samples determined that the highest levels of TCE in the air at the off-site location were approximately one-fourth the highest levels of TCE in the air at the on-site location. The baseline risk assessment determined that the levels of TCE in the air at the on-site location do not cause excess risk, and, therefore, the risk to off-site receptors is not an excess risk. This sampling and determination of risk are documented in the Remedial Investigation Report. Because

TCE is no longer used at Plant 4, any risk to the community from TCE evaporating and being carried off site is nonexistent.

Comment 1b:

The commentor wrote that because Plant 4 was and is a volume user of mercury, mercury vapors have been released to the atmosphere. Once in the atmosphere, the mercury vapors could have been carried by the wind to off-site locations where members of the community could be exposed to mercury. The commentor also expressed concern that mercury could migrate to groundwater and to surface water, ending up in Lake Worth. The mercury used at Plant 4 is a form, mercury oxide, that is not detectable by sampling methods. Also, the commentor was concerned that once the mercury was in Lake Worth, it would be flushed downstream where it could contaminate a source of the nation's food supply.

Air Force Response: The commentor is correct in that mercury was and is in instruments and equipment used at Plant 4. The historical record search does not show that mercury was disposed of at on-site locations. However, it is possible that instruments and other equipment containing mercury were disposed of on site. If they were disposed of on site, low amounts of mercury or mercury compounds could be in the soil at Plant 4, even though they were not detected by sampling conducted for the remedial investigation.

Also, if mercury were in the landfills near the surface, a portion of the mercury would vaporize to the atmosphere and once in the atmosphere could be transported by wind. However, any mercury vapors that were transported by the wind would be redeposited at concentrations significantly less than the concentration of the source of the mercury on Plant 4. Analyses of groundwater samples conducted as part of the remedial investigation detected the presence of mercury in two samples at very low concentrations. Mercury concentrations were detected in two samples from the Terrace Alluvial groundwater. The levels of mercury were approximately 0.2 microgram per liter (μg/L), which is 10 times less than the allowable level for drinking water. However, Terrace Alluvial groundwater is not used for drinking water. The presence of mercury was not detected in groundwater samples from the Paluxy aquifer (which is used for drinking water), in surface water, or in soil near the surface.

On the basis of sampling results conducted for the remedial investigation, the baseline risk assessment determined there is no excess risk from exposure to mercury in the groundwater, surface water, or soil. Because mercury was not detected in the surface soil samples, the air samples collected at the on-site and off-site locations were not analyzed for mercury.

The determination that there is no excess risk from mercury will be verified by monitoring described in the ROD. Sampling of surface water and groundwater will be conducted at areas on and near Plant 4. Future analyses will be able to detect mercury compounds, such as mercury oxide, that are insoluble in water; analyses performed for the remedial investigation also were able to detect insoluble mercury compounds. In addition, public water supplies are regularly sampled for mercury to ensure that drinking water supplies do not contain excess contaminants, including mercury.

Although the scenario described by the commentor is theoretically possible, it is highly improbable, given the results of the sampling performed for the remedial investigation, that mercury found on site has vaporized and then been carried off site by the wind at levels that will cause excess risk. Therefore, the Air Force, with the concurrence of the EPA and the State of Texas, does not plan to collect samples in the residential areas adjacent to Plant 4.

Comment 1c:

The commentor expressed concern that landfill material from Plant 4, containing hazardous contamination and some dies used for metal shaping, has been disposed of at various locations around Fort Worth, such as a low area south of Brewer High School. This landfill material is another way that contamination has been transported to residential areas.

Air Force Response: A records search in 1984 found no evidence of any removal or off-site disposal during the construction period for Brewer High School. The high school was constructed in 1953 (phone conversation with White Settlement Independent School District Communications Office) and contractor removal of Plant 4 material to off-site locations did not begin until 1966. During the period of construction for Brewer High School, two landfills were active at the facility and the necessity for off-site disposal was nonexistent. Records also indicate that all dies and metals used at Plant 4 during this time were recycled.

No other evidence is available that landfill material was transported to other locations in the Fort Worth area. Without an indication of where the contamination caused by Plant 4 could be, sampling to determine if contamination does exist at other locations is futile. Therefore, the Air Force does not plan to conduct any additional off-site soil sampling.

Comment 1d:

The commentor expressed concern that rainwater runoff from Plant 4 can transport contamination into residential areas.

Air Force Response: Soil analyses performed during the remedial investigation have shown that contamination in soils at the ground surface of Plant 4 is negligible and does not cause an excess risk, except at Landfill No. 4 and Landfill No. 3 where there is a potential for excess ecological risk (the potential risk is only to mice). Because surface soil on Plant 4 is the only source of contamination for rainwater runoff to transport contamination off site, the absence of soil contamination at the surface that causes excess risk eliminates the potential for the transportation of contamination via rainwater runoff.

Although surface contamination at Landfill No. 3 is low, it is higher than surface contamination at other areas and is the area most likely to be a source of contamination that could be transported off site by rainwater runoff. Other areas of Plant 4 are covered by concrete or asphalt and would not be affected by rainwater. Rainwater runoff from Landfill No. 3 drains into Meandering Road Creek. Contamination has been detected in samples from Meandering Road Creek but not at levels that cause excess risk. Monitoring of the surface water in Meandering Road Creek will be conducted to ensure that contamination levels in Meandering Road Creek do not increase to unacceptable levels.

