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INSTALLATION RESTORATION PROGRAM PHASE 2 CONFIRMATION AND QUANTIFICATION STAGE 2 WORK PLAN NAS FORT WORTH TX

1/1/1988

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File: 17G
A.F.

NAVAL AIR STATION FORT WORTH JRB CARSWELL FIELD TEXAS

ADMINISTRATIVE RECORD COVER SHEET

AR File Number 25

File:
D.B.

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227-005-04

INTEGRATED INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION
STAGE 2 - WORK PLAN

CARSWELL AIR FORCE BASE, TEXAS 76127

Contractor: Radian Corporation
8501 Mo-Pac Blvd.
P.O. Box 201088
Austin, Texas 78720-1088

January 1988

Work Plan

PREPARED FOR:

HEADQUARTERS, STRATEGIC AIR COMMAND
COMMAND SURGEON'S OFFICE (HQ SAC/SGPB)
OFFUTT AFB, NEBRASKA 68113

UNITED STATES AIR FORCE
OCCUPATIONAL & ENVIRONMENTAL HEALTH LABORATORY (USAFOEHL)
TECHNICAL SERVICES DIVISION (TS)
BROOKS AIR FORCE BASE, TEXAS 78235-5501

RADIAN
CORPORATION

INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION
STAGE 2
CARSWELL AIR FORCE BASE

WORK PLAN

HEADQUARTERS, STRATEGIC AIR COMMAND
COMMAND SURGEON'S OFFICE (HQSAC/SGPB)
JANUARY 1988

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USAF CONTRACT NO. F-33615-87-D-4023, DELIVERY ORDER NO. 0004
RADIAN CONTRACT NUMBER 227-005-04

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1.0 INTRODUCTION

1.1 U.S. Air Force Installation Restoration Program

The Department of Defense (DOD) is conducting a nationwide program to evaluate waste disposal practices on DOD property, to control the migration of hazardous contaminants, and to control hazards that may result from these waste disposal practices. This program, the Installation Restoration Program (IRP), consists of four phases: Phase I, Problem Identification/Records Search; Phase II, Problem Confirmation and Quantification; Phase III, Technology Base Development; and Phase IV, Remedial Actions in support to the program. The United States Air Force has initiated an IRP investigation at Carswell Air Force Base near Fort Worth, Texas. Phase I and Phase II Stage 1 have been completed. Radian Corporation will perform the Phase II Stage 2 Field Evaluation under USAF Contract No. F336615-87-D-4023, Delivery Order 4.

1.1.1 Program Origins

In 1976, the U.S. Department of Defense (DOD) developed the comprehensive Installation Restoration Program (IRP), in response to the Resource Conservation and Recovery Act of 1976 (RCRA), and in anticipation of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, the legislation that authorizes the U.S. EPA "Superfund" program). DOD issued a Defense Environmental Quality Program Policy Memorandum (DEQPPM) dated June 1980 (DEQPPM 80-6), that requires the identification of past hazardous waste disposal sites at DOD agency installations. The Air Force implemented the DEQPPM in December of 1980. The program was revised by DEQPPM 81-5, dated December 1981, which reissued and amplified all previous directives and memoranda on the IRP. The Air Force implemented DEQPPM 81-5 in January of 1982.

The IRP has been developed as the following four-phase program:

- Phase I - Problem Identification/Records Search
- Phase II - Problem Confirmation and Quantification
- Phase III - Technology Base Development
- Phase IV - Corrective Action

Since the initiation of the IRP, experience has been gained in all phases of the program, and the approaches used in the IRP have evolved accordingly. Based on experience at Air Force bases nationwide, the Air Force has adopted an approach that streamlines and integrates the elements of the program.

1.1.2 Program Objectives

The long-range objectives of the Carswell AFB IRP activities are to assess the extent and magnitude of contamination at past hazardous waste disposal and spill sites and to develop remedies consistent with the National Contingency Plan (NCP) for those sites that pose a threat to human health or welfare or the environment. Further, the IRP is to assess and control the migration of environmental contamination that may have resulted from past operations and disposal practices at DOD facilities. The program is designed to conduct remedial investigations and feasibility studies in parallel rather than serial fashion.

1.1.3 Program Organization

This subsection presents a description of the organization of the current IRP. It is the intent of the Air Force that the IRP will be equivalent to the NCP process in accordance with CERCLA procedures. Therefore, the NCP nomenclature is used throughout. Phases I, II/IVA, III, and IVB are briefly described below:

Phase I - The objectives of this phase are to identify and assess past disposal sites. This assessment considers whether or not each site poses a hazard to human health or the environment as a result of direct contact, contamination migration, or contaminant persistence.

Phase II/IVA (RI/FS) - The integration of these phases corresponds to the Remedial Investigation/Feasibility Study (RI/FS) programs described in the National Oil and Hazardous Substances Contingency Plan, also referred to as the National Contingency Plan (NCP) (40 CFR 300, November 20, 1985), and in the Superfund Amendment and Reauthorization Act of 1986 (SARA). Data collection and subsequent site characterization are the main objectives of Phase II, which will be conducted concurrently with Phase IVA. Development, screening, and detailed analysis of remediation alternatives form the main portion of Phase IVA, which leads to selection of the recommended remedial action alternative.

Phase III - This phase is the implementation of the research and technology development required for objective assessment of environmental effects or remedial technologies.

Phase IVB - Phase IVB involves the construction and implementation of the remedial alternatives.

1.1.4 Program Documents

The USAF Installation Restoration Program has been designed and is being conducted under guidance from the following applicable documents:

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Public Laws

United States Code

PL 96-510	Comprehensive Environmental Response Compensation, and Liability Act (CERCLA) of 1980
PL 99-499	Superfund Amendments and Reauthorization Act (SARA) of 1986

Regulations

Code of Federal Regulations

40 CFR 136.3e, Table II	Required Containers, Preservation Techniques, and Holding Times
40 CFR 136, Appendix A	Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater
40 CFR 136, Appendix B	Definition and Procedure for the Determination of the Method Detection Limit
40 CFR 136, Appendix C	Inductively Coupled Plasma - Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes Method 200.7
40 CFR 300.61 - 300.71 (Subpart F)	National Contingency Plan

Federal Register

Vol. 51, No. 114, 13 June 1986	Toxicity Characteristic Leaching Procedure (TCLP)

Residential Documents

Executive Orders

EO 12088	Federal Compliance with Pollution Control Standards (13 October 1978)
EO 12580	Superfund Implementation (23 January 1987)

Environmental Protection Agency

EPA-330/9-51-002	MEIC Manual for Groundwater/Subsurface Investigations of Hazardous Waste Sites
	Superfund Exposure Assessment Manual (January 1986)
EPA-600/4-79-020	Methods for Chemical Analysis of Water and Wastes (1983)
SW-846	Test Methods for Evaluating Solid Waste, Third Edition (1986)

American Public Health Association (APHA, AWWA, & WPCF)

	Standards Methods for the Examination of Water and Wastes (16th Edition)

American Society for Testing and Materials

D-1452	Soil Investigation and Sampling by Auger Boring
D-1586	Penetration Test and Split-Barrel Sampling of Soils
D-2487	Unified Soil Classification System
D-2488	Recommended Practices for Visual-Manual Description of Soils
Annual Book of ASTM Standards	Section 11, Water and Environmental Technology

Handbooks

Environmental Protection Agency

EPA-540/G-85-002	Guidance on Remedial Investigations under CERCLA
EPA-540/G-85-003	Guidance on Feasibility Studies under CERCLA

Analytical Chemistry

Vol. 55, Pages 2210 2218, December 83	Principles of Environmental Analysis

For a base-specific investigation, IRP reports that document Phase I or II activities will be the prime source documents for conducting current investigations at Carswell. The principal documents for the Carswell AFB IRP Phase II Stage 2 investigations will be:

- Installation Restoration Phase I Recrods Search for Carswell AFB, Texas, February 1984; and
- Installation Restoration Program Phase II - Confirmation/ Quantification, Stage 1 - Final Report, Carswell AFB, Texas, October 1986.

1.2 Current Study Objectives

The primary objective of the Carswell AFB IRP Stage 2 work is to integrate the past and present remedial investigations of the sites at the base in order to provide the information that is necessary and sufficient to conduct feasibility studies. This integration involves determining which sites pose a threat to human health and the environment and which sites do not. In order to complete this integration, the following efforts will be performed:

- Review previous Phase I and Phase II Stage 1 work and assess its adequacy for use in the current effort;
- Prepare the necessary procedural and administrative plans to control the quality and flow of information collected during Stage 2;
- Conduct follow-on field investigations at incompletely characterized sites;
- Conduct pathway characterization studies;

- Identify and screen remedial technologies;
- Define ARARs and develop an approach for public health evaluation;
- Evaluate and prioritize sites; and
- Develop and screen appropriate remedial alternatives;

2.0 BACKGROUND

2.1 Background of Base Activities

The United States Air Force (USAF) in August, 1983, initiated an IRP investigation at Carswell Air Force Base near Fort Worth, Texas. Subsequent to that time, a Phase I and II Stage 1 investigation have been completed. USAF contracted with Radian Corporation to conduct the Phase II Stage 2 Field Evaluation for Carswell Air Force Base (AFB) under Contract No. F33615-87-D-4023, Delivery Order 4.

Phase I studies for the Carswell AFB Installation Restoration Program were completed in February 1984. The purpose of the Phase I study was to conduct a records search for the identification of past waste disposal activities which may have caused groundwater contamination and the migration of contaminants off site.

Twenty-two disposal or spill sites at Carswell AFB and the Weapons Storage Area were identified as possibly containing hazardous waste during the Phase I study. Of these sites, fourteen were selected for environmental rating. The potential for adverse environmental consequences at each site was then evaluated and rated using the USAF Hazard Assessment Rating Methodology (HARM). The rating was based on the potential environmental contamination and migration of contaminants. The system took into account such factors as the site environmental setting, the nature of the wastes present, past waste disposal practices, and the potential for contaminant migration.

Twelve of the fourteen Phase I sites were selected for Phase II (Stage 1) studies. The IRP Phase II studies are for contaminant confirmation and quantification, which is executed in a staged approach. Stage 1 was the initial part of the investigation designed to confirm a contamination problem. Based upon the results of the Stage 1 activities completed in October 1986, additional investigations were deemed necessary for quantification of contaminants at all sites, which will require one or more successive stages.

2.1.1 Description of Installation

Carswell AFB is located on 2,751 acres of land in Tarrant County, Texas, 6 miles west of the center of Fort Worth and lies between the communities of White Settlement and River Oaks. Carswell AFB lies within a bend of the West Fork of the Trinity River which flows along the northern and eastern boundaries of the base. The river is dammed to form Lake Worth, a drinking water supply and recreation reservoir bordering Carswell AFB to the north. To the west, Carswell AFB is neighbored by AF Plant 4, an Air Force-owned, General Dynamics Corporation-operated, aircraft production plant that shares the runway and several facilities with Carswell AFB. To the south Carswell AFB is bordered by urban areas. Off-base facilities include the ILS Marker Beacon west of Carswell AFB and the Weapons Storage Area (WSA), 4 miles west of Carswell AFB.

Carswell AFB is the home of the Strategic Air Command's (SAC) 7th Bombardment Wing. As such, the mission of Carswell AFB is to maintain the capability of strategic warfare and air refueling operations. Assigned weapon systems include the Boeing B-52 "H" model bomber and the KC-135A tanker.

As host unit, the 7th Bombardment Wing overseas aircraft operations and maintenance agencies. In addition to maintaining bombers, tankers, and combat crews capable of strategic warfare, Carswell AFB also houses an extensive air training effort which includes the air training requirements of three tactical squadrons. The 7th combat Support Group and the USAF Regional Hospital Support the combat mission of the Wing. The total work force at Carswell AFB (as of 1984) was approximately 5,100 military and 1,000 civilian personnel.

2.1.2 Past Waste Management Practices

The Phase I report (CH_2M-Hill, 1984) has an account of the history of waste generation and disposal activities. The following paragraphs describing the waste disposal history are from the Phase I report.

Wastes have been generated and disposed of at Carswell AFB since the beginning of industrial operations in 1942. The major industrial operations at Carswell AFB now include: maintenance of jet engines, aerospace ground equipment (AGE), fuel systems, weapons systems, and pneudraulic systems; maintenance of general and special purpose vehicles; aircraft corrosion control; and non-destructive inspection (NDI) activities. All of these operations generate wastes such as primarily oils, recoverable fuels, spent solvents, and cleaners.

The total quantity of waste oils, recoverable fuels, spent solvents, and cleaners generated at Carswell AFB was estimated in 1984 to be approximately 55,000 gallons/year. This estimate was derived from a review of shop files and the best recollection of interviewees and is considered to be representative of the 1970s to 1983. Prior to the 1970s, the waste quantities were probably less because fewer aircraft were maintained at the base.

Prior to about 1970, some of the liquid waste oil, recovered fuels and possibly solvents were burned at two fire training areas at the Base. Both sites have been described as "gravel-lined," with one being used from 1942 to 1963. It is estimated that up to 156,000 gallons per year of waste oils, fuels, solvents and cleaners have gone to the fire training area before 1970. After 1970, the training exercises have been conducted about 2 to 3 times per month using an average of 1,300 gallons per month of clean or recovered JP-4 fuel.

Smaller amounts of liquid wastes are associated with pest and weed control activities at the Base. The pesticides have been stored at two locations, one at Facility 1338 before 1981, and thereafter at Facility 1217. Some of the chemicals in use are anticoagulant, Baygon, diazinon, malathion organophosphate and monosodium arenate. Used containers are triple rinsed, punctured and disposed of in dumpsters along with the empty bags. Rinse waters from container and equipment rinsing is discharged to a tank outside Facility 1217. The full tank is pumped out for proper disposal. Before 1981,

the rinse waters were discharged into a "dry well" sump located outside Facility 1338. This "dry well" sump has been identified as a potentially contaminated site (Site 15).

Practices for past and present industrial waste disposal are summarized below:

- 1942-1970: The majority of waste oils, recovered fuels, spent solvents, and cleaners were burned at the fire department training areas during practice exercises. Some waste oils and spent solvents were disposed of through contractor removal, while some waste paints (contaminated with thinners and solvents), waste oils, and PD-680 are suspected of having been disposed of in the base landfills. Some waste oils, recovered fuels, spent solvents, and cleaners were also discharged to sanitary and storm sewers. These discharges occurred primarily at the washracks. In 1955, an oil/water separator (Facility 1190) was installed to recover waste materials discharged from the washracks. Materials from the oil/water separators were pumped out and disposed of through contractor removal. Discharge from the oil/water separator was and still is into the sanitary sewers.

- 1970-1975: During this period, most waste oils, spent solvents, and cleaners were disposed of by contractor removal. A private contractor would pump the materials from oil/water separators and from 55-gallon drums and bowsers. Recovered JP-4 was still stored at the fire department training area and burned in practice exercises. Recovered JP-4 was also reused by AGE. Some waste paints (contaminated with thinners and solvents), waste oils, and PD-680 are suspected of having been disposed of in the base landfills. Some waste oils, solvents, and cleaners were discharged into sanitary drains. This primarily occurred at the washracks that discharge to the Facility

1190 oil/water separator. This oil/water separator was routinely pumped out by a private contractor and the recovered materials removed from the base by the contractor.

- 1975-1982: The majority of waste oils, spent solvents and cleaners were disposed of by service contract either directly or through the Defense Reutilization and Marketing Office (DRMO). Recovered JP-4 was stored at the fire department training area and burned during practice exercises. Recovered JP-4 was also used by AGE. PD-680 used at the washracks was discharged to the Facility 1190 oil/water separator which discharges to the sanitary sewers.

- 1982-Present: Waste oils, solvents, and cleaners are collected in 55-gallon drums and temporarily (less than 90 days) stored at 12 hazardous waste accumulation points located throughout the flightline area. They are subsequently disposed of by contractor removal through DRMO. Recovered JP-4 fuel is stored at the fire department training area for subsequent burning in practice exercises or is reused by AGE. Removal of waste oils and PD-680 (Type II) from oil/water separators is also handled by an off-base contractor through DRMO.

2.2 Site-Specific Background Information (By Site)

Phase II (Stage 2) work at Carswell AFB will focus on eleven sites on base shown on Figure 2-1 and the WSA, located four (4) miles west of the base. These sites consist of landfills, fire training areas, industrial areas, and spill sites. The following paragraphs provide brief descriptions of the locations and features of the Phase II sites. All of the information provided was obtained from the Installation Restoration Program Phase I record search report (CH_2M-Hill, 1984).