Comment 2:

The commentor is a member of the Restoration Advisory Board and requested the names and phone number of other members of the Restoration Advisory Board.

Air Force Response: The names and phone numbers of other Restoration Advisory Board members have been sent to the commentor. The Air Force only has the phone numbers of those that wished to provide them and, therefore, does not have the phone numbers of all Restoration Advisory Board members. However, the commentor was sent all the phone numbers available to the Air Force.

Comment 3:

The commentor requested consideration of installation of subsurface concrete walls around the site or around individual "dumps" (landfills). This written comment is a continuation of a comment made during the public meeting held December 14, 1995. During the public meeting, the response from the Air Force was that a subsurface wall was not needed. However, if a subsurface wall were needed, it would probably be constructed of bentonite rather than concrete. The commentor disagrees with the use of bentonite for a subsurface wall and stated that a concrete wall would be better because it is less permeable than bentonite.

Air Force Response: A subsurface wall is not needed around individual landfills, such as Landfill No. 3 or Landfill No. 4, or around the entire site because the levels of contamination that are being discharged from the groundwater to surface water is not causing excess risk. The main concern of the Air Force is if contamination at the landfills is migrating to the groundwater and then to the surface water at levels that will cause excess risk. Currently, small levels of contamination are migrating from the landfills but not at levels that cause excess risk. Therefore, a subsurface barrier is not needed. The determination that contamination is not causing excess risk will be verified with sampling of the surface water near the landfills.

Further, for a subsurface wall to be useful, such a wall would have to encompass each plume individually and entirely, or it would have to encompass the majority of the property within the boundaries of the two Federal facilities (Air Force Plant 4 and Naval Air Station Fort Worth). In either case, the wall would serve to stop contaminated groundwater flow through unconsolidated alluvial deposits at the location of the wall.

Also, the concrete wall would not prevent the slower migration occurring along bedding planes and in weathered bedrock.

Within the perimeter of the wall, groundwater recharge would continue, as would the flow of groundwater toward the edges of the plume where the wall is located. Because groundwater would not be able to go through the subsurface wall, water levels would increase until the water flowed over the top of the subsurface wall. To prevent this overflow, discharge pumps, wells, and/or drains would be required to extract contaminated water, which would then be treated at the surface. In short, the active remediation involving pumps, wells, etc., that this proposal seeks to avoid would still be required. If contamination levels do not increase, as is expected, a subsurface wall will not be required.

The comment also suggests that concrete is preferable to bentonite because the bentonite would become saturated and has only a limited capacity to adsorb contaminants. A bentonite wall is not under consideration for use at Plant 4 at this time. Contrary to the comment, bentonite walls do not become ineffective when saturated and they are not intended to adsorb contaminants. Bentonite walls are intended to provide a low permeability barrier to groundwater flow. To be effective, bentonite walls must be saturated. When dry, bentonite walls shrink and crack, losing low-permeability properties because of shrinkage and cracking. Also, the permeability (i.e., ability of water to flow through the wall) of bentonite is about the same as that of concrete.

A subsurface wall would have to be approximately 6 miles long to encircle all the groundwater contamination in the Terrace Alluvial flow system on Plant 4 and Naval Air Station Fort Worth. A subsurface wall constructed of a concrete/bentonite mixture would cost approximately $70 million over a 50-year operation period and $95 million over a 100-year operation period. A subsurface wall constructed of a bentonite/soil mixture would cost approximately $38 million over a 50-year operation period and $83 million over a 100-year operation period.

Comment 4:

The commentor suggested that the toxicity of heavy metals found on Plant 4 can be minimized by adding a safe naturalizing agent to the dump sites. This process was suggested as a low-cost way to detoxify the heavy metals before they leach from the dump sites.

(a) The commentor stated pure metals at the dump sites could be treated by spreading sulfur over a dump site. The sulfur would mix with the effluents and create a water-insoluble metal sulfide salt. The metal sulfide salt would be comparatively nontoxic and pose minimal threats to the environment.

(b) The commentor also suggested that metal salts could theoretically be converted to less-toxic insoluble products by adding a safe liquid, such as sodium silicate, that will precipitate largely insoluble silicates of metals elements.

In addition, the commentor stated that if a solid silicate type of reagent is preferred, aluminum silicate earth would be an inexpensive and effective method and that a number of other chemicals could be used.

Air Force Response: The commentor is suggesting various methods of stabilization or chemical fixation of the metals in the landfills, chrome pits, and dump areas. The important point is not if the suggested methods of stabilization are effective, but if stabilization is needed to manage risk to within acceptable levels. On the basis of results of the baseline risk assessment, metals do not present excess risk to human health (risk with an ILCR higher than 1.0×10^{-4} or a hazard quotient higher 1.0). There is a potential for excess risk to mice from metals. Because the potential risk was only to mice, a risk management decision was made that no action was acceptable. The findings of the baseline risk assessment will be verified over the long term by monitoring the groundwater and surface water.

The methods of stabilization suggested by the commentor may work for certain metals under certain conditions, but generally will not be effective for treating a mixture of metals and organics found in the landfills, chrome pits, and dump areas, with the exception of aluminum silicate. Aluminum silicate is a primary ingredient in Portland cement, and Portland cement is potentially the best method of stabilizing the waste mixtures found in the landfills. However, as stated earlier, stabilization of the metals and organics found in these waste areas was determined as not required to manage risk to within acceptable levels.