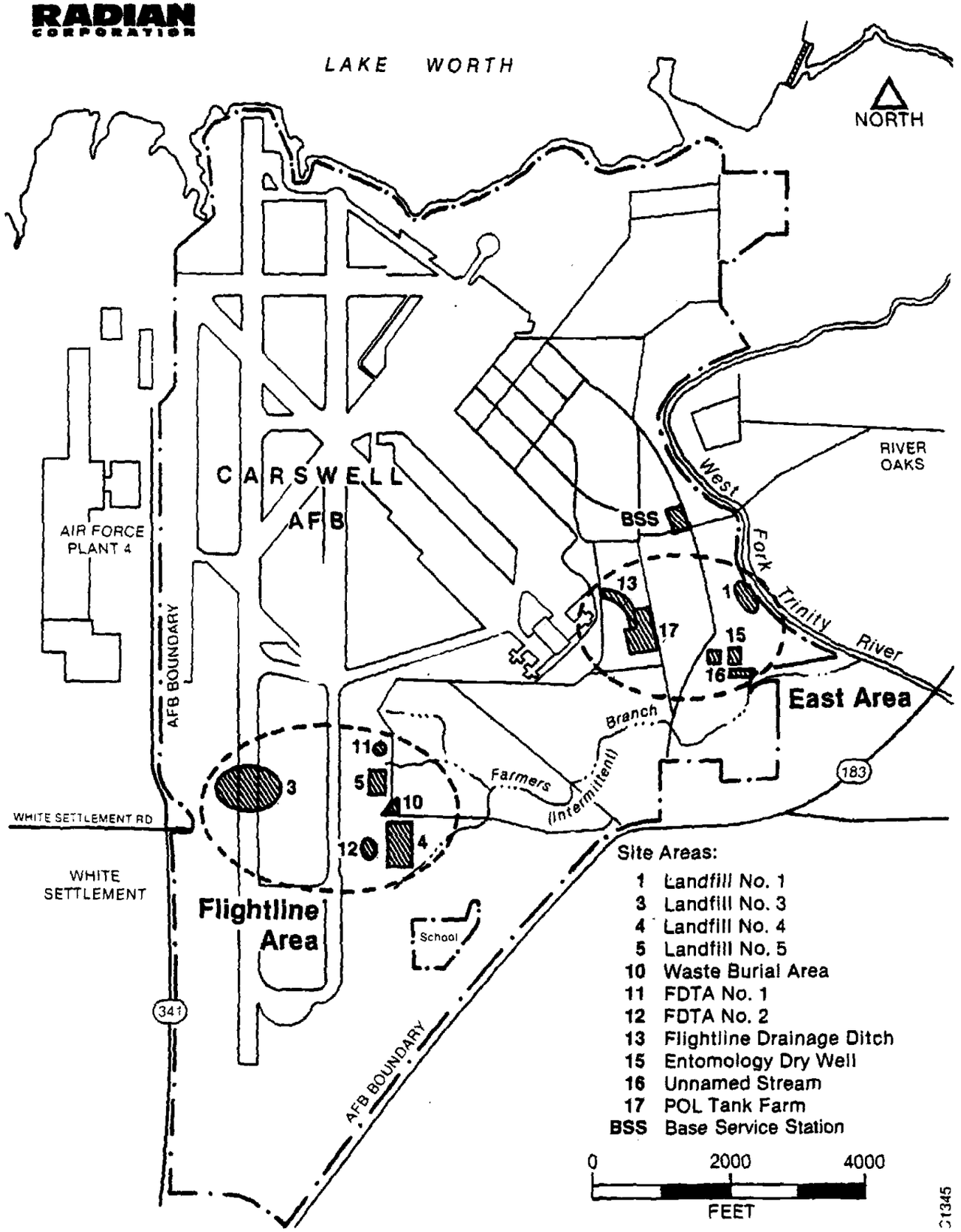

Figure 2-1. Location of Phase II, Stage 2 Sites, Carswell AFB, Texas

2.2.1 Description of Site Setting and Location

Site 1, Landfill 1

Landfill 1 was reported to be the original base landfill and was operated during the 1940s. This site is located adjacent to the Trinity River levee at the current DRMO storage yard. Due to the time elapsed since this site was closed, no information was available concerning past waste disposal practices at this location.

Site 3, Landfill 3

Landfill 3 is located under the main runway, immediately south of the culvert carrying the flow of Farmers Branch. During the period from 1950 until 1952, Site 3 was used for burial of all types of waste, but primarily construction rubble. During that period, the runway ended north of Farmers Branch, and a ravine present at this site was used as a fill area.

Site 4, Landfill 4

Landfill 4 was operated from approximately 1956 until 1975. This site, which includes 10 acres of land east of the runway and is currently the location of the radar site, was the main landfill during much of the history of Carswell AFB. All base refuse was buried here and burning was a regular practice. At least six large pits, approximately 12 feet deep were filled with refuse which was burned and buried. Various materials suspected of being hazardous were reportedly disposed at this site, including drums of waste liquids, partially full paint cans, and cadmium batteries. Written records indicate that routine disposal of waste paints, thinners, and strippers; oil containing adsorbent materials; PD-680 (a safety cleaning solvent) and oils may have been practiced at this location.

Site 5, Landfill 5

Landfill 5 was reportedly used between 1963 and 1975. This site is located northwest of Landfill 4 and was constructed adjacent to a small tributary to Farmers Branch. The landfill site was constructed by building a clay berm adjacent to the creek and then filling the area behind the berm up to its existing level. This fill site received all types of flightline wastes and refuse, and was regularly burned prior to covering.

Site 10, Waste Burial Area

Site 10, located adjacent to and south of White Settlement Road, where it dead-ends at the taxiway, was used for burial of wastes during the 1960s. Various types of hazardous materials, including drums of cleaning solvents, leaded sludge, and possibly ordnance materials, were reported disposed of at this site. Reportedly, these materials were buried in a natural clay strata. The site is currently identified by several signs reporting the presence of buried tetraethyl lead sludge.

Site 11, Fire Department Training Area 1

Site 11 is located north of Landfill 5 adjacent to a small tributary to Farmers Branch. This training area was the primary fire pit prior to 1963. The pit reportedly was gravel-lined and had a low concrete curb around its perimeter. Several fire training exercises are reported to have taken place at this site each month, with waste oils and contaminated fuels being the primary flammable liquids used in the exercises. Small quantities of solvents are also reported to have been used in these exercises.

Site 12, Fire Department Training Area 2

Site 12 is located between the north-south taxiway and the radar facility. This site, with only slight modifications, has been used as a fire department training area since 1963. The fire ring is gravel-lined with a low

berm around its perimeter. In the past, a pit was present at the site to collect runoff from training exercises, but his pit has been filled. At the beginning of Phase II, Stage 1 field work the berm had been breached by erosion and some runoff had collected outside the northeast corner of the ring. By the conclusion of field work, the breach had been repaired.

Two tanks located at the site have been used for storage of flammable liquids prior to training exercises. An 8,500-gallon aboveground tank is used to store clean or contaminated fuels, which are delivered to the ring via a pump and various pipes. An underground tank of approximately 9,500 gallons has been used for storage of waste oils and solvents from the flightline shops. Although normal disposition of the underground tank contents has been to off-base contractors, it is possible that contents of this tank have also been used for training exercises in the past.

Site 13, Flightline Drainage Ditch

Site 13 is located east of Haile Drive, directly east of the main base washrack (Pad 29) and Hangars 1049 and 1048. The ditch is unlined from Haile Drive to where it intersects at the POL tank farm, at which point it enters a concrete-lined channel. Contamination was visible at Site 13 during the base visit (1983) in the form of a white liquid (aircraft soap) originating at the washrack and entering the ditch through a small pipe; the presence of petroleum products on the surface of the water further downstream; and the presence of a dark zone of fuel or oil saturation along the banks of the ditch at least 10 inches above the surface of the water.

In addition to normal storm drainage, this ditch receives discharges from the aircraft washracks (18 and 29) and discharges from the Fuel Systems Shop (Building 1048). Washrack wastes (PD-680, a cleaning solvent, and soap) can be discharged directly to the Facility 1190 oil/water separator, located adjacent to the flightline drainage ditch, or into the drainage ditch via an

overflow pipe in the drain line between the washracks and the oil/water separator. Discharge to the oil/water separator or to the drainage ditch is controlled by a valve in the drain line just upstream of the separator.

Discharges from the Fuel Systems Shop consists of JP-4 fuel drained from fuel tanks. Prior to 1978, this fuel was piped via gravity to the Facility 1190 oil/water separator. The pipe was routed through the much larger stormwater culvert that begins the flightline drainage ditch. Approximately 5 years ago (1979), the pipe ruptured and JP-4 was allowed to enter the stormwater culvert and thus the ditch. The pipe was repaired in March 1984.

Site 15, Entomology Dry Well

Site 15 is located immediately west of the old entomology shed (Building 1338) in the present Civil Engineering Compound, east of Rogner Drive. A dry well at the site was used for disposal of insecticide rinsate between 1965 and 1981. The site is currently vacant; Building 1338 has been demolished and the site has been regraded. Building 1338 was used for the storage and mixing of insecticides including malathion, diazinon, dursban, and chlordane, and for storage and cleaning of spray equipment. Chlordane has been reported in samples taken from the well next to Building 1338, although no documented analytical results could be found during the records search to substantiate this report.

Site 16, Unnamed Stream

Site 16 is a small tributary of Farmers Branch, located south of the old entomology shed, and near the confluence of Farmers Branch and the Trinity River. This small stream is the discharge from an oil/water separator located immediately south of the fenced civil engineering yard, and receives its perenial flow from groundwater entering the separator. The separator is connected to a french underdrain system which was reportedly build in 1965 to capture POL leaking from the POL Tank Farm (see below) into the sewer pipes. This separator has not been routinely cleaned for a number of years and contained

hydrocarbon constituents. Overflow from this separator is apparently contributing POL and iron to the stream. The discharge has a petroleum odor, an oil sheen, and is reddish brown with extensive growths of what appears to be iron-reducing bacteria. Previous analyses completed on the stream have detected trace quantities of trichlorethylene.

Site 17, POL Tank Farm

Site 17 is located on the eastern side of Carswell AFB, adjacent to Knight's Lake Road. Currently, from above-ground tanks are located at this location; formerly, three additional tanks were also located here. During the early 1960s, fuels were discovered in the ground in this area, and also downgradient (southeast) from this site. A french drain was installed downgradient from this area to collect fuels in the ground. The french drain discharged through the oil/water separator mentioned above (Site 16). At that same time, the underground leaking POL pipes were reportedly located and replaced. No additional loss of POL to the ground is suspected to have occurred in this area since 1965. The french drain system is still continuing to collect POL as evidenced by the contents of the Unnamed Stream observed during the site visit. As a result, fuel is still suspected to be present in the ground in the area of the POL tank farm and downgradient (southeast and east) from it.

2.2.2 Types of Wastes and Concentrations

The Phase II Stage 1 investigation (Radian, 1986) documented the presence of organic contamination, mostly trichloroethylene (TCE), in the upper zone soil and groundwater at several sites. Concentrations of heavy metals were typically at background levels. No groundwater contamination was observed in the Paluxy aquifer. In addition, low levels of organic compounds were detected in small tributaries of Farmers Branch in the vicinity of several sites at the flightline. A summary of the analytical data for organic contaminants in upper zone groundwater is provided in Table 2-1. Results of analyses of surface water are provided in Table 2-2, and results of soil analyses are given in Table 2-3.

TABLE 2-1. SUMMARY OF ORGANIC COMPOUNDS IN UPPER ZONE GROUNDWATER, CARSWELL AFB, TEXAS

Parameter	Location								
	Site 1	Site 4	Site 5	Site 10	Site 11	Site 12	Site 15	Site 16	Site 17
ORGANIC INDICATORS (ug/L)									
Oil and Grease	<1-190	<1-23	<1-220	<1-310	<1-200	<1-69	<1-4	<1-7,100	<1-31,000
Phenols	0.005-0.074	<0.005-0.1	0.005-0.012	NA	0.005	0.005-0.021	NA	NA	NA
TOC	3-8	1-28	1-6	1-5	1-15	<1-5	NA	1-420	44-190
TOX	<0.01	NA	0.03-1.5	0.05-0.16	0.01-0.14	<0.01-0.38	NA	<0.01-0.04	<0.01-0.12
PESTICIDES/HERBICIDES (ug/L)									
2,4,5-TP	ND-0.2	ND	NA	ND	ND-0.2	NA	ND	NA	NA
Lindane	ND	ND	NA	ND	ND	NA	ND-<0.1	NA	NA
Endrin	ND	ND	NA	ND	ND	NA	ND-<0.1	NA	NA
PURGEABLE HALOCARBONS (ug/L)									
Vinyl Chloride	ND	ND-12.5	ND-178	ND-8.6	ND	ND-9.4	NA	ND	NA
Chloroethane	ND	ND-7.6	ND	ND	ND	ND	NA	ND	NA
Methylene Chloride	ND	ND	ND	ND	ND	ND	NA	ND	NA
Trichlorofluoromethane	ND-3.8	ND-6.8	ND	ND-5.3	ND-5.7	ND-15.7	NA	ND-4.2	NA
1,1-Dichloroethene	ND	ND-8.1	ND-7.5	ND	ND	ND-2.5	NA	ND	NA
1,1-Dichloroethane	ND	ND-4.4	ND	ND-6.8	ND	ND-5.9	NA	ND	NA
1,1,1-Trichloroethane	ND	ND-25.1	ND	ND	ND	ND-2.9	NA	ND-2.9	NA
1,2-Dichloropropane	ND	ND-2.3	ND-2.6	ND	ND	ND	NA	ND	NA
Trichloroethylene	ND-1.4	ND-4290	ND-3280	1870-5000	ND-1.8	ND-362	NA	ND	NA
Tetrachloroethylene	ND	ND-16.3	ND	ND-102	ND	ND-164	NA	ND	NA
Chlorobenzene	ND	ND-3.7	ND	ND	ND	ND	NA	ND	NA
Trans-1,2-Dichloroethene	ND-1.4	ND	ND	ND	ND	ND	NA	ND-0.1	NA
PURGEABLE AROMATICS (ug/L)									
1,4-Dichlorobenzene	ND	ND-9.1	ND	ND	ND	ND-3.9	NA	(very high)	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND-4.1	NA	(very high)	ND

NA = not analyzed
ND = not detected

TABLE 2-2. SUMMARY OF ORGANIC AND INORGANIC COMPOUNDS IN SURFACE-WATER SAMPLES, CARSWELL AFB, TEXAS

Parameter	Site 4	Site 5	Site 12	Site 16 Oil/Water Separator	Site 16 Unnamed Stream
ORGANIC INDICATORS (mg/L)					
Oil and Grease	NA	<1 - 350	1 - 84,000	1 - 640	<1
Phenols	NA	NA	0.14	NA	NA
TOC	2 - 3	8 - 12	86 - 50,000	4 - 200	4
TOX	NA	NA	<0.01 - 0.63	0.01	0.04
COD	<1 - 4	5 - 9	NA	NA	NA
INSECTICIDES/HERBICIDES (ug/L)	ND	ND	NA	NA	NA
PURGEABLE HALOCARBONS (ug/L)					
Vinyl Chloride	ND - 2.3	ND - 38.7	ND	ND	ND
Methylene Chloride	ND - 2.7	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND - 3.5	ND - 2.9	ND - 3.3
1,1,1 Trichloroethane	ND - 5.0	ND	ND	ND	ND
Trichloroethylene	1.4 - 4.3	ND - 4.4	ND	ND	ND
Tetrachloroethylene	ND	ND	ND	ND	ND - 3.4
Trans-1,2-Dichlorethene	ND	ND - 56.9	ND	ND	ND
PURGEABLE AROMATICS (ug/L)	ND	ND	ND	ND	ND
METALS (mg/1)					
Arsenic	NA	NA	<0.06 - 0.16	<0.06 - 0.16	<0.06
Barium	NA	NA	0.15 - 0.29	0.28 - 0.29	0.25
Cadmium	NA	NA	<0.002 - 0.007	<0.002 - 0.007	<0.002
Chromium	NA	NA	<0.005 - 0.017	<0.005 - 0.017	<0.005
Lead	NA	NA	<0.08 - 0.081	<0.08 - 0.081	<0.08
Mercury	NA	NA	0.0003 - 0.0006	0.0003 - 0.0004	0.0004 - 0.0005
Selenium	NA	NA	<0.08	<0.08	<0.08
Silver	NA	NA	<0.002	<0.002	<0.002

NA = Not analyzed
ND = Not detected

TABLE 2-3. SUMMARY OF ORGANIC AND INORGANIC COMPOUNDS IN SOIL SAMPLES, CARSWELL AFB, TEXAS

Parameter	Site 1	Site 4	Site 5	Site 10	Site 11	Site 12	Site 13	Site 16	Site 17	Site WSA
ORGANIC INDICATORS (ug/g)										
Oil and Grease	<10 - 210	NA	<10 - 10	<10	<10 - 2200	<10 - 13,000	<10 - 2,000	<10 - 240	<10 - 1,300	<10 - 14
Phenols	<0.1	<0.1 - 0.4	<0.1 - 0.3	NA	<0.1 - <10	<0.1 - 2.4	NA	NA	NA	NA
HERBICIDES (ug/g)										
2,4-D	ND - 0.00052	NA	ND	NA	ND	NA	NA	NA	NA	NA
INSECTICIDES (ug/g)	ND	NA	ND	NA	ND	NA	NA	NA	NA	NA
PURGEABLE HALOCARBONS (ug/g)										
Trichlorofluoromethane	ND	NA	ND	ND	ND	ND - 0.210	NA	ND	NA	ND
1,1,1 Trichloroethane	ND	NA	ND	ND - 0.044	ND	ND	NA	ND	NA	ND
Trichloroethylene	ND	NA	ND - 0.338	ND - 0.067	ND - 0.257	ND - 0.395	NA	ND	NA	ND - 0.0619
Tetrachloroethylene	ND	NA	ND	ND	ND	ND	NA	ND	NA	ND
Trans-1,2-Dichloroethene	ND	NA	ND - 0.033	ND	ND	ND	NA	ND	NA	ND
1,2-Dichlorobenzene	ND	NA	ND	ND	ND	ND - 1.659	NA	ND	NA	ND
1,3-Dichlorobenzene	ND	NA	ND	ND	ND	ND - 0.464	NA	ND	NA	ND
1,1,2,2-Tetrachloroethane	ND	NA	ND	ND	ND	ND - 1.000	NA	ND	NA	ND
PURGEABLE AROMATICS (ug/g)										
Benzene	ND	NA	ND	ND	ND	ND - 752.0	NA	ND	NA	ND
Ethyl Benzene	ND	NA	ND - 1.070	ND	ND	ND - 110.0	NA	ND	NA	ND
Toluene	ND	NA	ND - 0.460	ND	ND	ND - 134.0	NA	ND - 0.54	NA	ND
METALS (ug/g)										
Arsenic	<3 - 11	<5.1 - 9.4	<5.8 - 9.4	NA	<3 - 14	<3 - 19	<0.06 - 0.19	<5.8 - 11	NA	NA
Barium	16 - 48	2.6 - 50	2.8 - 70	NA	<0.23 - 47	4.4 - 100	0.37 - 1.2	45 - 85	NA	NA
Cadmium	<0.39 - <0.40	<0.17 - 0.64	<0.19 - 0.62	NA	<0.2 - <0.4	<0.16 - 0.69	<0.002 - 0.031	<0.2 - 0.89	NA	NA
Chromium	1.8 - 22	0.44 - 4.8	0.74 - 47	NA	2.0 - 7.9	1.4 - 35	<0.005 - 0.022	5.1 - 13	NA	NA
Lead	<4.0 - 10	<6.3 - 8.3	<7.8 - 8.4	NA	<4 - 13	<4 - 54	<0.08 - 0.12	3.6 - 20	NA	NA
Mercury	<0.05 - 0.17	<0.04	<0.05 - 0.21	NA	0.08 - 0.21	<0.04 - 0.21	0.0003 - 0.13	0.05 - 0.10	NA	NA
Selenium	<4.0 - 17	<6.0 - <7.6	<7.7 - <7.9	NA	<4 - 20	<4 - 38	<0.08 - 0.18	9.1 - 41	NA	NA
Silver	1.0 - 2.1	<0.19 - 2.0	<0.20 - 1.0	NA	<0.18 - 3.1	<0.16 - 2.8	<0.002 - 0.027	0.82 - 1.2	NA	NA

NA = Not analyzed
ND = Not detected

Site 1: Groundwater at Landfill 1 contains some elevated levels of oil and grease (not detected to 190 mg/L) and heavy metals, as well as some purgeable halocarbons in low concentrations. Groundwater movement is toward the Trinity River, adjacent to the site.

Sites 4, 5, 10: Groundwater in the vicinity of these sites was found to contain elevated levels of TCE. The occurrence of TCE was generally in the range of not-detected to 5,000 ug/L in the affected areas both upgradient and downgradient of the landfills. Results of soil analyses also indicated TCE (range from not detected to 0.338 ug/g) contamination at some areas near these sites. Most of the contamination is centered east of these sites at the golf course; however, the high levels of TCE were also discovered in the groundwater upgradient of Landfill 5 near the flightline.

Site 11: Low levels of TCE in soil (range from not detected to 0.249 ug/g) were detected at one location at Site 11, located just north of Landfill 5. In addition, TCE (range from not detected to 0.257 ug/g) was also detected in soil from a hand-augered boring at the center of the site and at the upgradient well.

Site 12: Results of analyses at Site 12 indicate that halogenated and aromatic organic compounds are present in soil (range from not detected to 752 ug/g) and groundwater (range from none detected to 362 ug/L). The highest levels of contamination occur in the center of the site, where benzene, toluene, and ethyl benzene were detected (from not detected to 752 ug/g, 134 ug/g and 110 ug/g, respectively) in soil. TCE also occurs in groundwater downgradient (north and east) of the site, but in lower concentrations (range from not detected to 362 ug/L) than at Sites 4, 5 and 10. The operations at this site have also affected the quality of surface water draining the area. Water samples from a drainage ditch near the site had oil and grease (range from 1 to 84,000 mg/L) and TOC (range 86 to 50,000 mg/L).

Site 13: Soil at the Flightline Drainage Ditch are contaminated with jet fuel, detergents, or both. It was observed that the distribution of

contaminants is somewhat erratic, suggesting that contaminant mobility and infiltration are controlled by local variations in soil composition and texture.

Site 15: Insecticides and herbicides from the former Entomology Building and Entomology Dry Well have not been released in significant quantities into the soil and water. Lindane and endrine were detectable, but not quantitatively measurable in one downgradient well.

Site 16: Hydrocarbon fuels (gasoline or JP-4) were observable (range of oil and grease was <1 to 7,100 mg/L, with high levels of aromatic compounds) in the groundwater at Site 16. The source of the contamination is either a former gasoline station at the site or the POL Tank Farm. Results of analyses at the Unnamed Stream suggest that the oil/water separator does not always ensure that oil and grease are not released to the stream.

Site 17: Organic compounds were observed in the groundwater (<1 to 31,000 mg/L) and soil (<1 to 1,300 ug/g) underlying the POL Tank Farm. The organic compounds are most likely fuel hydrocarbons from the storage and handling of fuels. One water sample from borehole 17D suggests that organic solvents (based on TOX levels) may be present in the groundwater.

WSA Site: Groundwater from the potable supply well was found to contain total radium (8.5 pCi/L) in excess of federal standards for drinking water. In addition, analysis of soil west of the Inspection Shop site revealed the presence of TCE (range from none detected to 0.0619 ug/g).

2.2.3 Pathways Affected

Three pathways of possible contaminant movement were investigated during the Phase II Stage 1 work at Carswell AFB. Each of these pathways--groundwater, surface water, and soil--were discovered to have contamination as summarized in Section 2.2.2. An investigation of air quality was not performed during the Stage 1 effort.

3.0 ENVIRONMENTAL SETTING

The following discussion of the Carswell AFB environmental setting is derived primarily from the Installation Restoration Program Phase I Records Search Report (CH2M Hill, 1984). Information from that report is supplemented by information from the literature and from the general findings of this study. The following sections describe the environmental setting of Carswell AFB. Basic features and history of the sites investigated in this study are also discussed below.

3.1 Geophysical Setting

Carswell AFB is located in northeastern Texas in Tarrant County, six miles west of downtown Fort Worth (Figure 3-1). The base is bordered by Lake Worth to the north, the West Fork of the Trinity River and the community of Westworth to the east and southeast, the community of White Settlement to the south and southwest and Air Force (AF) Plant 4 to the west. The location of Carswell AFB is shown in Figure 3-2. One off-base facility, the Weapons Storage Area (WSA), is included in this study. The WSA location, four miles west of Carswell AFB on White Settlement Road, is also shown in Figure 3-1.

The base lies within an area of primarily residential, recreational, and industrial/commercial land use. The principal industrial use of the area is AF Plant 4, an aircraft production plant that borders Carswell AFB to the west and shares the runway with the base. Recreational land use includes the Y.M.C.A.'s Camp Carter, and various parks on the shores of Lake Worth.

3.1.1 Physiography

The majority of Carswell AFB is located within the Grand Prairie section of the Central Lowlands Physiographic Province. This area is characterized by broad terrace surfaces sloping gently eastward, interrupted by

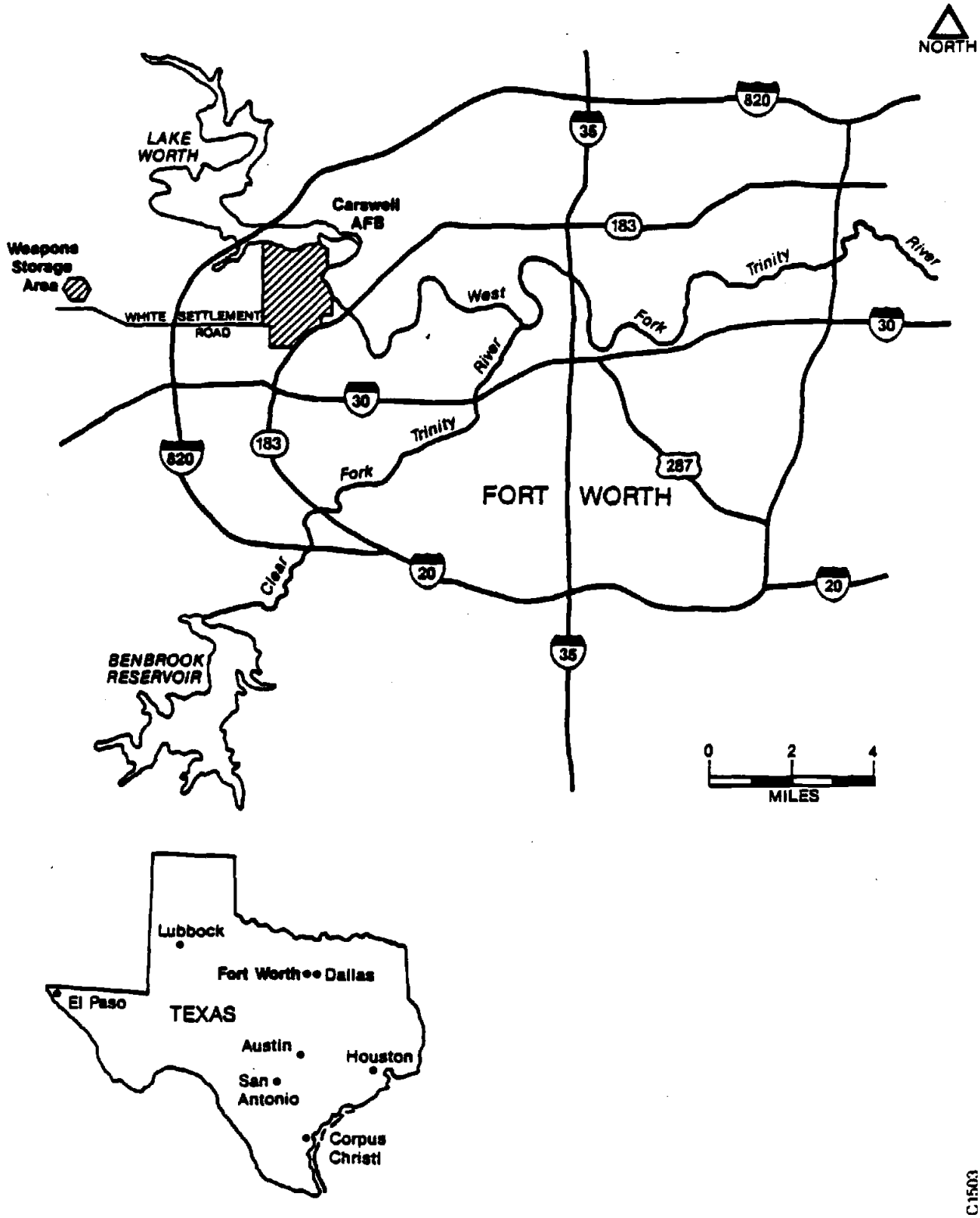

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Figure 3-1. Regional Setting of Carswell AFB, Texas.

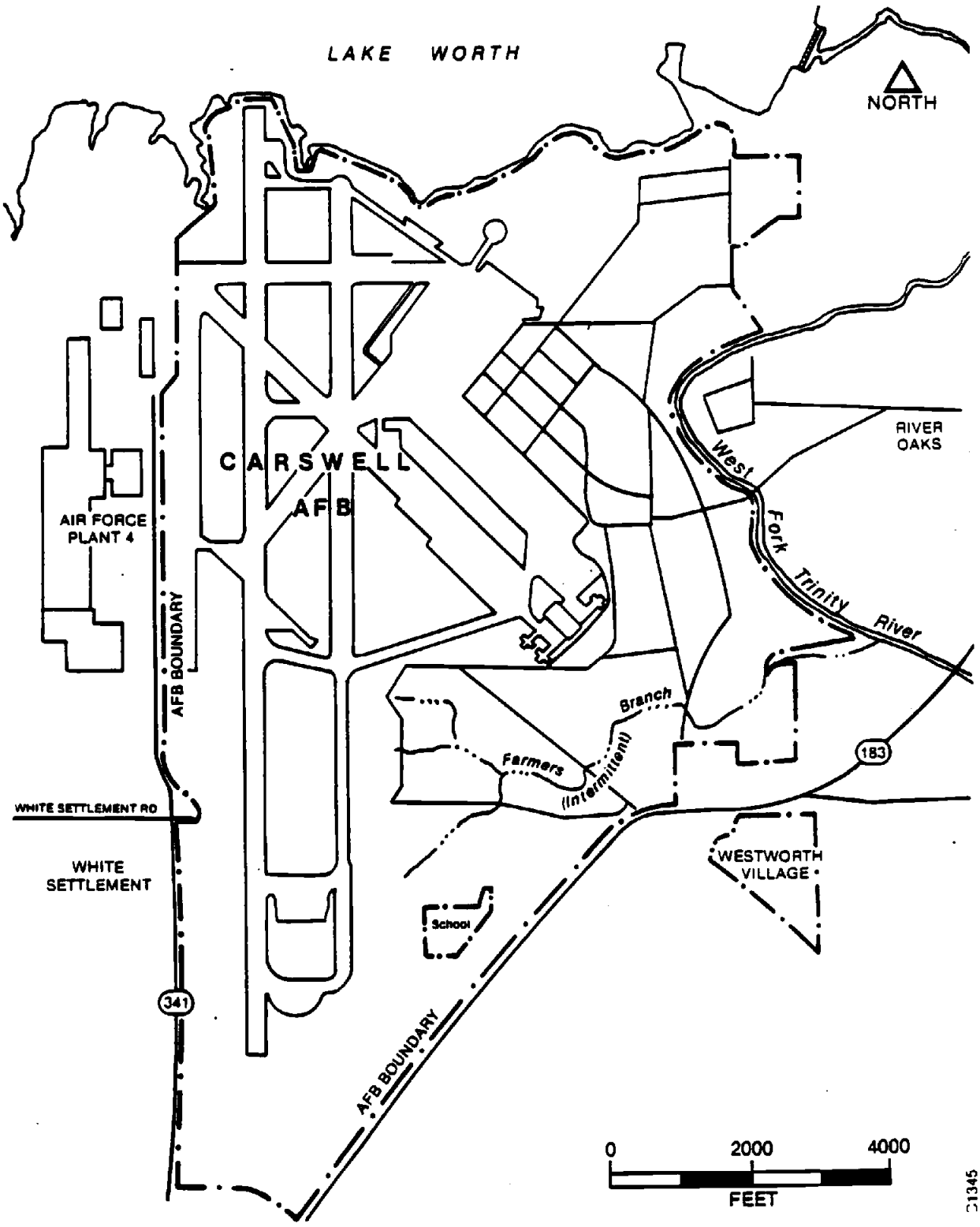

Figure 3-2. Area Location Map of Carswell AFB, Texas

westward-facing escarpments. The land is typically grass covered and treeless, except for isolated stands of upland timber. The northwestern part of Carswell AFB is within the Western Cross Timbers Physiographic Province that is characterized by rolling topography and a heavy growth of post and blackjack oaks.

3.1.2 Topography

The topography of the base is fairly flat except for areas near Farmer's Branch and the Trinity River. Land surface slopes gently northeast toward Lake worth and east toward the West Fork of the Trinity River. Elevations on base range from a high of approximately 690 feet above mean sea level (msl) at the southwest corner of the base to a low of approximately 550 feet msl at the east side of the base. The elevation of Lake Worth usually approximate the elevation of the dam spillway, 594 feet msl.

The principal drainage for Carswell AFB is the West Fork of the Trinity River. Farmers Branch drains the southern portion of the base, but in turn discharges into the Trinity. A small portion of the north end of the base drains into Lake Worth.

3.2 Geology

Surficial Soils

The U.S.D.A. Soil Conservation Service has identified four soil associations at Carswell AFB. The soils are described in Table 3-1, and their occurrences on base are shown on Figure 3-3. The surficial soils of the installation area are primarily nearly level to gently sloping clayey soils of the Sanger-Purves-Slidell and Aledo-Bolar-Sanger Associations. In addition to the above, the clayey soil of the Frio-Trinity Association and the loamy soil of the Bastsil-Silawa Association occur on the floodplain and stream terraces of the West Fork of the Trinity River.

TABLE 3-1. SOIL ASSOCIATIONS FOR CARSWELL AFB, TX

Association	Description	Thickness (inches)	Permeability (cm/sec)
Sanger-Purves-Slidell: Clayey soils of nearly level to gently sloping uplands.	Clay loam Clay over bedrock Silty clay	8-80	$<4.2 \times 10^{-5}$ to 3×10^{-4}
Aledo-Bolar-Sanger: Loamy and clayey soils of gently sloping to moderately steep uplands.	Clay loam over bedrock Clay loam	8-70	$<4.2 \times 10^{-5}$ to 9×10^{-4}
Frio-Trinity: Clayey soil on nearly level flood plains.	Silty clay loam Clay	25-75	$<4.2 \times 10^{-5}$ to 3×10^{-4}
Bastsil-Silawa: Loamy soils on nearly level to sloping stream terraces.	Sandy clay loam	40-80	9×10^{-4} to 3×10^{-3}

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

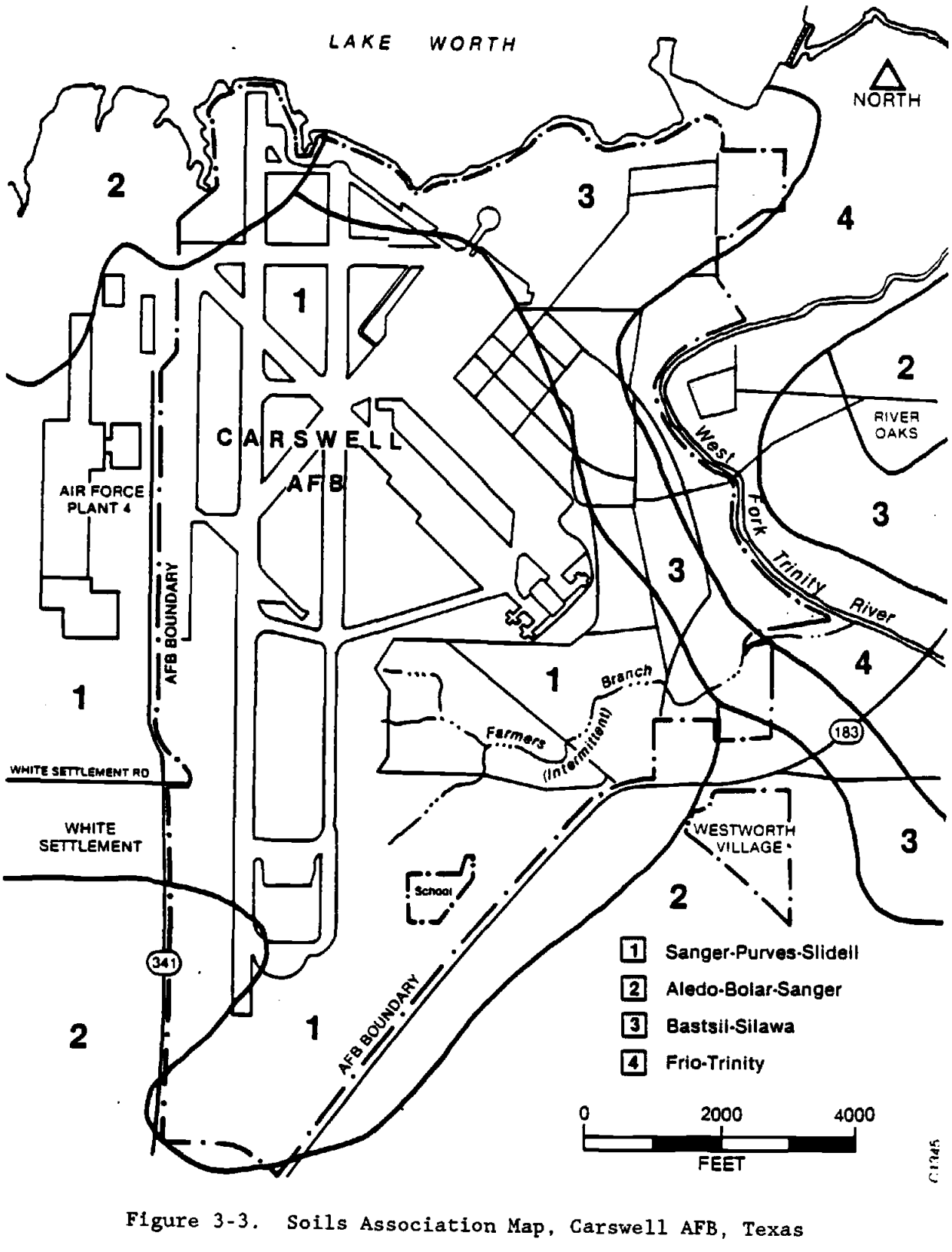

Figure 3-3. Soils Association Map, Carswell AFB, Texas

Lithology

A geologic section showing the rock formations beneath Carswell AFB is presented in Figure 3-4. Descriptions and properties of units pertinent to this study are summarized in Table 3-2. From youngest to oldest, the geologic units of interest to Carswell AFB are as follows: 1) Quaternary Alluvium, 2) Cretaceous Goodland Limestone, 3) Cretaceous Walnut Formation, 4) Cretaceous Paluxy Formation, 5) Cretaceous Glen Rose Formation, and 6) Cretaceous Twin Mountains Formation. The occurrence of these units on base is shown on a geologic map, Figure 3-5.