Comment 5:

The commentor is concerned that the analysis of water samples taken as part of the remedial investigation will not detect insoluble compounds, such as radioactive dust and small radioactive particles in the water. These compounds are likely present at the site but have not been detected because they are insoluble. The commentor suggested that if radioactive elements are detected above safe levels, the area should be capped to prevent radioactive dust from being transported by the wind. The commentor also recommended two actions to detect the presence of radioactive elements.

(a) The commentor suggested that a Geiger-counter scan of the selected areas be performed to verify the presence or the absence of radioactive materials.

(b) The commentor also suggested extracting soil samples with a strong oxidizing acid as a way to detect radioactive materials that would not be detected in analysis of a water sample.

Air Force Response: The only area where radioactive metals and compounds were used or stored on Plant 4 is at NARF. During the remedial investigation, sediment samples and groundwater samples were collected from the drainage near NARF and analyzed for radioisotopes. Previous investigation activities also included the collection and analysis of soil samples from boreholes drilled around the perimeter of NARF.

Results from previous soil analyses indicate gross alpha, gross beta, and radioisotopes levels are within background ranges. Maximum uranium, radium, and thorium concentrations were 2.7 milligrams per kilogram, 1.19 picocuries per gram (pCi/g), and 2.0 pCi/g, respectively, which are well within equilibrium levels. The maximum cesium concentration was 0.53 pCi/g, which is within expected levels that are due to fallout from worldwide nuclear testing. The presence of cobalt was not detected in any sample. These concentrations are within the range of normal background levels; therefore, no action is necessary for the NARF area. In addition to laboratory analyses, a field scan was performed for alpha, beta, and gamma radiation on all samples collected from sediments near the former NARF site; no radiation levels above background were detected.

In response to the commentor's suggestion to use a Geiger counter to verify the presence or the absence of such radioactive materials, a Geiger counter is not as effective at detecting the presence of plutonium or uranium because Geiger counters only detect gamma radiation and are not as sensitive as gamma spectroscopy, the method used in the remedial investigation. Plutonium and uranium emit low levels of gamma radiation but are primarily alpha particle emitters.

In response to the commentor's suggestion to extract soil samples with a strong oxidizing acid, such a procedure can be performed, but is unnecessary. Radioactive elements will decay and emit alpha, beta, or gamma radiation regardless of the matrix. The methods used in the remedial investigation are established and proven methods to detect radioactive elements.

Comment 6:

The commentor stated that waste disposal by deep-well injection was probably used at Plant 4. Unless records are available to prove that deep-well injection did not occur at Plant 4, it must be assumed to have occurred and a "deep-well survey" should be conducted to investigate this supposed problem. The commentor did not specify what constitutes "deep-well disposal."

Air Force Response: A records search and subsequent telephone conversations with Plant 4 personnel indicate there never has been deep-well disposal of wastes on site. Waste disposed of by deep-well injection at off-site locations was manifested waste and the waste was disposed of in permitted off-site wells.

If records documenting the occurrence of deep-well injection on site were available, further investigation might be warranted. However, investigating the potential of deep-well disposal of wastes simply because there is no evidence to prove it did not occur is an expensive use of resources.

Analyses required by the Safe Drinking Water Act are performed on samples of all groundwater pumped from aquifers in the area that is used as a municipal water supply. These analyses have not shown any contamination problems in the drinking water aquifers that could be attributed to Plant 4. Given the absence of Plant 4 records documenting deep-well disposal on site and the lack of evidence supporting contamination that could be caused by Plant 4, there is insufficient justification to search for contamination caused by deep-well injection at Plant 4.

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Appendix B

Administrative Record Index

Prepared by
U.S. Army Corps of Engineers
Louisville District

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Contents

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Administrative Record for U. S. Air Force Plant 4

Introduction

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 requires establishing administrative records.

The administrative record established under § 113(k) of CERCLA serves two primary purposes. First, the record contains those documents which form the basis for selection of a response action under § 113(j). Judicial review of any issue on the adequacy of a response action is limited to the record. Second, § 113(k) requires that the administrative record act as a vehicle for public participation in selecting a response action.

This administrative record file and accompanying index have been compiled according to provisions of the U. S. Environmental Protection Agency's Office of Solid Waste and Emergency Response (OSWER) Directive No. 9833.3A-1, "Final Guidance on Administrative Records for Selecting CERCLA Response Actions."

The documents included in this administrative record are a subset of information included in the project files for this site. Documents contained in the administrative record file are identified with unique numbers to aid in tracking and retrieval of the documents.

The index and file will be updated about once each quarter. As the updates are issued, the file will be inventoried against the new index to ensure its completeness.

According to OSWER Directive No. 9833.3A-1, certain documents are not physically included in this administrative record file but are included by reference. Among these documents are chain-of-custody forms and sampling data, such as laboratory analytical results. The sampling data are summarized in the reports included in the administrative record file. Typically, the sampling data and related chain-of-custody forms are retained by the contractors that published the reports and/or their subcontractors. To receive further information concerning specific sampling data and chain-of-custody forms, please reference the document number of the report and write to the individual identified below.

Please forward any questions, comments, or requests for additional information or copies to: (**Note:** Costs for copies are borne by the requester.)