The majority of the base is covered by alluvium deposited by the Trinity River. The alluvium is composed of gravel, sand, silt, and clay of varying thicknesses and lateral extents. The Goodland Limestone is exposed on the southern portion of the base, south of White Settlement road. The Goodland is a chalky-white, fossiliferous limestone and marl. A small area exposing the Walnut and Paluxy Formations occurs in the northwestern corner of the base along the shores of Lake Worth. The Walnut Formation is a shell-agglomerate limestone with varying amounts of clay and shale. The Paluxy Formation is primarily a fine- to coarse-grained sand with minor amounts of clay, sandy clay, pyrite, lignite, and shale. Neither the Glen Rose Limestone, nor the Twin Mountains Formation are exposed at Carswell AFB.

Structure

Carswell AFB is located on the relatively stable Texas craton, west of the faults that lie along the Ouachita Structural Belt. No major faults or fracture zones have been mapped near the base. The regional dip of the rocks beneath Carswell AFB is between 35 and 40 feet per mile in an easterly to southeasterly direction. The stratigraphic and structural relationships of the uppermost geologic units at Carswell AFB are illustrated in Figure 3-6 which shows a cross section from Site 12 eastward to the Trinity River at Site 1.

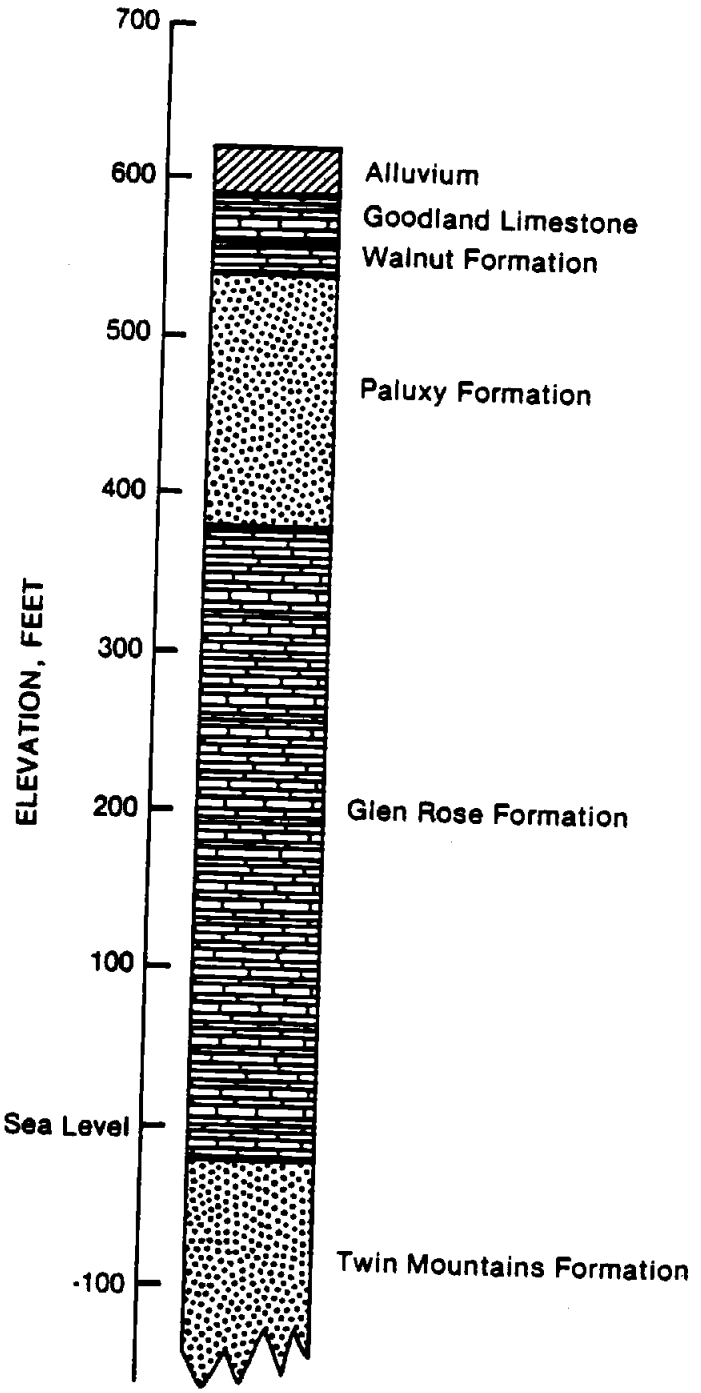

Figure 3-4. Stratigraphic Column at Carswell AFB, Texas

TABLE 3-2. GEOLOGIC FORMATIONS BENEATH CARSWELL AFB, TEXAS

System	Series and Group	Formation and Member	Thickness (ft)	Character of Rocks	Topographic Expression	Water-Bearing Properties
Quaternary	Recent and Pleistocene	Alluvium	0-45	Sand, gravel, clay, and silt.	Terrace and flood-plain deposits.	Small to moderate yields. Water unsatisfactory for use unless treated.
Cretaceous	Comanche Series Washita Group	Duck Creek Formation	0-90	Impure limestone and marl, which is blue when fresh and straw-colored when weathered. Fossiliferous with distinctive ammonites.	Bench topography produced by lower limestone unit. Upper marl forms slope separating the Duck Creek from Fort Worth limestone.	Small to moderate yields. Water unsatisfactory for use unless treated.
	Comanche Series Fredericksburg Group	Kiamichi Formation	0-40	Blue and brownish-yellow marl, thin limestone and sandstone flags.	Grassy slope separating scarps of Goodland and Duck Creek formations.	Small to moderate yields. Water unsatisfactory for use unless treated.
		Goodland Limestone	0-130	Chalky-white fossiliferous limestone, and blue to yellowish brown marl.	Prominent glaring-white escarpment along streams.	Small to moderate yields. Water unsatisfactory for use unless treated.
		Walnut Clay	0-20	Shell agglomerate fossiliferous clay and limestone, sandy clay, and black shale.	Forms conspicuous escarpment and waterfalls in western Cross Timbers belt.	Not known to yield water to wells in Tarrant County.
				UNCONFORMITY		
Cretaceous	Comanche Series Trinity Group	Paluxy Sand	140-190	Fine-grained sand, shale, sandy shale, lignite and pyrite.	Sandy soil, hummocky topography, heavily wooded with oaks.	Source of supply for most households, smaller cities, and some industries.
		Glen Rose Limestone	250-450	Fine-grained limestone, shale, marl, and sandstone.	Not exposed in Tarrant County.	Beds yield small supplies to wells in Fort Worth and western Tarrant County. Water too highly mineralized east of Fort Worth.
		Twin Mountains Formation (Formerly Travis Peak Formation)	250-450	Coarse to fine-grained sandstone, red shale, red and yellow clay at base.	Not exposed in Tarrant County.	Principal aquifer in Tarrant County. Yields large supplies for municipal and industrial purposes. Water in upper sands east of Fort Worth may be highly mineralized.
				MAJOR UNCONFORMITY		
Pennsylvanian	Undifferentiated		6,000-7,000	Gray, sandy shale, tight quartzitic sandstone, black limestone. Probably represents Strawn formation.	Not exposed in Tarrant County.	Not tested. Probably would not yield fresh water.

Source: E.A. Leggat.

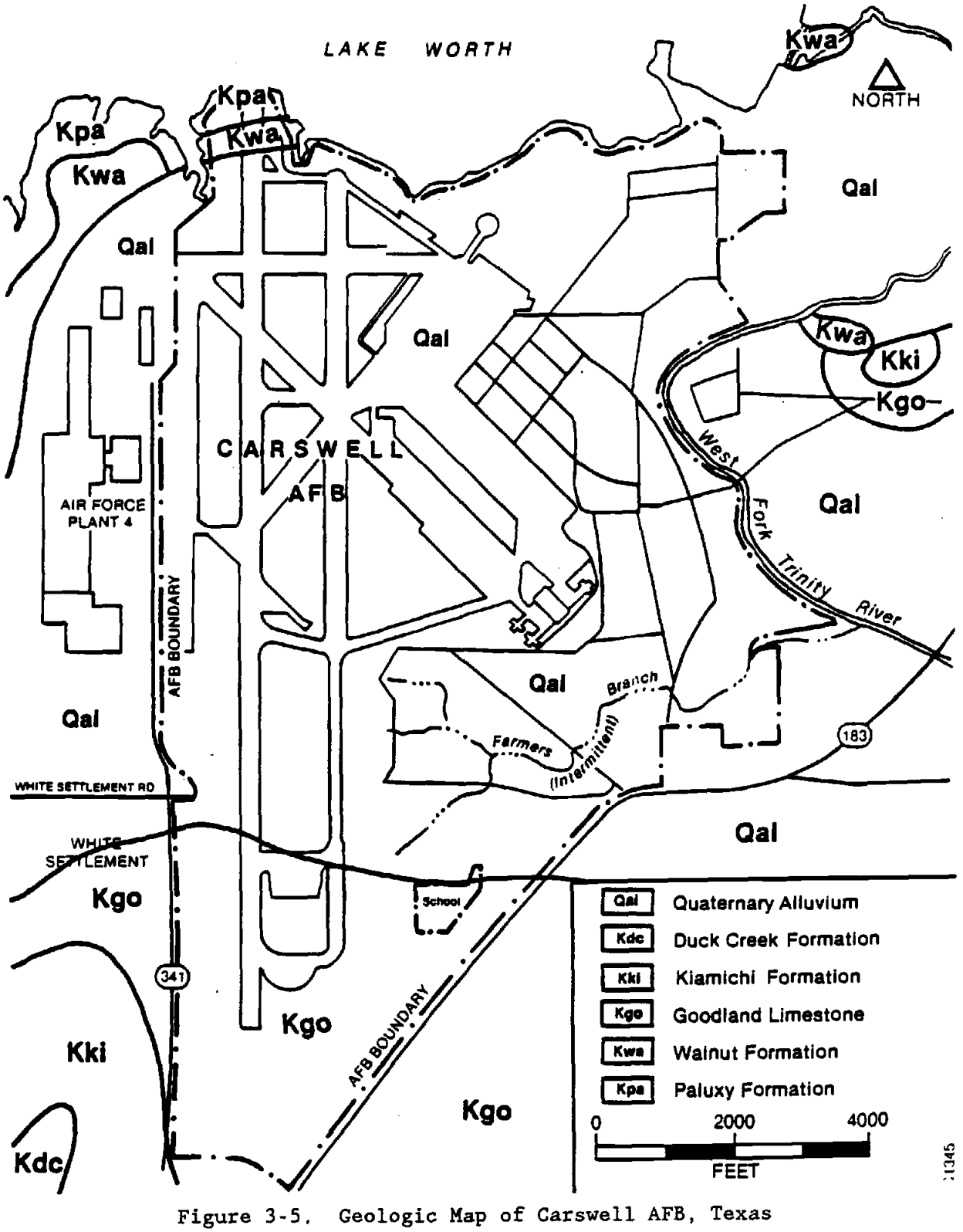

Figure 3-5. Geologic Map of Carswell AFB, Texas

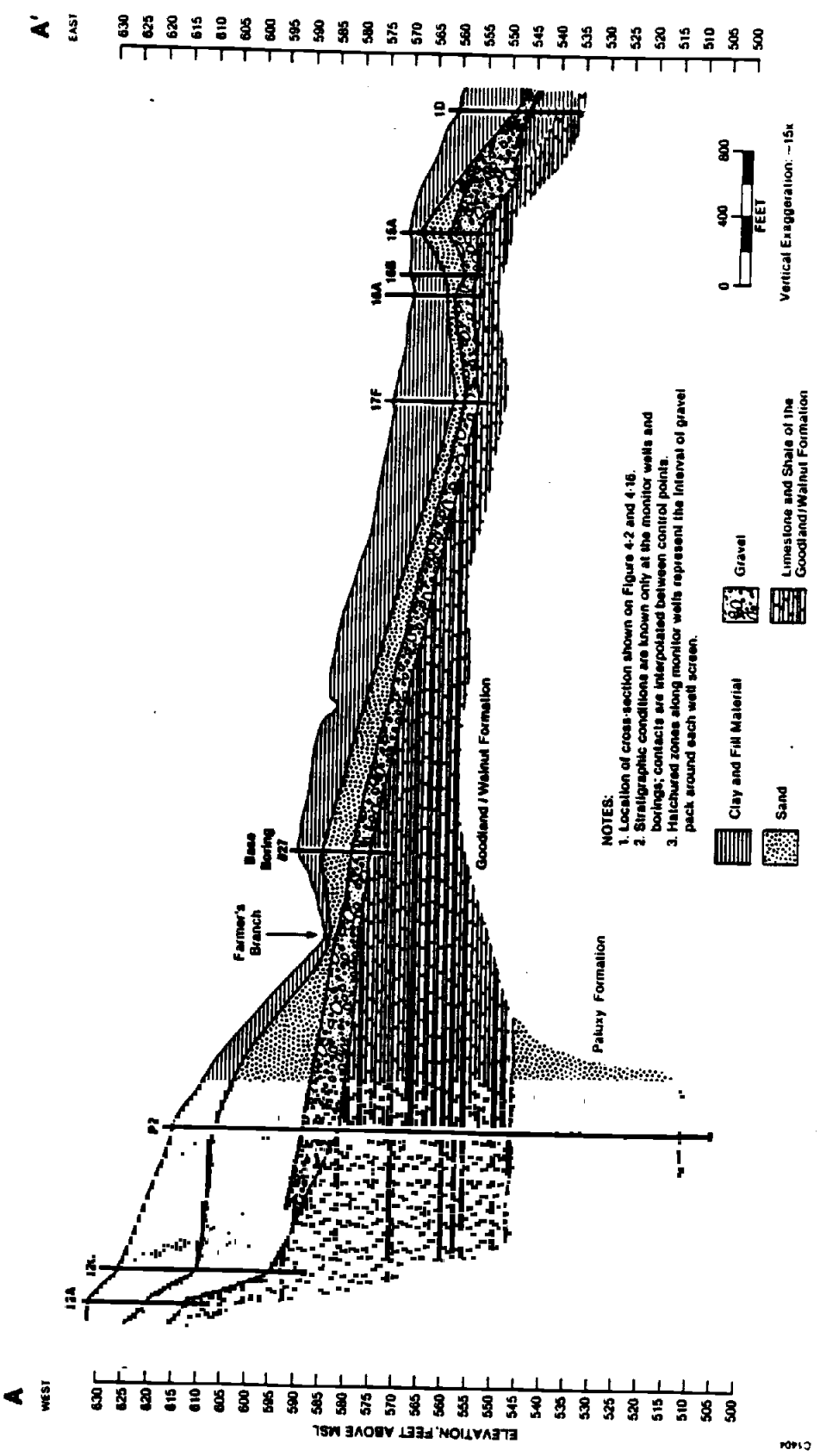

Figure 3-6. Geologic Cross Section A-A', Carswell AFB, Texas

3.3 Hydrogeology

3.3.1 Surface Water

Carswell AFB is located within the Trinity River basin just south of Lake Worth, a man-made reservoir on that river. Part of the base is drained by Farmers Branch which discharges into the West Fork Trinity River just south of the Contonment area. Farmers Branch begins within the community of White Settlement and flows eastward. Just south of AF Plant 4, Farmers Branch flows under the runway within two large culverts.

Most of the base surface drainage is intercepted by a series of storm drains and culverts, directed to oil/water separators and discharged to the West Fork Trinity River downstream of Lake Worth. A small portion of the north end of the base drains into Lake Worth.

3.3.2 Groundwater

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

Upper Zone - Groundwater occurs within the coarse sand and gravels deposited by the Trinity River, but these deposits are usually limited in areal extent and isolated by surrounding low-permeability clays and silts. Recharge to the water-bearing deposits is local, from rainfall and infiltration from stream channels and drainage ditches. Water flow in the alluvium is basically eastward, toward the West Fork of the Trinity River.