U. S. Air Force, ASC/EMR, Building 8
1801 10th Street, Suite 2
Wright-Patterson AFB, OH 45433-7626

Attention: Mr. David Lawrence

Administrative Record Index Guide

The Administrative Record file for Air Force Plant 4 Installation Restoration Program (IRP) has been assembled per the Administrative Record Category List. The category list was developed based upon OSWER Directive No. 9833.3A-1.

The Index contains the following fields: DOCNO, CATEGORY, TITLE, AUTHOR, PAGE, and DATE. A description of each field is presented below.

1. DOCNO: This is the unique document number assigned to each document contained in the Administrative Record file. The first two digits identify the general category (e.g., 01-Site Identification, 03-Remedial Investigation, etc.). The last three digits are a sequential number assigned from the database as documents are entered into the Administrative Record file.

2. CATEGORY: This is the specific category identification from the Administrative Record Index Category List (e.g., 01.04-Site Investigative Reports, 03.04-Remedial Investigation Work Plans, etc.). Documents of a specific nature can be located through review of this field.

3. TITLE: This is the complete title as it is shown on each document. Clarifications have been provided where appropriate.

4. AUTHOR: This is the specific organization responsible for generating the document. Individuals are identified where known.

5. PAGE: This is the number of pages contained in each document. For documents containing more than one thousand pages, the total page count is identified as 999.

6. DATE: This is the date of each document. If an actual date is not provided, the last date of the month is used (e.g., a document dated September 1991 is listed as 09/30/91).

7. Notes: Documents listed in Section 11.00 are available to the public through original sources and are included in this Administrative Record file for reference only.

   Document titles preceded by an asterisk (*) will be included in the Administrative Record file at the next scheduled update.

Administrative Record
Index Category List

01.00 SITE IDENTIFICATION

- 01.01 Background
- 01.02 Notification/Site Inspection Reports
- 01.03 Preliminary Assessment Reports
- 01.04 Site Investigative Reports
- 01.05 Miscellaneous Investigation Reports
- 01.06 Correspondence
- 01.07 Quality Assurance Program/Project Plans
- 01.08 Health and Safety Plans
- 01.09 Miscellaneous Program/Project Management Documents

02.00 REMOVAL RESPONSE

- 02.01 Sampling and Analysis Plans
- 02.02 Sampling and Analysis Data/Chain-of-Custody Forms
- 02.03 Engineering Evaluation/Cost Analysis (EE/CA)
- 02.04 EE/CA Approval Memorandum
- 02.05 Action Memorandum and Amendments
- 02.06 Correspondence

03.00 REMEDIAL INVESTIGATION (RI)

- 03.01 Sampling and Analysis Plans
- 03.02 Sampling and Analysis Data/Chain-of-Custody Forms
- 03.03 Manifests
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- 03.05 Remedial Investigation Reports
- 03.06 Correspondence

04.00 FEASIBILITY STUDY (FS)

- 04.01 Applicable or Relevant and Appropriate Requirement (ARARs) Determinations
- 04.02 Feasibility Study Reports
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05.00 RECORD OF DECISION (ROD)

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06.00 STATE COORDINATION

06.01 Cooperative Agreements/State Memorandums of Agreement (SMOAs)
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07.00 ENFORCEMENT

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07.07 Notice Letters and Responses
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08.00 HEALTH ASSESSMENTS

08.01 Agency for Toxic Substance and Disease Registry (ATSDR) Health Assessments
08.02 Toxicological Profiles

09.00 NATURAL RESOURCE TRUSTEES

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10.00 PUBLIC PARTICIPATION

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10.06 Fact Sheets and Press Releases
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11.00 TECHNICAL SOURCES AND GUIDANCE DOCUMENTS

11.01 U. S. Environmental Protection Agency (EPA) Headquarters' Guidance
11.02 EPA Regional Guidance
11.03 State Guidance
11.04 Technical Sources
11.05 Department of the Air Force Guidance
11.06 Technical Information Reports

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DOCNO	CATEGORY	TITLE	AUTHOR	PAGE	DATE
1001	1.04	Phase I Investigation, Drilling and Construction of Upper Zone Test Holes and Monitor Wells	Hargis & Montgomery, Inc.	13	01/31/83
1002	1.04	Installation Phase I Investigation of Subsurface Conditions at U.S. Air Force Plant 4, Fort Worth, Texas, Volume I (Text)	Hargis & Montgomery, Inc.	73	02/03/83
1003	1.04	Installation Phase I Investigation of Subsurface Conditions at U.S. Air Force Plant 4, Fort Worth, Texas, Volume II, (Illustrations)	Hargis & Montgomery, Inc.	9	03/03/83
1004	1.04	Installation Phase I Investigation of Subsurface Conditions at U.S. Air Force Plant 4, Fort Worth, Texas, Volume III (Appendices)	Hargis & Montgomery, Inc.	168	03/03/83
1005	1.04	Construction of Paluxy Monitor Well P-1, U.S. Air Force Plant 4, Fort Worth, Texas	Hargis & Montgomery, Inc.	17	03/18/83
1006	1.04	Specification for Waste Disposal Project - West Parking Lot	General Dynamics	93	06/30/83
1008	1.04	Environmental, Energy, and Resource Conservation Review of Air Force Plant 4	JRB Associates	250	09/30/83
1009	1.04	Seismic Refraction Survey, Letter Report, General Dynamics, Ft. Worth Division, Project No. 840002	D'Appolonia Waste Management Services	8	12/31/83
1010	1.04	Copy of Field Engineer's Notes for Die Yard and Chrome Pits Excavation Project and Analytical Lab Results	General Dynamics	77	01/31/84
1011	1.04	Installation/Restoration Program Records Search for Air Force Plant 4, Texas	CH2M Hill	394	08/31/84
1012	1.04	Conclusion and Recommendations for Completion of Phase II Investigation	Hargis & Associates, Inc.	35	10/25/84
1013	1.04	Phase II Investigation of Subsurface Conditions Vol. I	Hargis & Associates, Inc.	155	09/30/85
1014	1.04	Phase II Investigation of Subsurface Conditions, Volume II, Appendices A-E	Hargis & Associates, Inc.	300	09/30/85
1015	1.04	Phase II Investigation of Subsurface Conditions, Volume III, Appendices F-G	Hargis & Associates, Inc.	238	09/30/85
1016	1.04	Phase II Investigation of Subsurface Conditions, Volume IV, Appendices H-I	Hargis & Associates, Inc.	264	09/30/85
1017	1.04	Phase II Investigation of Subsurface Conditions, Volume V, Appendices J-M	Hargis & Associates, Inc.	167	09/30/85
1018	1.04	Draft Installation Restoration Program, Phase II, Confirmation/Qualification, Stage 1, Volume 1, Final Draft Report for Carswell AFB	Radian Corporation	237	09/30/85

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1019	1.04	Installation Restoration Program, Phase II, Confirmation/Qualification, Stage 1, Volume 2 - Appendix A, Draft Final Report for Carswell AFB	Radian Corporation	728	09/30/85
1020	1.04	Installation Restoration Program, Phase II, Confirmation/Qualification, Stage 1, Volume 3 - Appendices B-L, Draft Final Report for Carswell AFB	Radian Corporation	362	09/30/85
1021	1.04	Assessment of French Drain Pumpage	Hargis & Associates, Inc.	27	12/06/85
1022	1.04	Results of Soil and Groundwater Assessment for the Proposed Systems Development Laboratory and Anechoic Chamber Buildings	Hargis & Associates, Inc.	60	12/16/85
1023	1.04	Proposed 1986 Hydrologic Monitoring Plan.U.S. Air Force Plant No. 4, Ft. Worth, Texas	Hargis & Associates,Inc.	48	01/02/86
1024	1.03	Three-Site RAP Review Action Items, Attachment A Design Basis and Preliminary Calculations for Conceptual Design of Alternate 4, Onsite Contaminated Groundwater Treatment and Discharge to AFP No. 4 Process Water Makeup System	Intellus Corporation	53	07/16/86
1025	1.04	Draft Remedial Action Plan and Conceptual Documents for Fuel Saturation Areas No. 1 and No. 3	Intellus Corporation	501	07/31/86
1026	1.04	Interim Report for Ten-Site Field Investigation, Prepared for Air Force Plant 4, Fort Worth, Texas	Intellus Corporation	461	11/30/86
1027	1.04	Construction Site Assessment Report for the Die Yard Zone, Plant Services Contract No. 5161	Intellus Corporation	90	01/30/87
1028	1.04	Summary Report Window Area Investigation	Hargis & Associates, Inc..	69	04/21/87
1029	1.04	Assessment Report for Landfill No.3,Prepared for U.S. Air Force Plant No. 4, Fort Worth, Texas	Intellus Corporation	51	08/31/87
1031	1.04	Proposed 1988 Hydrologic Monitoring Plan	Hargis & Associates, Inc.	123	12/02/87
1032	1.04	Installation Restoration Program, Phase II, Confirmation/Quantification, Stage 1, Volume 2 - Appendix A-1, Final Report for September 1985 through September 1986	Radian Corporation	621	12/31/87
1033	1.04	Installation Restoration Program, Phase II, Confirmation/Quantification, Stage 1, Volume 3, Appendix A-1 (continued), Final Report for September 1985 through September 1986	Radian Corporation	552	12/31/87
1034	1.04	Installation Restoration Program, Phase II, Confirmation/Quantification, Stage 1, Volume 4 - Appendix A-1 (continued), Final Report for September 1985 through September 1986	Radian Corporation	603	12/31/87