In parts of Tarrant County, generally close to the Trinity River, water in the alluvium is developed for irrigation and residential use. The community of River Oaks, immediately east of Carswell AFB, had supply wells that developed water from the alluvial deposits at a location near the USAF Hospital. The wells were abandoned when Carswell AFB purchased the property for hospital construction. For the most part, groundwater is not economical to develop from the alluvium due to the water's limited distribution and susceptibility to surface/stormwater pollution.

Goodland/Walnut Aquitard - The perched water present in the alluvium is separated from the aquifers below by the low permeability limestones and shales of the Goodland Limestone and Walnut Formation. The aquitard is composed of moist clay and shale layers interbedded with dry limestone beds. Though primarily dry, drillers in the area report that small amounts of water enter the borehole while drilling through the Walnut Formation, suggesting that groundwater may move through the Walnut along bedding planes (Hargis and Associates, Inc., 1984). The thickness of the Goodland/Walnut aquitard is approximately 25 feet or greater beneath most of Carswell AFB. However, the top of the aquitard is an erosional surface and weathering may have reduced the thickeness of the limestone in isolated areas. A soil boring at AF Plant 4, across the runway to the west from Carswell AFB, revealed that the Goodland Limestone had been completely eroded and only three feet of the Walnut Formation remained (Hargis and Associates, Inc., 1984). It is also reported that the upper zone and Paluxy Formation are in contact at the eastern boundary of AF Plant 4, where both the Goodland and Walnut Formations have been removed by erosion (Hargis and Associates, 1985). In areas of similarly extensive erosion, water in the upper zone could come in contact with water in the Paluxy aquifer.

Paluxy Aquifer - The Paluxy aquifer is the most shallow aquifer occurring beneath Carswell AFB. The aquifer's area extent is shown in Figure 3-7. In the base area, water in the Paluxy would naturally occur under confined conditions beneath the Goodland/Walnut aquitard (except where the aquitard is missing due to erosion, as discussed above). However, extensive

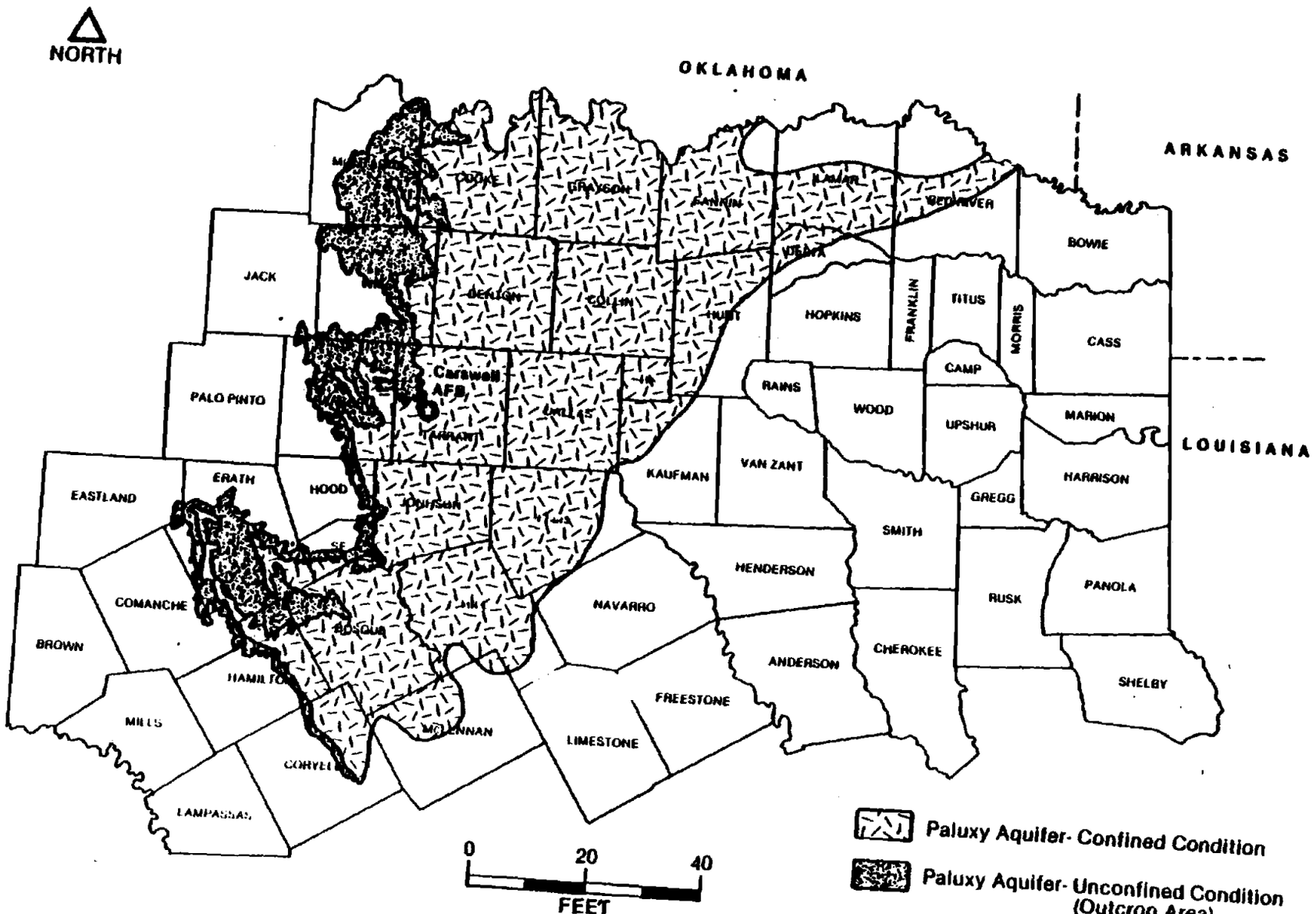

Figure 3-7. Areal Extent of the Paluxy Aquifer, North Texas

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pumping in the Fort Worth area has lowered the Paluxy potentiometric surface below the top of the formation, resulting in unconfined conditions beneath the base. The Paluxy Formation is divided into upper and lower sand members and the aquifer is likewise divided into upper and lower aquifers. The upper sand is fine-grained and shaley and the lower sand is coarser; therefore, most wells are completed in the lower section.

Recharge to the Paluxy aquifer occurs where the formation outcrops west of Carswell AFB. The Paluxy also outcrops north of the base in the bed of Lake Worth. The lake represents a significant recharge point for the aquifer and creates a potentiometric high in its vicinity. Regional groundwater flow within the Paluxy is eastward, in the direction of the regional dip. At Carswell AFB, groundwater flow is influenced by the Lake Worth potentiometric high and by a potentiometric low created by the groundwater withdrawals of the community of White Settlement, resulting in a more southeasterly flow direction.

Transmissivities in the Paluxy aquifer range from 1,263 to 13,808 gallons per day per foot (gpd/ft) and average 3,700 gpd/ft. The Paluxy Formation thickness ranges from 140 to 190 feet and averages 160 feet in Tarrant County. The actual water-bearing thickness in the Carswell AFB area probably approximates the formation thickness, but the aquifer is separated into two distinct water-bearing zones. In the vicinity of Carswell AFB, permeabilities range from 13 to 140 gpd/ft^2 (based on an approximate thickness for the aquifer of 100 ft.) Well yields within the Paluxy aquifer range from ml0 to 480 gallons per minute (gpm) and average approximately 100 gpm.

The Paluxy aquifer is an important source of potable groundwater in the fort Worth area. Communities surrounding Carswell AFB, especially White Settlement, develop municipal water supplies from the Paluxy, as well as from the deeper Twin Mountains aquifer. As a result of its extensive use as a water supply, water levels in the Paluxy aquifer have declined significantly over the years. Water levels in the immediate Carswell AFB vicinity have not

decreased as much as in the Fort Worth area in general because of the proximity of the Lake Worth recharge area and because the base does not develop water from the Paluxy.

Water quality in the Paluxy aquifer is generally good and is satisfactory for potable use. The range of chemical constituents occurring within Paluxy water is given in Table 3-3.

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

Twin Mountains Aquifer - The Twin Mountains Formation is the oldest formation used for water supply in the Carswell AFB area. The formation consists of a vasal conglomerate of chert and quartz, grading upward into coarse- to fine-grained sand interbedded with shale. The thickness of the formation varies between 250 and 430 feet.

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

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

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

Constituent or Property	Concentration
Bicarbonate (HCO_3)	177-689
Boron (B)	0.1-0.6
Calcium (Ca)	0-120
Chloride (CL)	5-117
Fluoride (F)	0-4.5
Iron (Fe)	0-9.9
Magnesium(Mg)	0-43
Nitrate (NO_3)	0-10.0
Silica (SiO_2)	1-30
Sodium (Na)	11-740
Sulfate (SO_4)	6-1,080
Dissolved Solids	264-2,176
Total Hardness ($CaCO_3$)	2-401
Percent Sodium (%)	7.1-99.5
pH	7.1-9.2
Sodium-Absorption Ratio (SAR)	0.2-68.8
Residual Sodium Carbonate (RSC)	0-10.0
Specific Conductance (umhos at 25°C)	427-3,193

NOTE: Analyses given are in milligrams per liter except percent sodium, specific conductance, pH, SAR, and RSC.

SOURCE: Texas Department of Water Resources, 1982.

Groundwater withdrawals from the Twin Mountains aquifer, primarily for municipal water supply, have resulted in declining water levels. Between 1955 and 1976, the potentiometric surface of the aquifer dropped approximately 250 feet. Water quality in the Twin Mountains aquifer is suitable for potable use throughout the Fort Worth area. Water in the upper sands of Fort Worth may be too mineralized for human consumption.

3.4 Climatology/Air

Carswell AFB is located near 33' north latitude in north central Texas. The climate is humid subtropical with hot summers and dry winters. Tropical maritime air masses control the weather during much of the year; however, the passage of polar cold fronts and continental air masses create large variations in winter temperatures. Meteorological data summarizing the period 1946 through 1978 are presented in Table 3-4 and discussed briefly below.

The average annual temperature for Carswell AFB is 66'F and monthly mean temperatures vary from 45'F in January to 86'F in July. The average daily minimum temperature in January is 35'F and he lowest recorded temperature is 2'F. The average daily maximum temperature in July and August is 95'F and the highest temperature recorded at the base was 111'F in the month of June. On the average, freezing temperatures occur at Carswell AFB on 33 days per year.

Mean annual precipitation recorded at Carswell AFB is 32 inches. The wettest month is May with a secondary maximum in September. The period from November to March is generally dry with a secondary minimum in August. Snowfall Accounts for a small percentage of the total precipitation between November and March. On the average, measurable snowfall occurs on 2 days per year. Lake evaporation at Carswell AFB is estimated to be approximately 57 inches per year. Evapotranspiration over land areas may be greater or less than lake evaporation depending on vegetative cover type and moisture availability. Average net precipitation is expected to be equal to the difference

TABLE 3-4. METEOROLOGICAL DATA SUMMARY FOR CARSWELL AFB, TEXAS

	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Temperature (°F)													
Mean	45	50	57	66	74	82	86	85	78	68	56	49	66
Average Daily Maximum	55	60	67	76	83	91	95	95	88	78	66	59	76
Average Daily Minimum	35	39	46	56	64	72	75	75	68	57	46	38	56
Highest Recorded	88	88	85	89	100	111	109	110	107	105	89	91	110
Lowest Recorded	2	6	11	31	42	55	61	60	46	33	17	11	2
Precipitation (inches)													
Mean	1.7	1.9	2.1	3.9	4.2	3.1	2.5	2.1	3.6	3.1	1.8	1.9	31.9
Maximum Monthly	5.9	4.7	6.5	14.2	15.2	8.8	9.0	6.0	9.6	10.7	7.4	6.7	15.2
Minimum Monthly	0.1	0.1	a	0.8	0.8	0.1	a	a	a	a	a	a	a
Maximum in 24 hours	2.8	3.2	3.4	3.3	5.7	3.5	5.9	3.1	4.0	3.2	2.8	2.9	5.9
Days with Thunderstorms	1	2	3	6	8	6	5	5	4	3	1	1	45
Snowfall (inches)													
Mean	2	1	6	0	0	0	0	0	0	0	b	b	3
Maximum Monthly	8	12	7	0	0	0	0	0	0	0	4	3	8
Maximum in 24 hours	5	8	7	0	0	0	0	0	0	0	4	3	8
Relative Humidity (%)													
Mean	62	61	61	64	68	64	58	60	65	65	63	62	63
Surface Winds (knots)													
Mean	8	8	9	9	7	8	6	5	6	6	8	8	7
Maximum	50	63	69	64	68	65	56	54	80	45	54	58	80
Prevailing Direction	S	S	S	S	S	S	S	S	S	S	S	S	S

Source: United States Air Force, Carswell AFB, Texas. Period of Record: 1946-1978.

[a]Less than one tenth inch.

[b]Less than 1 inch.

between average total precipitation and average lake evaporation or approximately minus 25 inches per year.

Thunderstorm activity occurs at Carswell AFB an average of 45 days per year. The greatest number of these storms occurs between April and June. Hail may fall on two to three days per year, and the maximum precipitation recorded in a 24-hour period is 5.9 inches.

Mean cloud cover averages 50 percent at Carswell AFB with clear weather occurring frequently during all months. Some fog is present on an average of 83 days per year. Wind speed averages 7 knots; however, a maximum of 80 knots has been recorded. Wind direction is predominantly from the south during all months.

3.5 Human Environment

3.5.1 Population

The total work force at Carswell AFB is approximately 6,100, which includes about 1,000 civilian personnel.

3.5.2 Demographics

The City of Fort Worth had a population of 414,562 based on a 1984 estimate. This estimate also included a population density of 1,617 people per square mile. The smaller suburbs of Fort Worth adjacent to Carswell AFB had 1980 population data as follows:

White Settlement	- 13,508
Westworth	- 3,651
River Oaks	- 6,890

3.5.3 Land Use

The base is surrounded by residential, commercial, recreational, and industrial land. Residential land use is to the southwest, southeast, and east of the base. Commercial property is south and recreational (Lake Worth) is north of the base. AF Plant 4 is the industrial facility directly west of Carswell AFB.

4.0 BASIS FOR PROGRAM APPROACH

The Stage 1 activities conducted at Carswell AFB documented the presence or absence of contamination at the study sites. The results of the Stage 1 investigation are the basis for the Stage 2 activities at Carswell AFB, to be described in Section 5. A major focus of the Stage 2 investigation is to fill data gaps remaining after the Stage 1 effort. This will result in further definition of the nature and extent of contamination at the Stage 2 sites and will allow evaluation of potential impacts to off-base areas and receptors. The Stage 2 effort will include borehole drilling and monitor well construction, surface water and sediment sampling, and geophysical and soil gas surveys.

4.1 Physiochemical Properties of Contaminants

The hazards to potential receptors associated with any specific contaminant are related to its physical and chemical characteristics, its concentration, and the availability and nature of potential pathways for exposure. Contaminants that reach the groundwater will migrate in a generally downgradient direction and may eventually cross the base boundary. Due to differing physicochemical properties, some chemicals may tend to float on top of groundwater in a separate immiscible phase. Others may be dissolved in the groundwater. Some controls on the rate of contaminant migration in groundwater are the solubility of the contaminant in water, the persistence of the contaminant and/or its transformation products, and its potential adsorption onto subsurface materials. In general, most groundwater contaminants at the Carswell AFB IRP sites were introduced by downward migration of relatively dilute solutions rather than of concentrated streams. Therefore, density stratification of contaminants dissolved in the groundwater is not expected. Once a contaminant reaches a receptor, characteristics that define its hazardousness are of particular concern, e.g., toxicity, carcinogencity, flammability, etc. Human health threats, if any, will be evaluated during this investigation as part of the risk assessment.

4.2 Pathways and Receptors

The potential pathways whereby contaminants could exit the base are infiltration through the shallow surface soils and migration within the unsaturated zone, shallow groundwater underflow, and surface water runoff. One group of sites (i.e., Sites 1, 15, 16, 17, and the Base Service Station) is located near the base property line; the remaining sites are located near the flightline in the interior of the base. Specific surface runoff pathways of concern for this investigation are the Flightline Drainage Ditch (Site 13) and Farmers Branch and its tributaries on the base. These pathways lead to the West Fork of the Trinity River located east of the base.

The potential receptors to contaminants found at and around the study site are limited because all sites are located inside the base property and access is controlled. The main potential receptors on-base are the field team members, especially during drilling activities. During drilling well installation and water sampling operations, the greatest potential exists for exposure to contaminants from the groundwater, surface water or soils.

Potential off-base receptors include people coming into contact with groundwater contaminants from either shallow wells in the alluvium or deeper wells in the Paluxy aquifer. If the groundwater exits the aquifer as seeps or springs into surface drainages, another potential route exists for receptor contact.

4.3 Environmental/Health Effects

The relationships between contaminants identified in Stage 1 and potential receptors have not been formally evaluated. Potential environmental and human health effects will be determined under the Risk Assessment task of this investigation. The objective is to identify and quantify potential environmental and health hazards within the base and in the off-base areas.

4.4 Preliminary Technologies

Preliminary technologies for alternative remedial actions are developed to identify general response actions, or classes of responses once a site or operable unit has been assessed. Site and operable unit assessments will be conducted during the Stage 2 IRP work. The data developed during the Stage 2 effort will be used to determine preliminary technologies per the statement of work. The preliminary technologies will be selected based on their applicability to site-sopecific conditions. No remedial alternatives will be implemented during this investigation.

4.5 Applicable or Relevant and Appropriate Requirements (ARARs)

All soil and water analyses will be compared to available regulatory criteria which include maximum contaminant levels (MCLs) and maximum contaminant level guidelines (MCLGs). Any applicable State water quality criteria will also be used. This information will be used to assess the applicability of preliminary technologies, and to determine whether an alternative remedial action can meet or exceed the ARARs. The ARARs are also useful in defining data sufficiency and developing an approach for the public health evaluation task. These activities will involve close interaction with regulatory agencies in order to agree on criteria and methods.