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1035	1.04	Installation Restoration Program, Phase II, Confirmation/Quantification, Stage 1, Volume 5 - Appendix A-2, Final Report for September 1985 through September 1986	Radian Corporation	326	12/31/87
1036	1.04	Installation Restoration Program, Phase II, Confirmation/Quantification, Stage 1, Volume 6 - Appendix A-2 (continued), Final Report for September 1985 through September 1986	Radian Corporation	492	12/31/87
1037	1.04	Installation Restoration Program, Phase II, Confirmation/Quantification, Stage 1, Volume 7 - Appendices A-3 and A-4, Final Report for September 1985 through September 1986	Radian Corporation	394	12/31/87
1038	1.04	Installation Restoration Program, Phase II, Confirmation/Quantification, Stage 1, Volume 8 - Appendices B-E, Final Report for September 1985 through September 1986	Radian Corporation	155	12/31/87
1039	1.04	Installation Restoration Program, Phase II, Confirmation/Quantification, Stage 1, Volume 9 - Appendices F-K, Final Report for September 1985 through September 1986	Radian Corporation	353	12/31/87
1040	1.04	Installation Restoration Program, Phase II, Final Report - Volume 10, Appendix L, Final Report for September 1985 through September 1986	Radian Corporation	622	12/31/87
1041	1.04	Installation Restoration Program, Phase II, Confirmation/Quantification, Stage 1, Volume 1, Report Text, Final Report for September 1985 through September 1986	Radian Corporation	491	12/31/87
1042	1.07	Installation Restoration Program,Phase II, Confirmation/Quantification, Stage 2, Carswell Air Force Base Quality Assurance Project Plan	Radian Corporation	174	01/31/88
1043	1.04	Evaluation of Condenser Water Pipeline and Interim Remedial Measures Fuel Saturation Area No. 3	Hargis & Associates, Inc.	37	07/15/88
1044	1.04	Engineering Report Remedial Action for Fuel Saturation Areas 1 and 3 and treating leachate of French Drain No. 1, Air Force Project 1-86-59, Plant Services Contract 6246	General Dynamics	101	03/02/89
1045	1.04	Underground Storage Tank Program Evaluation, Analysis of USTS at AFP No. 4, Ft. Worth, Texas, Volume III, Appendix F	Hargis & Associates, Inc.	309	06/02/89
1046	1.04	Industrial Hygiene Assessment of Organic Solvents at General Dynamics Plant Fort Worth, Texas	Clayton Environmental Consultants, Ltd. for Hargis & Associates, Inc.	37	08/28/89

DOCNO	CATEGORY	TITLE	AUTHOR	PAGE	DATE
1047	1.04	Environmental Assessment, Advanced Materials Development Laboratory Site	Hargis & Associates, Inc.	122	10/20/89
1048	1.07	Preliminary Assessment/Site Inspection and Remedial Investigation/Feasibility Studies, Final Quality Assurance Project Plan, Air Force Plant 4, Volume III	UNC Geotech	60	08/31/90
1049	1.08	Preliminary Assessment/Site Inspection and Remedial Investigations/Feasibility Studies, Final Health and Safety Plan, Air Force Plant 4, Volume IV	UNC Geotech	300	08/31/90
1050	1.04	Draft Decision Paper for Landfill Number 2 Site	Geotech, Inc.	34	09/30/90
1051	1.04	Draft Decision Paper for Chrome Pit Number 1 Site	Geotech, Inc.	22	09/30/90
1052	1.04	Draft Decision Paper For Chrome Pit Number 2 Site	Geotech, Inc.	19	09/30/90
1053	1.04	Draft Decision Paper for Fire Department Training Area Number 4 Site	Geotech, Inc.	34	09/30/90
1054	1.09	Preliminary Water Quality Monitoring Plan	Geotech, Inc.	86	10/31/90
1055	1.04	Installation Restoration Program, Stage 2, Site Characterization Report for the Flightline Area, Carswell Air Force Base	Radian Corporation	321	11/30/90
1056	1.09	Preliminary Assessment/Site Inspection and Remedial Investigations/Feasibility Studies, Waste Management Plan,Air Force Plant 4	Chem-Nuclear Geotech, Inc.	15	12/03/90
1057	1.05	Draft Final Groundwater Quality Monitoring Report, January 1992, GJPO-WMP-68, prepared for Headquarters Department of the Air Force, Aeronautical Systems Division, Wright-Patterson AFB, Ohio, Volumes 1 through 5	Chem-Nuclear Geotech, Inc.	999	01/31/92
1058	1.04	Investigation of Ground Water Pollution at Air Force Plant No. 4, Fort Worth, Texas	U.S. Army Corps of Engineers, Kansas City District, Fort Worth District	142	10/31/86
1059	1.04	Phase II Report, Field Sampling, Analysis and Testing, Air Force Plant 4, Window Area, Fort Worth, Texas	International Technology Corporation	56	08/31/93
1060	1.04	Installation Restoration Program, Quarterly Groundwater Monitoring Comprehensive Sampling Round Letter Report, Air Force Plant 4, Fort Worth Texas	Jacobs Engineering Group Inc.	99	08/31/93
1061	1.04	Installation Restoration Program (IRP) Quarterly Groundwater Monitoring Quarterly Letter Report, Air Force Plant 4; Texas	Jacobs Engineering Group, Inc.	317	02/28/95
1062	1.04	Installation Restoration Program (IRP) Quarterly Groundwater Monitoring Data Validation Letter Report: Air Force Plant 4; Texas	Jacobs Engineering Group, Inc.	161	02/28/95