During the review of each alternative technology, a summary of its effectiveness for protecting public health will be prepared. Each alternative will be evaluated to determine the extent to which it meets, exceeds or falls short of the ARARs. The analysis for each alternative will involve discussion of the technical issues including contaminant control and minimization, estimated time required to achieve ARARs; and the degree to which the technology is proven for the proposed application. Potential routes of exposure to contaminants during the remedial actions will be addressed along with the ARARs. If an alternative technology cannot attain an ARAR, it will be examined to determine its potential to reduce the present or future threats to any identified receptors.

4.6 Data Requirements

The results of the Stage 1 activities are confirmed the presence of contamination at various sites at Carswell AFB. For the most part, the data represent only one or two sampling events and therefore do not adequately define the range of site-specific environmental conditions. Additional data are needed to characterize the site in sufficient detail to identify and screen preliminary technologies and develop alternative remedial actions. The general categories of data needed to fill gaps in the Stage 1 database relate to:

- Hydrogeologic setting;
- Groundwater flow directions and velocity estimates;
- Contamination distribution (vertical and horizontal);
- Contamination concentrations; and
- Off-base receptors and users of shallow groundwater.

These data will be obtained during the IRP Stage 2 activities described in Section 5.

5.0 SCOPE OF WORK

The IRP Phase II Stage 2 investigation at Carswell AFB will involve a series of field activities to collect environmental data at selected sites. The data collected will be used to determine the need for, and type of, remedial action for contaminated areas that pose a risk to public health or the environment. These activities will proceed in parallel at the different sites. The following subsections describe the work to be performed for this study. The activities are based upon the Statement of Work (SOW) in Appendix A.

5.1 Organization of Effort

5.1.1 Operable Units

Thirteen sites will be individually investigated as single operable units. These sites, as presented in the Statement of Work are:

- Site 1 - Landfill 1
- Site 3 - Landfill 3
- Site 4 - Landfill 4
- Site 5 - Landfill 5
- Site 10 - Waste Burial Area
- Site 11 - Fire Department Training Area 1
- Site 12 - Fire Department Training Area 2
- Site 13 - Flightline Drainage Ditch
- Site 15 - Entomology Dry Well
- Site 16 - Unnamed Stream
- Site 17 - POL Tank Farm
- Site WSA - Weapons Storage Area
- Site BSS - Base Service Station

These sites are shown on Figure 2-1. Site WSA (Weapons Storage Area) is located 4 miles west of Carswell AFB (Figure 3-1).

5.1.2 Combined Site Investigations

Combined site investigations will not be performed as part of the Stage 2 work. However, sites have been grouped into two main areas (Flightline Area and East Area) shown on Figure 2-1.

5.2 General Discussion of Integrated IRP Tasks

This subsection provides a discussion of techniques and/or methodologies that will be used to accomplish this investigation. In general, these have been grouped into field evaluation and feasibility study tasks. These sections describe how the field activities will be conducted, and data evaluation will be conducted All of the resulting information can be used for supporting the feasibility studies.

5.2.1 Field Related Tasks

The field investigation including all drilling and sampling operations will be supervised by a registered geologist or hydrogeologist certified by the American Institute of Professional Geologists (AIPG) or equivalent organization. A detailed log of the conditions and materials penetrated during the course of the work will be maintained by the geologist/hydrogeologist on site. Decisions on well locations, well depths, screened intervals, and other construction details will be made collectively by the USAFOEHL Technical Program Manager (TPM) and the Radian Project Director.

A summary of the field related tasks for the Stage 2 investigation is provided in Table 5-1. This table illustrates the type and amount of field work, consisting of soil gas surveys, geophysical surveys, drilling and well installation and soil and water sampling analysis.

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TABLE 5-1. SUMMARY OF PHASE II STAGE 2 FIELD ACTIVITIES AT CARSWELL AFB, TEXAS

SITES (b)	1	3	4	5	10	11	12	13	15	16	17	WSA	BSS	BKGND	TOTAL
BOREHOLES (c)	2	6	3	5	3	0	7	0	0	0	5	0	4	0	35
BOREHOLE DEPTH	60	403	105	173	69	0	184	0	0	0	173	0	138	0	1305
UZ WELLS (from boreholes above)	2	5	3	5	0	0	2	0	0	0	5	0	4	0	26
DEPTH UZ WELLS	60	173	105	173	0	0	69	0	0	0	173	0	138	0	891
PALUXY WELLS	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
DEPTH PALUXY WELLS	0	200	0	0	0	0	0	0	0	0	0	0	0	0	200
HAND AUGERS	0	0	0	0	0	0	0	0	3	0	0	8	0	0	11
DEPTH AUGERS	0	0	0	0	0	0	0	0	30	0	0	40	0	0	70
SOIL SAMPS FROM AUGERS	0	0	0	0	0	0	0	0	15	0	0	16	0	0	31
SPLIT SPOON SAMPLES	6	15	9	15	18	0	28	0	0	0	15	0	12	0	118
SLUG TESTS	2	0	5	5	0	0	3	0	0	0	3	0	0	0	18
SOIL GAS DAYS	0	0	0	0	0	0	0	0	0	0	2	0	2	0	4
SOIL-SED SAMP ROUNDS	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
SOIL-SED SAMPLE POINTS	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5
SOIL-SED SAMPLES	0	0	0	0	0	0	0	10	0	0	0	0	0	0	10
SURF WATER SAMP ROUNDS	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
SURF WATER SAMP POINTS	0	0	0	0	0	0	0	0	0	4	0	0	0	0	4
SURF WATER SAMPLES	0	0	0	0	0	0	0	0	0	8	0	0	0	0	8
GW SAMPLING ROUNDS	2	2	2	2	0	2	2	0	0	0	2	0	2	0	2
GW SAMP POINTS	6	6	9	9	0	2	5	0	0	0	5	0	4	0	50
TOT GW SAMPLES	12	12	18	18	0	4	10	0	0	0	10	0	8	0	100

NOTES

a. The numbers in this table represent the maximum effort to be performed. Actual work performed may be less due to technical considerations.

b. Sites are as follows:

Site 1	Landfill 1
Site 3	Landfill 3
Site 4	Landfill 4
Site 5	Landfill 5
Site 10	Waste Burial Area
Site 11	Fire Department Training Area 1
Site 12	Fire Department Training Area 2
Site 13	Flightline Drainage Ditch
Site 15	Entomology Dry Well
Site 16	Unnamed Stream
Site 17	POL Tank Farm
WSA	Weapons Storage Area (Off Base)
BSS	Base Service Station

c. Some boreholes are not to be completed as monitoring wells.

5.2.1.1 Soil Gas Survey

Soil gas surveys will be conducted at two sites at Carswell AFB. The field crew will collect soil gas samples for on-site analyses over a four day period. The samples will be analyzed for hydrocarbons characteristic of JP-4 and MOGAS fuels at the POL Tank Farm (Site 17) and the Base Service Station (BSS). These sites represent fuel tank storage and pipeline areas.

The objectives of the soil gas investigation are to confirm the possible existence of subsurface contaminants, and to determine the areal extent and migration direction of hydrocarbon contamination from the sites. This information will also aid in selecting drilling locations.

The contractor will use a field vehicle equipped with a gas chromatograph. The sampling probes will be pushed to the desired depth (probably less than 10 feet). Soil gas will be flushed through the probe, then samples will be collected from the Teflon tubing attached to the probe. Soil gas samples will be analyzed immediately for real time evaluation of the data.

5.2.1.2 Geophysical Surveys

Magnetometer surveys will be performed at Sites 1 (Landfill 1) and 10 (Waste Burial Area) to investigate anomalies found in the Stage 1 investigation and assist in the location of boreholes in the Stage 2 investigation. Readings of the total magnetic field and magnetic gradient will be taken at appropriate locations using an EDA PPM 500 proton magnetometer (or equivalent).

5.2.1.3 Subsurface Soil Surveys

Up to thirty-five boreholes and 11 hand augers will be drilled among ten sites for this investigation. These sites are:

- Site 1 - Landfill 1;
- Site 3 - Landfill 3;
- Site 4 - Landfill 4;
- Site 5 - Landfill 5;
- Site 10 - Waste Burial Area;
- Site 12 - Fire Department Training Area 2;
- Site 15 - Entomology Dry Well;
- Site 17 - POL Tank Farm;
- Site WSA - Weapons Storage Area; and
- Site BSS - Base Service Station

The boreholes at these sites are to provide geologic and chemical data of the subsurface to detect and define lateral or vertical extent of contamination at a site. As many as 26 of the boreholes will be converted to monitoring wells.

Soil samples from boreholes will be obtained using ASTM Method D-1586. The samples will be collected at 2.5 foot intervals for the first 10 feet and at 5 foot intervals to the total depth drilled. The total depth of each borehole is expected to range between 20 and 40 feet.

Selected samples will be chosen for chemical analyses and soil tests as shown in Table 5-2. Also shown are sediment and drill cutting samples to be collected per the statement of work. Details of the quality control, handling and screening procedures are provided in the Quality Assurance Project Plan provided under separate cover.

Air monitoring during all well drilling and soil boring work will be accomplished with an organic vapor analyzer utilizing a photoionization detector (PID) or flame ionization detector (FID) to identify the presence of potentially hazardous and/or toxic vapors or gases. The air monitoring results will be noted in the boring logs. If soil encountered during borehole drilling is suspected to be hazardous because of abnormal discoloration, odor or air monitoring levels, the drill soil cuttings will be containerized in new, unused drums. A different drum will be used for each boring where soil

TABLE 5-2. SUMMARY OF PHASE II STAGE 2 SOIL ANALYSES AT CARSWELL AFB, TEXAS

PARAMETER [Soil Samples]	ANALYTICAL METHOD	SITE 1	SITE 3	SITE 4	SITE 5	SITE 10	SITE 11	SITE 12	SITE 13	SITE 15	SITE 16	SITE 17	BSS	WSA	Drill Back-Cuttinground		Total
Oil and Grease	SW3550/ E413.2	6	15	9	15	18	–	–	–	–	–	–	–	–	–	–	63
Petroleum Hydrocarbons	SW3550/ E418.1	–	–	–	–	18	–	28	10	–	–	15	12	–	–	–	83
Metal Screen (23 metals)	SW3050/ SW6010	6	15	9	15	18	–	28	10	–	–	–	–	16	–	–	117
Arsenic	SW3050/ SW7060	6	15	9	15	18	–	–	–	–	–	–	–	–	–	–	63
Lead	SW3050/ SW7420	–	–	–	–	–	–	–	–	–	–	15	12	–	–	–	27
Mercury	SW7471	6	15	9	15	18	–	–	10	–	–	–	–	–	–	–	73
Selenium	SW3050/ SW7740	6	15	9	15	18	–	–	–	–	–	–	–	–	–	–	63
Organochlorine Pesticides and PCB's	SW3550/ SW8080	–	–	–	–	18	–	–	–	15	–	–	–	–	–	–	33
Volatile Organic Compounds	SW5030/ SW8240	6	15	9	15	18	–	28	10	–	–	15	12	16	50	–	194
Semivolatile Organic Compounds	SW3550/ SW8270	6	15	9	15	18	–	28	10	–	–	–	–	16	50	–	167
Chlorinated Phenoxy Herbicides	SW8150	–	–	–	–	18	–	–	–	15	–	–	–	–	–	–	33
Organophosphorous Pesticides	SW8140/ SW3550	–	–	–	–	–	–	–	–	15	–	–	–	–	–	–	15
Extraction Procedure Toxicity	40 CFR 261.24	–	–	–	–	–	–	–	–	–	–	–	–	–	50	–	50
Soil Moisture Content	ASTM D2216	6	15	9	15	18	–	28	–	15	–	15	12	16	–	–	149

encountered is suspected to be hazardous. The field log will reflect the boring logs depth(s) from which the suspected contaminated soil cuttings were collected. Composite drill cutting samples will be obtained for chemical analysis as shown on Table 5-2 and described later in Section 5.2.1.9 Drum Sampling.

The discrete soil and formation samples will be screened using either the organic vapor analyzer described above and/or Draeger tubes in order to detect the presence of volatile organic contaminants. Selected samples will be placed into a clean glass jar for detailed contaminant screening. The volatile organic levels will be recorded on the field log. These field analyzers, although calibrated, will be useful only as indicators of the presence of significant contaminant levels. Because the instruments are sensitive to moisture and fluctuating environmental conditions at the site, small concentrations above background listed on the field logs would be considered insignificant. The organic vapor concentrations which may be detected in disturbed soil samples represent an indication of the presence of gross contamination only, and in no way are intended to represent the actual levels of contaminants present in the formations.

5.2.1.4 Borehole Geophysical Surveys

No borehole geophysical surveys will be conducted during this IRP Phase II Stage 2 investigation.

5.2.1.5 Monitoring Wells

An overall objective of the investigation at Carswell AFB is to define the presence, magnitude, direction, rate and extent of movement of any identified contaminants. To accomplish this task, a maximum of 27 monitoring wells will be installed. Well construction will be in accordance with the SOW for the purpose of examining the ground water for the presence of contamination and defining the local hydrogeology. For this investigation installation of monitor wells are planned at Sites 1, 3, 4, 5, 12, 17, and BSS. The exact

location, depth and number of test wells for each site will be determined in the field by the contractor in consultation with the Air Force Technical Program Manager. All wells will be completed in the upper zone (alluvium); the Paluxy well identified in the SOW will be considered optional (verbal communication between the USAFOEHL TPM and the Radian Project Director). Field drilling operations and logistics will be coordinated with Civil Engineering facility personnel to avoid interference with existing utilities and traffic patterns.

The field team will use a hollow-stem auger rig to drill the upper zone monitoring wells. This method performs well in unconsolidated sediments, allows the rig to operate without the use of drilling fluids, and permits ease of collection for formation samples. The hollow-stem auger can be used as a temporary casing to prevent the borehole from caving during drilling and completion of test wells. For the depths and geology involved, this drilling method will provide fast, efficient performance at a relatively low operating cost.

Following the completion of drilling operations, each well will be screened above and below the water table surface with a minimum of 10 feet and maximum of 35 feet of screen. The screen will consist of two-inch diameter, PVC casing with up to 0.020-inch slots. The material lengths selected will be based upon site-specific ground water conditions encountered. The screen will be capped at the bottom. All connections will be flush jointed and threaded.

The screened section will be joined to a two-inch diameter, Schedule 40 PVC, flush threaded casing. The casing will extend from the top of the screen to at least ground surface. To ensure the chemical integrity of the test wells, no glues, solvents, or thread compound will be employed during screen and casing installations. Prior to installation, the casing and screen sections will be thoroughly washed using a high-temperature, high-pressure sprayer, with Base potable water only.

After the casing and screen have been installed for each well, a sand or gravel pack will be emplaced between the screen and the boring wall. The pack will consist of washed and bagged rounded sand or gravel with a grain size distribution compatible with the screen and the formation. The pack will be emplaced from the bottom of the borehole to two feet above the top of the screen. The auger flights will be used as the tremie pipe.

Granulated or pelletized bentonite will be placed above the sand/-gravel pack to a minimum thickness of two feet to provide an adequate seal. The bentonite seal will be wetted in the hole using 1-2 gallons of Base potable water to endure that the seal is developed before cementing operations begin.

Neat cement (Type I Portland cement) grout will be emplaced from above the top of the bentonite seal to land surface. No more than an eight percent gel mixture may be used. For water table conditions grout will be emplaced through the augers and then the auger string withdrawn. If artesian conditions exist a small diameter tremie pipe will be used to emplace the grout.

Surface Completions of Monitoring Wells

Two methods for the well surface completions will be employed at Carswell AFB depending on input from base officials. If well stick-up is of concern in an area, the well will be completed flush with the land surface. In the case of flush completion, the PVC casing will be cut two to three inches below land surface, and a protective locking lid will be cemented in place. The protective lid will consist of a cast-iron valve box assembly cemented in place with concrete. Care will be taken to maintain free drainage from the valve box such as with a subsurface drain tube. Also, a water tight PVC casing cap will be provided to prevent infiltration of surface water. A locking system will be provided to discourage any tampering.

When above-ground surface completion is used, the PVC well casing will be extended about two or three feet above land surface. An end plug or casing cap will be provided for each well. The extended PVC casing will be shielded with at least a four-inch diameter steel guard pipe. The guard pipe will be placed over the PVC casing and cap and will be seated in a 24-inch by 24-inch by 4-inch concrete surface pad. The protective casing will be installed with a lockable cap or lid to discourage vandalism.

In the case of an above-ground completion, three 3-inch diameter steel guard posts, five feet in total length each will be installed radially from each wellhead. The guard posts will be placed approximately two to three feet into the ground and may at some sites be removable to facilitate access for sampling activities. In these cases a locking mechanism will be provided to prevent unauthorized removal.

Monitoring Well Development

Each new monitoring well will be developed as soon as practical after completion. The monitoring wells will be developed by a submersible pump, and/or bailer. Monitoring well development will continue until the discharge water is clear and free of sediment to the fullest extent possible. All water during development will be collected and disposed of through an existing oil/water separator connected to a base sanitary sewer. The development water production (rates), pH, specific conductances and water temperature will be measured. These data will be included in the final report.

Surveying of Monitoring Wells and Boreholes

All monitoring wells and boreholes will be surveyed for elevations and locations. A registered professional land surveyor will be retained to survey the vertical elevations of the wells and the tops of the boreholes. This survey will have an accuracy for vertical elevations of ± 0.01 foot for all monitoring wells and ± 0.1 for bore holes. Horizontal locations will be

accurate to ±1 foot. All surveying will use an established U.S.C. & G.S. or U.S.G.S. bench mark as point of origin. All surveyed points and bench marks used will be recorded on site maps.

5.2.1.6 Aquifer Tests

Slug tests will be conducted on eighteen of selected monitoring wells (new and Stage 1 wells) after the completion of groundwater sampling. The slug test provides an indication of aquifer characteristics such as hydraulic conductivity. Also, this test is ideally suited for low-producing formations that cannot be pumped. Monitoring wells will be selected with the hydrogeologic characteristics that will optimize slug testing. The resulting data will be used in conjunction with the groundwater geologic data. The slug test equipment will be decontaminated between monitoring wells to prevent any cross contamination.