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1063	1.08	Soil Vapor Extraction Pilot Plant Site Specific Health and Safety Plan; Air Force Plant 4, Fort Worth Texas	Environmental Science and Engineering, Inc.	111	09/30/93
1064	1.04	Results of Chemical Analyses of Liquid Samples Various Sites; Air Force Plant 4, Fort Worth Texas	U.S. Army Corps of Engineers Southwest Division Laboratory, Dallas, Texas	122	01/27/93
1065	1.08	Site Health and Safety Plan, Groundwater Remediation of Landfills 4 and 5, Carswell Air Force Base, Fort Worth, Texas	IT Corporation, Monroeville, PA	82	04/30/93
1066	1.07	Contractor Quality Control Plan (Addendum) Groundwater Remediation System Installation and Startup, Landfills 4 and 5 (Carswell); Air Force Plant 4, Fort Worth, Texas	IT Corporation, Monroeville, PA	215	01/31/94
1067	1.03	Soil Vapor Extraction Pilot Plant Operations and Maintenance, Sampling, and Test Manual; Air Force Plant 4, Fort Worth Texas	Environmental Science and Engineering, Inc.	43	09/30/93
1068	1.04	Installation Restoration Program (IRP) Data Validation Letter Report; Air Force Plant 4, Fort Worth, Texas	Jacobs Engineering Group, Inc.	234	08/31/95
1069	1.04	Installation restoration Program (IRP) Basewide Groundwater Monitoring Quarterly Letter Report; Air Force Plant 4, Fort Worth, Texas	Jacobs Engineering Group, Inc.	690	08/31/95
3001	3.02	Water Quality Data, May 1985 to May 1986	Hargis & Associates, Inc.	326	08/15/86
3002	3.02	Water Quality Data, May 1986 to May 1987, Volume I, Appendices A through C	Hargis & Associates, Inc.	344	08/05/87
3003	3.02	Water Quality Data, May 1986 to May 1987, Volume II, Appendices D through G	Hargis & Associates, Inc.	149	08/31/87
3004	3.04	Final Draft Work Plan, Remedial Investigation and Feasibility Study, Volume I (Text)	Hargis & Associates, Inc.	202	01/31/89
3005	3.04	Final Draft Work Plan, Remedial Investigation and Feasibility Study, Volume II, Appendices C through I	Hargis & Associates, Inc.	255	01/31/89
3006	3.04	Final Draft Work Plan, Remedial Investigation and Feasibility Study, Volume III (Figures)	Hargis & Associates, Inc.	0	01/31/89
3007	3.02	Water Quality Data, May 1987 to January 1989, Volume I, Appendix A	Hargis & Associates, Inc.	263	04/20/89
3008	3.02	Water Quality Data, May 1987 to January 1989, Volume II, Appendices B through G	Hargis & Associates, Inc.	211	04/20/89
3009	3.01	Draft Annual Hydrologic Monitoring Plan	Hargis & Associates, Inc.	181	07/19/89
3010	3.05	Summary of Interim Remedial Investigations, January 1987 to April 1989, Volume I, Text, Tables and Illustrations	Hargis & Associates, Inc.	61	07/19/89

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3011	3.05	Summary of Interim Remedial Investigations, January 1987 to April 1989, Volume II, Appendices A through F	Hargis & Associates, Inc.	252	07/19/89
3012	3.05	Summary of Interim Remedial Investigations, January 1987 to April 1989, Volume III, Appendices G through L	Hargis & Associates, Inc.	279	07/19/89
3013	3.01	Annual Hydrologic Monitoring Plan	Hargis & Associates, Inc.	189	01/31/89
3014	3.01	Water Sampling Manual, Preliminary Draft	Hargis & Associates, Inc.	127	02/27/89
3015	3.02	Collection and Analysis of Soil Samples	Versar, Inc.	180	01/24/90
3016	3.02	Installation Restoration Program(IRP),Quarterly Groundwater Monitoring, Quarterly Letter Report, Air Force Plant 4, Texas	Jacobs Engineering Group, Inc.	217	06/30/92
3018	3.01	Preliminary Assessment/Site Inspection and Remedial Investigations/Feasibility Studies, Final Sampling and Analysis Plan, Air Force Plant 4, Volume II	UNC Geotech	330	08/31/90
3019	3.04	Preliminary Assessment/Site Inspection and Remedial Investigation/Feasibility Studies, Final Work Plan, AirForce Plant 4, Volume I	UNC Geotech	117	08/31/90
3020	3.06	Coordination of Installation Restoration Program (IRP) Efforts for Carswell AFB and AFP4 (RE: Letter 14Mar84)	AFSC	9	04/24/84
3021	3.02	Installation Restoration Program (IRP) Quarterly Groundwater Monitoring Quarterly Letter Report, Air Force Plant 4, Fort Worth, Texas	Jacobs Engineering Group, Inc.	254	03/31/94
3022	3.02	Installation Restoration Program (IRP) Quarterly Groundwater Monitoring Quarterly Letter Report; Air Force Plant 4, Fort Worth, Texas	Jacobs Engineering Group, Inc.	353	07/31/94
3023	3.05	Soil Vapor Extraction, Pilot Plant Study; Air Force Plant No. 4, Building 181; Fort Worth Texas	Environmental Science and Engineering, Inc.	240	08/31/94
3024	3.02	Installation Restoration Program (IRP) Quarterly Groundwater Monitoring Quarterly Letter Report: Air Force Plant 4; Fort Worth, Texas	Jacobs Engineering Group, Inc.	265	11/30/94
3025	3.05	Groundwater Monitor Well Installation, Landfill No. 4, U.S. Air Force Plant No. 4, Fort Worth, Texas	Geo-Marine, Inc.	393	11/30/94
3026	3.02	Installation Restoration Program (IRP) Quarterly Groundwater Monitoring Data Validation Letter Report; Air Force Plant 4, Fort Worth, Texas	Jacobs Engineering Group, Inc.	132	11/30/94
4001	4.02	Characterization of Trichloroethene Plume, Air Force Plant 4 and Carswell Air Force Base, Fort Worth, Texas	Environmental Science & Engineering Group	63	07/31/94
4002	4.02	Final Report - Summary of Remediation Projects at Air Force Plant 4 and Carswell Air Force Base, Fort Worth, Texas, Volume I	Environmental Science & Engineering, Inc.	207	07/31/94