5.2.1.7 Groundwater Samples

Groundwater Level Measurements

Following completion and development of the monitoring wells, but prior to sampling activities at each site, a round of water level measurements will be conducted on the monitoring wells. Water levels will be measured to the nearest 0.01 feet from the top of the marked casing using an electric line water level indicator. When the electrode of the water level meter comes in contact with the water, a meter reacts or a tone sounds. Additionally, the surface of the water will be examined for the presence of hydrocarbons. If hydrocarbons are present the thickness of the layer will be measured and recorded.

On-Site Field Analyses

Well Purging -- Each monitoring well will be purged immediately prior to sample collection to insure that fresh formation water is collected.

Purging will occur at least three days after completion of monitoring well development. When possible sampling will begin at upgradient monitoring wells and/or low contamination areas then move to downgradient and/or higher contamination areas.

Purging operations will be conducted using a submersible pump or a bailer. Purging operations will be considered complete when three wetted well casing volumes have been removed or when the pH (±0.1 unit), temperature (±0.5°C), specific conductance (±10 micromhos), color and odor of the discharge are stabilized. After purging the wells, groundwater samples will be collected from the discharge line of the submersible pump or with a Teflon bailer or 2-inch stainless steel Kemerer sampler. This latter sampler can provide non-aerated groundwater samples at discrete depths which aids in insuring the integrity of any volatiles in the groundwater.

The methods for obtaining the water data are as follows: All downhole equipment used during the purging of the monitoring wells will be carefully washed to prevent cross-contamination. Details of the decontamination process are provided in the Quality Assurance Project Plan (QAPP). As an additional step to prevent cross-contamination of the wells, purging/sampling operations will progress from areas suspected to contain little or no contamination to areas assumed to have higher contamination levels. The purged groundwater will be disposed through an oil/water separator connected to a sanitary sewer.

Temperature -- Measurements of the sample temperature will be taken using a mercury thermometer. The field measurement represents the temperature of the groundwater at a particular location and time.

pH -- The pH of each sample will be measured with a Myron L pDS (Model EP11/pH) meter or equivalent. The pH of the sample will be measured as quickly as possible after collection.

Specific Conductivity -- The specific conductivity of each sample will be measured with a Myron L pDS meter (Model EP11/pH) or equivalent. Elevated specific conductivities indicate the presence of conductive ions in the groundwater.

Sampling for Laboratory Analysis

Water samples collected from the wells will be placed in laboratory prepared containers, preserved as appropriate, chilled to 4°C and shipped to Radian laboratories in Austin, Texas and/or Sacramento, California. The groundwater samples and type of analysis are summarized on Table 5-3. Also shown on the table are data for surface water sampling. Radian chain of custody documents will accompany all samples. Analytical methods, preservations and holding times are provided in detail in the QAPP.

Split Sample Procedures

When split samples are required, the sample will be divided such that all the containers have a representative portion. In the case of solid samples (soil and formation), samples will be split longitudinally when possible and any loose material will be divided as equally as possible among the containers. Samples for volatile contaminants will be placed directly into the sample container with minimal disturbance. Water samples will be split by pouring an equal volume of liquid among the containers for each collection. The containers will then be labeled on-site and the samples recorded in a log book.

5.2.1.8 Trenching

No trenching activities are planned for this investigation.

TABLE 5-3. SUMMARY OF PHASE II STAGE 2 WATER ANALYSES AT CARSWELL AFB, TEXAS

PARAMETER [Water Samples]	ANALYTICAL METHOD	Approximate Number of Analyses by Site: SITE 1	SITE 3	SITE 4	SITE 5	SITE 10	SITE 11	SITE 12	SITE 13	SITE 15	SITE 16	SITE 17	BSS	WSA	Base Wells	Surface Samples	Total
Alkalinity – Carbonate, Bicarbonate, & Hydroxide (Field Test)	A403	12	12	18	18	–	4	10	–	–	8	10	8	–	–	–	100
Fluoride	E340.2	12	12	18	18	–	4	10	–	–	8	10	–	–	–	–	92
Chloride	E325.3	12	12	18	18	–	4	10	–	–	8	10	–	–	–	–	92
Nitrate	E353.1	12	12	18	18	–	4	10	–	–	8	10	–	–	–	–	92
Orthophosphate	E365.1	12	12	18	18	–	4	10	–	–	8	10	–	–	–	–	92
Sulfate	E375.4	12	12	18	18	–	4	10	–	–	8	10	–	–	–	–	92
Chlorinated Phenoxy Acid Herbicides	A509B	–	12	–	–	–	–	–	–	–	–	–	–	–	–	–	12
Specific Conductance (Field Test)	E120.1	12	12	18	18	–	4	10	–	–	8	10	8	–	–	–	100
pH (Field Test)	E150.1	12	12	18	18	–	4	10	–	–	8	10	8	–	–	–	100
Total Dissolved Solids	E160.1	12	12	18	18	–	4	10	–	–	8	10	8	–	–	–	100
Temperature (Field Test)	E170.1	12	12	18	18	–	4	10	–	–	8	10	8	–	–	–	100
Metal Screen (25 metals)	E200.7	12	12	18	18	–	4	10	–	–	8	10	8	–	–	–	100
Arsenic	E206.2	12	12	18	18	–	4	10	–	–	8	10	8	–	–	–	100
Lead	E239.2	12	12	–	–	–	–	–	–	–	8	10	8	–	–	–	50
Mercury	E245.1	12	12	18	18	–	4	10	–	–	8	10	8	–	–	–	100
Selenium	E270.2	12	12	18	18	–	4	10	–	–	8	–	8	–	–	–	90
Oil and Grease	E413.2	12	12	–	–	–	–	–	–	–	8	–	–	–	–	–	32
Petroleum Hydrocarbons	E418.1	–	–	–	–	–	4	10	–	–	–	10	8	–	–	–	32
Purgeable Halocarbons	E601	12	12	18	18	–	4	10	–	–	8	10	8	–	–	–	100
Phenols	E604	–	12	–	–	–	–	–	–	–	–	–	–	–	–	–	12
Organochlorine Pesticides	E608	–	12	–	–	–	–	–	–	–	–	–	–	–	–	–	12
Extractable Priority Pollutants	E625	2	2	2	2	–	2	2	–	–	–	2	–	–	–	–	14
Purgeable Aromatics	SW5030/ SW8020	12	12	18	18	–	4	10	–	–	8	10	8	–	–	–	100

5.2.1.9 Drum Sampling

During the borehole and monitoring well drilling activities cuttings that are suspected of being hazardous because of abnormal discoloration, odor or air monitoring levels will be containerized as discussed previously in Subsection 5.2.1.3 Subsurface Soil Surveys. To determine the final disposition of the cuttings in the drums, a composite sample will be obtained from each drum identified using a stainless steel scoop. Up to 50 composite samples will be collected for chemical analysis.. Each composite sample of the drill cuttings will be analyzed as shown on Table 5-2 for EP Toxicity 40 CFR 261.24, (metals, pesticides and herbicides) volatile organic compounds (Method SW5030/SW240), and for base/neutral and acid extractable organic compounds (Method SW3550/SW8270) to determine if the soil cuttings must be disposed of as a hazardous waste.

5.2.2 Evaluation-Related Tasks

The objectives of the data evaluation process are to summarize the existing information on the hazardous waste sources, pathways, receptors, and to evaluate potential impacts on the base and public health, and the environment. Site-specific analytical data resulting from the field investigation at the Base as well as regional information are considered in the evaluation process.

5.2.2.1 Data Management

The field investigation will generate large amounts of data on the hydrogeology and chemistry about the study sites. Therefore, the data will be managed through a computerized database system called Empress®. This system will be used to convert the raw field data and analytical data into usable form for reporting. In addition, this will support the USAFOEHL Installation Restoration Program Information Management System (IRPIMS) and data formats. Therefore, the data base will be designed to support the following activities:

- Archive, analyze and manipulate physical, chemical, biological and geological data collected during the IRP program;

- Analyze data with respect to trends or violations of environmental protection guidelines;

- Produce subsets of data to form summary reports and data files which can be analyzed by environmental models and statistical algorithms; and

- Interpret relationships between contaminant migration and biogeochemical relationships existing at a particular site.

Predefined Codes As part of the data management, the documentation and procedures used during collection of sampling data will follow appropriate protocols and guidelines to eliminate data gaps. Data will be classified according to guidelines that will use predefined codes from USAFOEHL. The coded values will minimize the size of the database and will reduce the time needed to perform the data entry effort.

Data Collection Forms -- Data collection forms will be provided by USAFOEHL and will be revised to record data gathered by field personnel or measured by laboratory technicians.

Automated Data Processing (ADP) Format -- In the USAFOEHL-specified ADP format all technical data, including site information, well characteristics, hydrogeologic, geologic, physical and chemical sampling results will be stored on magnetic media (floppy disk or magnetic tape). The technical data will be organized in ASCII flat files using data files specified in a USAFOEHL format.

5.2.2.2 Hydrogeologic Assessment

The purpose of the hydrogeologic assessment is to develop a complete understanding of the ground water system on-and off-base by integrating the available data from earlier investigations and by conducting additional field studies to fill data gaps or provide additional detail where necessary. Specific purposes of this evaluation include: developing a better understanding of on-and off-base ground water flow; relationships between saturated zones; extent and migration of contamination plumes; seasonal changes in water levels and flow. Results of this study will form the framework of the evaluation of ground water impacts, qualitative risk assessment, and remedial action alternatives discussed in Section 5.2.3.

The focus of this task will be on developing a comprehensive knowledge of base-wide groundwater conditions at Carswell AFB. The information developed in the detailed site characterization of individual contamination areas will form an integral part of the data used in this task.

The hydrogeologic assessment will draw on the results of all previous groundwater investigations conducted as part of the IRP at Carswell AFB. In addition to those sources, previous IRP studies will now be updated with any regional and area studies by federal, state, and local agencies and other published and unpublished information will be used.

5.2.2.3 Demographic Survey

The potential for contaminants to come in contact with various receptors is of prime concern during this investigation. This is particularly the case when waste sites exist close to the base boundary where a greater potential exists for off-base migration. Once a contaminant exits, a site, on or off-base human contact or other receptors can be impacted. Therefore, in order to evaluate the contaminant threat, it is necessary to identify the possible receptors. Data are readily available to determine on-base receptors,

while off-base demographic data will need to be generated during this investigation. Demographic and land use information will be developed during the program literature search, and specifically during a water well inventory within a mile around Carswell AFB. These activities will identify the demographics for potential human receptors, as well as determining the nature of the land use such as agricultural, industrial, commercial, or residential. Water wells, whether residential, municipal, or industrial, will also identified.

5.2.2.4 Evaluation and Screening of Data

The basis for assessing the impact of a site on the environment is based on the value of the data collected about the site. These data are from field observations as well as physical and chemical data collected during the project. This information forms the foundation for making the interpretations about the site and its potential for adverse health determinations.

The data will be screened for quality control purposes as it is received. The content will be screened for appropriateness and completeness. All of the data collected in the field and subsequent chemical analysis will be reviewed prior to sending informal copies to USAFOEHL. The data will be screened in accordance with the Work Plan, Statement of Work, Data Base Management System and the QAPP.

5.2.2.5 Endangerment Assessment

The confirmation of a hazardous substance at a site will be evaluated to determine the relative danger it can pose to public health, welfare or the environment. The data collected during this effort will be integrated with the results of the previous Stage 1 activities to provide a comprehensive picture of the threat potential. Pathways, receptors, and the nature of the contaminants will be used in conducting an endangerment or risk assessment. The result of this evaluation will be to identify what is or has been affected

by a site. These activities will be part of a risk assessment conducted during this investigation. During this endangerment or risk assessment the following will be identified:

- Receptors;
- Threat to human health and environmentally sensitive areas; and
- Carcinogenic risks.

5.2.2.6 Map Preparation

To support the reporting effort, maps will be prepared utilizing an inhouse PC-based system Autocad. This system will permit relatively fast development of report maps and map changes. The system permits the integrating and development of geologic cross sections and plane maps. Additionally, the system permits various scales to provide the optimum map size for the report. The results will be maps, figures and legends that are clear for ease of interpretation and of publishable quality. Map and figure preparation will be developed from the applicable sections in the Statement of Work and the USAFOEHL handbook. In general, the following types of maps and figures will be developed:

- General Carswell AFB installation features and boundaries (e.g., major installation support and operational facilities);
- Site locations and plan views;
- Monitoring well/boring/sampling locations/cross sections; and
- Surface drainages and water bodies.

Some of the specific types of maps and figures that will be developed include hydrogeological cross-sections, water table elevation contour maps, water well inventory locations, and soil gas survey grids and related data.

5.2.2.7 Treatability Studies

No treatability studies are planned for this present effort. Requirements for treatability studies will be considered during the review of alternative remedial actions during this investigation.

5.2.2.8 IRP Reports

When evaluating a site, all site-specific data are important to understand the physical and chemical factors controlling the migration and distribution of contaminants at a site. Past site-specific data will be available from previous IRP activities which are summarized in the corresponding Phase I and Phase II Stage 1 reports. These reports, in general, and specifically the Phase II Stage 1 report, will be reviewed for the identification of data gaps. Therefore, any existing data gaps can be addressed in the present investigation to complete the data base and prevent duplications of effort within the present statement of work.

Preparation of Preliminary and Final Reports

Radian will prepare a draft report documenting all the findings from this study. A first draft report will be submitted to USAFOEHL and their comments incorporated prior to submittal of a second draft report. A final report will then be published after incorporating the second draft comments. Report distribution will be specified by USAFOEHL per the statement of work.

As part of the reporting task the following items will be provided as separate documents and/or included into the main report:

- Qualitative risk assessment;
- Finding of no significant impact;
- Preliminary alternative remedial actions;
- Data quality objectives;
- Informal technical informative report;

- Work plan and QAPP for next effort; and
- Cost estimate for next effort.

5.2.3 Feasibility Study Tasks

The purpose of this feasibility study is to select preliminary alternative remedial action for the various sites at Carswell AFB. This objective will be accomplished through the following general elements:

- Identify general response actions;
- Identify of remedial technologies and alternatives;
- Initial screening of technologies and alternatives; and
- Develop remedial alternatives for remaining technologies.

5.2.3.1 Identification of General Response Actions

Radian will identify general alternatives that address all significant site problems and pathways of contamination identified for the study sites at the base during the remedial investigation. Based on site information from the remedial investigation, Radian will identify general response actions, or classes of response without necessarily identifying specific technologies. General response actions considered will include the "no action" alternative as a baseline against which other measures can be measured. Examples of general response actions include the following:

- No Action
- Containment
- Pumping
- Collection
- Complete Removal
- Partial Removal
- On-site Treatment
- In-situ Treatment
- Storage

- On-site Disposal
- Off-site Disposal
- Other Off-site Measures

5.2.3.2 Identification and Screening of Remedial Technologies

A list of potential remediation technologies for both on-site and off-site remedies will be developed for the general response actions noted above. The list of technologies will then be narrowed through an initial screening process based on known site conditions, waste characteristics, and technical requirements. Those technologies which are difficult to implement; require unreasonable time periods, or rely on unproven methods will be eliminated. Special consideration will be given to technologies that permanently contain, immobilize, destroy, or recycle contaminants, and technologies that promote energy recovery.

Waste characteristics that limit the effectiveness or feasibility of the remedial technologies will also be identified in this process. Such characteristics include: 1) physical properties such as volatility, solubility, and density; 2) specific chemical constituents such as chlorinated organic chemicals or metals; and 3) properties that determine the waste's toxicity or degree of hazard, such as persistence, acute toxicity, and ignitability. Technologies clearly limited by waste characteristics should be eliminated from consideration.

Radian will refer to the EPA "Handbook for Remedial Action at Waste Disposal Sites" (June 1982) for a more comprehensive description of technologies. During technology screening, the use of this list will help ensure that all remedial technologies are considered.

5.2.3.3 Development of Alternatives

During this task, the potential technologies for each of the general response actions will be developed and compiled into comprehensive, site-

specific remediation alternatives. Emphasis will be placed on long-term mitigation potential and protection of public health and the surrounding sensitive biological areas. The development of alternatives will be consistent with EPA guidance in Section 300.68 of the National Contingency Plan and the requirements of other federal and state regulations.

In developing remedial alternatives, Radian will rely on acceptable engineering practice to determine which of the screened technologies appear most suitable for the site. Consideration will be given to recycle, reuse, waste minimization, destruction, or other advanced, innovative, or alternative technologies, if appropriate. Radian will document the reasons for excluding technologies that passed the technology screening. But, as part of this study, at least one alternative for each of the following will be evaluated:

- Alternatives for treatment or disposal at an off-site facility approved by EPA (including Resource Conservation Recovery Act (RCRA), Toxic Substance Control Act (TSCA), Clean Water Act (CWA), Clean Air Act (CAA), Marine Protection, Research and Sanctuaries Act (MPRSA), and Safe Drinking Water Act (SDWA) approved facilities), as appropriate.

- Alternatives which attain applicable or relevant and appropriate Federal public health or environmental standards.

- As appropriate, alternatives which exceed applicable or relevant and appropriate public health or environmental standards;

- Alternatives which do not attain applicable or relevant and appropriate public health or environmental standards but will reduce the likelihood of present or future threat from the hazardous substances. This will include an alternative which closely approaches the level of protection provided by the applicable or relevant standards and meets CERCLA's objective

of adequately protecting public health, welfare, and environment.

- A no action alternative.

As part of the feasibility study, alternate contaminant levels (ACL's) of potential contaminants may be proposed. An ACL may be established for any contaminant upon a determination that the ACL will not be a substantial hazard to human health or the environment as long as the ACL is not exceeded. The ACL's will be based on a demonstration that there is a lack of exposure or that levels of exposure are adequate to protect human health. In establishing ACL's, Radian will consider isolation, attenuation, degradation, and dilution of the contaminants before they reach possible receptors.