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4003	4.02	Final Report - Summary of Remediation Projects at Air Force Plant 4 and Carswell Air Force Base, Fort Worth, Texas Volume II	Environmental Science & Engineering, Inc.	293	07/31/94
4004	4.02	Final Report - Summary of Hydrologic and Chemical Characterization Studies Volume I; Air Force Plant 4, Fort Worth, Texas	Environmental Science & Engineering, Inc.	196	07/31/94
4005	4.02	Final Report - Summary of Hydrologic and Chemical Characterization Studies Volume II; Air Force Plant 4, Fort Worth, Texas	Environmental Science & Engineering Group, Inc.	284	07/31/94
4006	4.02	Final Report - Summary of Hydrologic and Chemical Characterization Studies Volume III; Air Force Plant 4, Fort Worth, Texas	Environmental Science & Engineering, Inc.	411	07/31/94
5001	5.04	Draft Final No Further Action Decision Document, Landfill No. 2, Site LF02	Chem-Nuclear Geotech, Inc.	29	09/30/91
5002	5.04	Draft Final No Further Action Decision Document, Chrome Pit No. 1, Site DP11	Chem-Nuclear Geotech, Inc.	17	09/30/91
5003	5.04	Draft Final No Further Action Decision Document, Chrome Pit No. 2, Site DP10	Chem-Nuclear Geotech, Inc.	15	09/30/91
5004	5.04	Draft Final No Further Action Decision Document, Fire Department Training Area No. 4, Site FT07	Chem-Nuclear Geotech, Inc.	30	09/30/91
5005	5.04	Air Force Plant 4, Draft No Further Action Decision Document, Nuclear Aerospace Research Facility, IRP Site OT19	Chem-Nuclear Geotech, Inc.	20	09/30/92
5006	5.04	Air Force Plant 4, Draft No Further Action Decision Document, West Compass Rose, IRP Site OT21	Chem-Nuclear Geotech, Inc.	18	09/30/92
5007	5.04	Air Force Plant 4, Draft No Further Action Decision Document, Solvent Lines, IRP Site ST18	Chem-Nuclear Geotech, Inc.	22	09/30/92
7001	7.01	Investigation of Disposal/Cleanup Activities, Waste Disposal Project - West Parking Lot, USAF Plant 4, General Dynamics, Fort Worth Division, Fort Worth, Texas	U.S.Environmental Protection Agency Office of Enforcement and Compliance Monitoring	106	12/31/83
11001	11.03	Texas State Board of Water Engineers, Ground Water Resources of Fort Worth and Vicinity, Texas	W.O. George and N. A. Rose - Prepared in cooperation with the U.S.G.S.	0	09/30/42
11002	11.03	Geology and Ground Water Resources of Tarrant County, Texas	Texas State Board of Water Engineers	0	09/30/57
11003	11.03	Bulletin 6309, Reconnaissance Investigation of the Ground Water Resources of the Trinity River Basin,Texas	Texas Water Commission	0	09/30/63

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11004	11.03	Water-level and Water-Quality Data From Observation Wells in Northeast Texas, Report 198	Texas Water Development Board	0	03/28/76
11005	11.03	Variations in Specific Yield in the Outcrop of the Carrizo Sand in South Texas as Estimated by Seismic Refraction	Texas Department of Water Resources	0	04/30/79
11006	11.03	Texas Surface Water Quality Standards	Texas Department of Water Resources	0	04/30/81
11007	11.03	Occurrence, Availability, and Chemical Quality of Ground Water in the Cretaceous Aquifers of North-Central Texas, Report 269, Volume 1	Texas Department of Water Resources	0	04/30/82
11008	11.03	Occurrence, Availability, and Chemical Quality of Ground Water in the Cretaceous Aquifers of North-Central Texas, Report 269, Volume 2	Texas Department of Water Resources	0	07/31/82
11009	11.03	Air Force Installation Restoration Program Management Guidance	Department of the Air Force	0	07/30/85
11010	11.04	Water Resources Data, Texas 86, Volume 1	U.S. Geological Survey	0	01/31/86
11011	11.04	Water Resources Data, Texas 87, Volume 1	U.S. Geological Survey	0	01/31/87
11012	11.03	Ground Water Conditions in Texas 1980-1985, Report 309	Texas Water Development Board	0	10/31/88
11013	11.03	Permanent Rule Change	Texas Water Commission	0	12/28/88
11014	11.03	Official Texas Administrative Code, Title31, Natural Resources and Conservation	The State of Texas	0	01/31/89
11015	11.03	Water Resources Data, Texas 89, Volume 1	U.S. Geological Survey	0	01/31/89
11017	11.03	Official Texas Administrative Code, Title 31, Natural Resources and Conservation, 1990-1991 Supplement, Amendments effective through April 1, 1990	The State of Texas	0	01/31/90
11018	11.03	Index to Texas Water Well Drillers Board		0	/ /
11019	11.03	FEMA, Flood Insurance Study, Tarrant County, Texas Unincorporated Areas	Federal Emergency Management Agency	126	08/04/87
11020	11.04	Geotech, Soil & Water Sample Analytical Data	U.S. Department of Energy	0	05/22/90
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