5.2.3.4 Screening of Alternatives

Screening of the alternatives identified above will be undertaken. The objective of this screening will be to eliminate any alternatives that are clearly not feasible, appropriate, or competitive with other alternatives because of environmental considerations, engineering considerations, or cost. The following paragraphs provide a brief discussion of three factors that will be considered during the screening of alternatives.

Environmental Effects and Environmental Protection -- The potential for adverse environmental or public health impacts during implementation or during the service life will be evaluated for each alternative. Factors considered under this subtask will be the following: 1) comparison of expected rates of release of contaminants and exposure levels; 2) minimizing the disruption of habitat; 3) aesthetic considerations; and 4) public acceptance and institutional and legal issues. Alternatives which have significantly greater risks or environmental impacts than other alternatives will be eliminated.

Implementation and Reliability -- Alternatives will be reviewed to determine the ease of implementation and the proven reliability of the technologies. Alternatives that rely on technologies which are unproven, are unduly complex, require unreasonable time periods, institutional and legal requirements, or are prone to construction or operational error will be considered for elimination.

5.2.3.5 Technical Evaluation of Alternatives

For all past hazardous waste disposal and spill sites investigated at Carswell AFB, Texas, except those where a FONSI is applicable, the data and conclusions obtained from the hydrogeological survey, site characterization, and qualitative risk assessment will be used to technically evaluate the preferred alternative remedial actions.

Remedial alternatives will be developed based upon the technologies remaining after the initial screening. Alternatives developed will include the five following categories:

1) Alternatives for off-site treatment or disposal;
2) Alternatives that attain ARARs;
3) Alternatives that exceed ARARs
4) Alternatives that do not attain ARARs; and
5) No action.

Further, alternatives outside of these categories may also be developed, such as non-cleanup alternatives (e.g., alternative water supply, relocation, etc).

If applicable, the technologies will be grouped into operable units (OUs). An operable unit is a discrete part of the entire response action that decreases a release, threat of release, or pathway of exposure.

Documentation of the remedial alternative development process, including the decision rationale, along with the finalized list of preliminary remedial alternatives will be included in the final report.

5.2.3.6 Institutional Requirements Evaluation

The institutional factors associated with each alternative will be defined and the requirements of each identified. These include identifying applicable regulatory requirements, permits needed and participating agency cooperation. In addition, potential for public acceptance of each alternative will be estimated.

5.2.3.7 Exposure Assessment

Each alternative will be qualitatively assessed in terms of its ability to minimize public exposure to residual contamination both during and after completion of the remedial action. Estimates of residual contamination and further reduction over time will be made for each alternative and compared to the no action alternative. Short-term exposure mechanisms will also be identified. Where appropriate, reductions in impact will be determined by comparing residual levels to existing criteria, standards or guidelines.

5.2.3.8 Environmental Impact Evaluation

The environmental impacts of each of the alternative remedial actions will be assessed. This will provide information on impacts and measures to mitigate these impacts for each of the alternatives. Both short-term implementation impacts and long-term impacts will be considered. An evaluation of beneficial impacts will also be included.

5.2.3.9 Cost Analysis of Selected Alternatives

Cost as a screening factor will only be used to differentiate technologies which provide similar results. At this stage in the development of

the remedial alternatives, the engineering design of alternatives is quite general, so cost estimates will be approximations. Such approximations will be developed on a consistent basis, however, so that comparisons of these costs will be useful in comparing the cost-effectiveness of alternatives. A technology which will result in the destruction or reduction of a waste's mobility, toxicity and volume (MTU), although it may have a high capital cost, should not be eliminated. Alternatives which are more expensive than other alternatives without significant compensating advantages will be eliminated.

5.3 Site-Specific Discussion

The following will describe the specific work elements for each site or operable unit to be conducted during this investigation per the statement of work. Also a brief discussion of the rationale for the work activities will be provided.

5.3.1 Field Investigation

Site 1, Landfill 1

Results of Stage 1 groundwater sampling and analysis at Landfill 1 are somewhat conflicting, but do suggest that groundwater contamination may be present. The physical setting of the landfill, including the occurrence of groundwater and the thickness and character of upper zone deposits, appears to be adequately characterized. It is also recognized that the landfill is adjacent to the Trinity River, which would be the immediate receptor for any contamination that migrated off-base. Accordingly, the following Stage 2 work will be performed:

- Install two upper zone monitoring wells.

- Conduct two rounds of sampling at the four existing and two new upper zone monitoring wells in order to determine if contamination exists in the groundwater. Samples will be analyzed for general water quality parameters, purgeable organics, heavy metals, and oil and grease.

- Perform two single well aquifer tests (slug tests) on selected upper zone wells in order to determine the physical characteristics (e.g., transmissivity) of the upper zone.

Site 3, Landfill 3

The geophysical surveys performed during Stage 1 at the landfill suggest that soil or groundwater contamination may be present in the upper zone. In addition, hydrogeologic investigations conducted at AF Plant 4 have revealed significant levels of contamination in the upper zone on the east side of that facility, bordering the active runway in the area north of Landfill 3. Results of drilling have also shown that the Goodland/Walnut aquitard may be thin or absent on the east side of AF Plant 4, suggesting an increased possibility of degradation of water quality in the Paluxy aquifer. However, analyses of Paluxy aquifer groundwater from wells at the southeast corner of AP Plant 4 have not revealed contamination. Based on these observations, the following work will be performed:

- Install three upper zone monitor wells at the site. The wells will be located southeast, northwest and northeast of the inferred site boundaries, flanking the active runway.

- Install two upper zone monitor wells west of the landfill, adjacent to the drainageway (Farmers Branch) leading from AF Plant 4.

- Install one well (optional) into the upper Paluxy aquifer at a location west of the landfill site (between the landfill and the drainage coming from AF Plant 4).

- Conduct two rounds of sampling at these six wells and analyze for general water quality parameters, metals, oil and grease, phenols, organochlorine pesticides, and purgeable organic compounds.

Site 4, Landfill 4

Results of Stage 1 water quality analyses indicated that the upper zone groundwater is contaminated with halogenated organic compounds east of the landfill. The degree of TCE (trichloroethylene) contamination far exceeds the federal guidelines for TCE in drinking water. A variety of other halogenated compounds are present in lower concentrations, but still in excess of federal guidelines. The downgradient limits of the contaminated groundwater are not presently defined. The following additional activities will be conducted:

- Install three upper zone monitor wells east and north of the landfill. These wells will be located on the golf course so that at least one well monitors conditions directly north of the landfill at White Settlement Road, and other wells monitor conditions at greater distances east of the landfill.

- Perform five single well aquifer tests (slug tests) on selected upper zone wells in order to determine the physical characteristics (e.g., transmissivity) of the upper zone.

- Sample groundwater in two rounds from the existing Paluxy well (P2) and both new and existing upper zone wells. The samples will be analyzed for general water quality parameters, metals, and purgeable organic compounds.

Site 5, Landfill 5

Results of water quality analyses indicate that the upper zone groundwater is contaminated with halogenated organic compounds both upgradient and downgradient of the landfill. The degree of TCE contamination far exceeds the federal guidelines for TCE in drinking water. A variety of other halogenated compounds are present in lesser concentrations. The upgradient and downgradient limits of the contaminated groundwater are not presently defined. The stream north of the landfill, as well as monitor well 5B, also shows evidence of contamination with vinyl chloride. The following work will be performed:

- Install five upper zone monitor wells east, west, and south of the landfill. Three wells will be located on the golf course east of the landfill in order to define water quality conditions downgradient of the site. Two wells will be installed west of the landfill in order to define hydraulic and water quality conditions closer to the taxiway.

- Perform five single well aquifer tests (slug tests) on selected upper zone wells in order to determine the physical characteristics (e.g., transmissivity) of the upper zone in order to support eventual design of remedial actions.

- Sample groundwater in two rounds from the existing Paluxy well (P1) and from both new and existing upper zone wells. The samples will be analyzed for genreal water quality parameters, metals, and organic compounds.

Site 10, Waste Burial Area

Considering that the Waste Burial Area (Site 10) is very close to both Landfills 5 and 4 (Sites 5 and 4) and recognizing that there are few hydrogeologic distinctions between Sites 10 and 5, the follow-on activities at

Landfill 5 incorporate work that would be appropriate for Site 10. However, since Site 10 is identified as a waste burial area, rather than a landfill, it is also appropriate to perform direct waste/soil sampling within Site 10. Three borings will be taken within the site, with analyses for:

- Oil and grease;
- Petroleum hydrocarbons;
- Metals;
- Organochlorine pesticides and PCBs;
- Volatile and semivolatile organic; and
- Chlorinated Phenoxy Herbicides.

These borings will be preceded by a magnetometer survey, in order to preclude drilling directly into a buried drum. Exact location of these borings will be selected on the basis of the geophysics.

Site 11, Fire Training Area 1

Results of the Stage 1 investigation have shown that very low levels of organic compounds are present in the upper zone groundwater. Therefore, no additional wells are recommended for this site. However, the discovery of TCE in soils suggests that continued groundwater monitoring is warranted. Follow-on investigations will include two rounds of sampling and analysis of the two existing wells for general water quality parameters, metals, petroleum hydrocarbons, pesticides and volatile organic compounds.

Site 12, Fire Training Area 2

Results of soil and water quality analyses indicate that the upper zone is contaminated with halogenated and aromatic organic compounds. The degree of contamination, particularly in soil downgradient and at the center of the site, is significant enough to warrant additional monitoring and analysis. In addition, levels of TCE in groundwater downgradient of the site exceed the federal guidelines established for TCE in drinking water. A

variety of other halogenated compounds are present in lower, but excessive concentrations. The downgradient limits of the contaminated groundwater are not presently defined. The intermittent drainage that flows to the north from the site also shows evidence of contamination. The following additional characterization will be performed

- Install two upper zone groundwater monitor wells north and east of the site in order to determine the downgradient water quality conditions. These wells will be located in the vicinity of the intersection of White Settlement Road and Coody Drive and near the western boundary of Landfill 4.

- Conduct a series of five soil borings within the fire training area in order to assess near-surface soil conditions. Analyze samples recovered for:

  - Petroleum hydrocarbons;
  - Metals;
  - Volatile and semivolatile organic compounds; and
  - Soil moisture content.

- Conduct two rounds of sampling and analysis of groundwater from new and existing monitor wells. The parameters for analysis will include general water quality parameters, metals, volatile organics, petroleum hydrocarbons, and oil and grease.

- Perform three single well aquifer tests (slug tests) on selected upper zone wells in order to determine the physical characteristics (e.g., transmissivity) of the upper zone.

Site 13, Flightline Drainage Ditch

Phase II (Stage 1) data gathered at the Flightline Drainage Ditch confirmed that soils were affected by runoff from the flightline. Groundwater

conditions directly under the site are not known, although monitor wells proposed at Site 17 would detect downgradient movement of any contamination. Otherwise the soils data were considered sufficient for development of corrective actions. Since that time, the ditch has been cleaned and the waste treatment facilities redesigned and upgraded. The only remaining issue at the Flightline Drainage Ditch is the degree of residual contamination, if any. Therefore, a very limited program will be conducted. Soil or sediment samples will be collected at five locations in the bottom of the ditch to verify that cleanup has occurred. Samples recovered will be analyzed for petroleum hydrocarbons, metals, and volatile and semivolatile organic compounds.

Site 15, Entomology Dry Well

Results of drilling and analysis of samples collected from three upper zone monitor wells do not reveal contamination at the site. However, because the dry well was not located, the degree of soil contamination, if any, in the former location of the Entomology Building is not known. The following activities will be performed:

- Three hand augers will be drilled at the location of the former Entomology Building. Samples of soil will be analyzed for pesticides and herbicides.

- Water levels at the existing upper zone monitor wells will continue to be measured in order to define the direction of groundwater flow and provide groundwater flow information for the investigation at Site 16.

Site 16, Unnamed Stream

Field activities at Site 16 have documented the presence of organic contamination in upper zone groundwater west of the inferred location of the french drain. In addition, elevated levels of metals and some organic compounds have also been discovered at the Unnamed Stream. These conclusions are

based on a one-time sampling event; monitor wells were not installed as part of the Stage 1 actions. Therefore, the areal limits of contamination, as well as groundwater flow patterns, are not known in enough detail to proceed with design of corrective measures. Further, the results of the one-time sampling event are not sufficient to warrant immediate consideration of remedial actions.

The following activities will be performed at the Unnamed Stream:

- Resample the stream at four locations in two separate events.
- The samples will be analyzed for general water quality parameters, petroleum hydrocarbons, and purgeable organic compounds.

Site 17, POL Tank Farm

The POL Tank Farm currently consists of four large, above-ground fuel storage tanks. Recently, the tank farm area has been enclosed with concrete-lined spill retention basins. It is likely that any future activities at the site will not affect the subsurface environment, since permanent drainage and surface sealing have been installed. However, the issue of past occurrences of subsurface hydrocarbons must be addressed.

As reported in the Phase I document, fuels were discovered in the ground in this area during the 1960s. Samples of groundwater collected from Phase II (Stage 1) borings placed in the vicinity of the POL Tank Farm showed that the upper zone was contaminated with organic compounds. Because the borings were grouted upon completion, no additional data are available.

In order to determine the current conditions at the site and assess the likely environmental impacts of past releases, it will be necessary to perform additional site exploration. This exploration can be done in

conjunction with the previously recommended site definition activities. The actions to be performed at Site 17 are:

- Conduct a soil gas survey of the complete area surrounding the tank farm as it is presently configured to identify current extent of subsurface hydrocarbon vapors. This survey will not only show extent, but also aid in proper placement of the monitoring wells discussed below.

- Install five upper zone groundwater monitoring wells near the POL Tank Farm in order to assess the degree of groundwater contamination. The first three wells will be installed and water level measurements taken in order to identify current groundwater flow directions. The five wells will be installed with long screens extending above the water table to intercept floating hydrocarbon product (if any).

- Conduct two rounds of groundwater sampling, and analyze for general water quality parameters, petroleum hydrocarbons, metals, and purgeable organic compounds.

- Perform three single well aquifer tests (slug tests) on selected upper zone wells in order to determine the transmissivity of the upper zone.

Weapons Storage Area

Field activities in the Stage 1 investigation consisted of shallow soil sampling which revealed low levels of TCE in soil. The Stage 2 investigation will consist of the following activities:

- Eight hand augers will be drilled in and around the drainage ditch west of the Inspection Shop.

- Soil samples will be analyzed for metals, volatile and semivolatile organic compounds, and moisture content.

Base Service Station

The Phase II (Stage 1) investigation did not include any field activities at the Base Service Station. Therefore, the Base Service Station area will have the following Stage 2 activities:

- A soil gas survey will be performed of the BSS site as well as the property east (toward Trinity River) of the site to identify the current extent of subsurface hydrocarbon vapors (if any). This survey will not only show extent, but will also aid improper placement of the monitoring wells discussed below.

- Install four upper zone groundwater monitoring wells to assess the degree of groundwater contamination.

- Conduct two rounds of ground sampling and analyze for metals, petroleum hydrocarbons, and purgeable organic compounds.

5.3.2 Evaluation of Alternatives

No site-specific alternatives have been identified for evaluation during this investigation. Alternatives will be identified as discussed in Section 5.2.3 Feasibility Studies.

6.0 REPORTING REQUIREMENTS

6.1 Monthly Research and Development (R&D) Status Report

Each month a project status report will be provided to USAFOEHL. The report will include all appropriate data required as delineated in the Statement of Work and USAFOEHL Handbook. Field and laboratory results along with QA/QC data will be incorporated into the next monthly R&D status report as they become available and after internal QA/QC checks have been accomplished.

6.2 Informal Technical Information Report (ITIR)

Upon completing all chemical analyses, the results will be tabulated, and compiled into an informal report. The ITIR will contain the laboratory test results, QA/QC data, a discussion of analytical methods and holding times, and chain-of-custody documents. This report will be provided to USAFOEHL.

6.3 RI/FS Reports

A final report will be prepared delineating all findings from the Stage 2 investigation. The reports to be submitted will reflect an integrated IRP approach with elements of the RI/FS. All reports will be submitted per the Statement of Work. The final report will also include a detailed discussion of the recommended alternative remedial and a description of the work proposed, including the Data Quality Objectives, for any follow-on RI/FS work.

RADIAN CORPORATION

7.0 SCHEDULE

The schedule for the IRP Phase II Stage 2 activities at Carswell AFB is provided on Table 7-1. This schedule is based on the proposed revision of the current Statement of Work. A final field schedule and milestone will be completed upon receipt of final approval of the work plan from USAFOEHL.

TABLE 7-1. SCHEDULE FOR CARSWELL AFB IRP PHASE II STAGE 2 ACTIVITES

Activity	Estimated Completion or Start Date
Notice to proceed	25 Sep 87
Final Health & Safety Plan	29 Oct 87
Draft Work Plan	13 Nov 87
Final Quality Assurance Project Plan	20 Nov 87
Literature Search	14 Dec 87
Final (Plans) Submission	20 Jan 88
Field Effort Begins	14 Dec 87
Soil Gas Surveying	14 Dec 87
Borehole and Monitor Well Drilling Begins	25 Jan 88
Borehole and Monitor Well Drilling Ends	26 Feb 88
Surveying	23 Mar 88
Aquifer Testing	29 Feb 88
Sampling Begins	1 Feb 88
Sampling Ends	15 Apr 88
Sampling Analytical Data completed	1 Jun 88
Field Effort Ends	15 Apr 88
Reporting Activities	15 Apr 88
Informal Technical Information Report	18 Jul 88
Technical Report (Draft)	15 Aug 88
Qualitative Risk Assessment	15 Aug 88
Finding of No Significant Impact (FONSI)	15 Aug 88
Preliminary Remedial Actions	15 Aug 88
Work Plan IRP Stage 3	15 Dec 88
QAPP Stage 3	15 Dec 88
Technical Report (Final)	15 Dec 88
Cost Letter for Proposed Stage 3 Activities	15 Dec 88

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