DRAFT WORK PLAN FOR REMEDIAL INVESTIGATION FEASIBILITY STUDY NAS FORT WORTH TX

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NAVAL AIR STATION FORT WORTH JRB CARSWELL FIELD TEXAS

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INSTALLATION RESTORATION PROGRAM (IRP)
REMEDIAL INVESTIGATION / FEASIBILITY STUDY

WORK PLAN

Carswell Air Force Base, Fort Worth, Texas

Law Environmental, Inc.
Kennesaw, Georgia 30144

June 1993

Draft

PREPARED FOR

7TH SUPPORT GROUP
7TH CIVIL ENGINEERING SQUADRON
ENVIRONMENTAL MANAGEMENT FLIGHT
CARSWELL AIR FORCE BASE, TEXAS 76127

UNITED STATES AIR FORCE
HUMAN SYSTEMS DIVISION (AFSC)
AIR FORCE CENTER FOR ENVIRONMENTAL
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LAW
ENGINEERING AND ENVIRONMENTAL SERVICES

148002

June 25, 1993

Air Force Center for Environmental Excellence
AFCEE/ESB
Building 624 West
Brooks Air Force Base, TX 78235-5328

Attention: Chris Hobbins (Team Chief)

Subject: Carswell Air Force Base
Draft Work Plan
Contract No. F33615-90-D-4008
Delivery Order No. 0011
Law Project No. 11-3517-0111

Dear Mr. Hobbins:

Law Environmental, Inc., Government Services Division is pleased to submit the enclosed eight (8) copies of the Draft Work Plan to the Air Force Center for Environmental Excellence (AFCEE) for review and comment.

If you have questions or comments, please contact us at (404) 499-6800.

Sincerely,

John O'Brien
Project Manager

Winifred H. Curley, Ph.D.
Principal

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3517-0111.02

INSTALLATION RESTORATION PROGRAM (IRP)
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
DRAFT WORK PLAN
FOR
CARSWELL AFB
FORT WORTH, TEXAS 76127-5000

JUNE 1993

Prepared by:

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CONTRACTOR CONTRACT NO. F33615-90-D-4008 DELIVERY ORDER NO. 0011

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LAW ENVIRONMENTAL INC., (LAW), WILL, INITIALLY, CONDUCT A REMEDIAL INVESTIGATION/FEASIBILITY STUDY AT TWO SITES AT CARSWELL AIR FORCE BASE, TEXAS, UNDER THE AIR FORCE INSTALLATION RESTORATION PROGRAM (IRP). THE PROJECT FOLLOWS THE REQUIREMENTS OF IRP, AND THE WORK DESCRIBED IN THIS WORK PLAN (WP) IS DESIGNED TO CHARACTERIZE ENVIRONMENTAL CONDITIONS AND QUANTITATIVELY ESTIMATE THE RISK TO HUMAN HEALTH AND THE ENVIRONMENT AT THE TWO SITES AND TO ENSURE SUBSEQUENT REMEDIAL DESIGN AND REMEDIAL ACTION CONSISTENT WITH THE OBJECTIVES OF THE BASE REALIGNMENT AND CLOSURE (BRAC) PROGRAM. THE TWO SITES TO BE INVESTIGATED ARE THE UNNAMED STREAM (SD-13) AND THE POL TANK FARM (ST-14).

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WORK PLAN
DISCLAIMER NOTICE

This Work Plan has been prepared for the United States Air Force by Law Environmental, Inc. for the purpose of aiding in the implementation of a final remedial action plan under the Air Force Installation Restoration Program (IRP). As the report relates to actual or possible releases of potentially hazardous substances, its release prior to an Air Force final decision on remedial action may be in the public's interest. The limited objectives of this Work Plan and the ongoing nature of the IRP, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this Work Plan, since subsequent facts may become known which may make this Work Plan premature or inaccurate. Acceptance of this Work Plan in performance of the contract under which it is prepared does not mean that the United States Air Force adopts the conclusions, recommendations or other views expressed herein. which are those of the contractor only and do not necessarily reflect the official position of the United States Air Force.

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5285 Port Royal Road
Springfield, VA 22161

PURPOSE OF DOCUMENT

This Work Plan is for use for the Remedial Investigation/ Feasibility Study (RI/FS) activities at Carsewll Air Force Base (Carswell AFB). Procedures outlined in this plan are designed to describe the work to be performed, explain the project objectives, and present the rationale for conducting specific project activities. The plan will be effective upon final approval by the Air Force Center For Environmental Excellence (AFCEE).

Every effort will be made to fully comply with this plan. The success of Carswell AFB's Installation Restoration Program depends on team effort and total dedication from the various parties involved. Therefore, efforts will be focused on achieving and maintaining compliance with this Work Plan and pertinent regulations.

The point of contact for this investigation is as follows:

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PREFACE

Law Environmental, Inc. (Law) was contracted by the U.S. Air Force Center For Environmental Excellence (AFCEE) to perform a Remedial Investigation/Feasibility Study (RI/FS) at two (2) sites at Carswell AFB, Texas. The two sites to be investigated include: Unnamed Stream (SD-13) and POL Tank Farm (ST-14). The primary objectives of this field investigation are to: 1)investigate the extent of soil and ground water contamination at each site; 2) assess the overall environmental status of the sites; and 3) evaluate the appropriate remedial action for contaminated sites. these objectives will be achieved through the use of the following methods of investigation: geophysical and geochemical surveys; stratigraphic borings and hand auger borings; monitoring wells; soil and ground-water sampling for field screening and laboratory analyses; and surface water and sediment sampling for laboratory analysis. This Work Plan summarizes the history of the IRP at Carswell AFB with respect to the two sites and outlines the project and methodology of the RI/FS.

Mr. John O'Brien is the Project Manager for the RI/FS. Members of the field team will be selected prior to commencement of field activities.

This Work Plan was prepared by Mr. Bill Olsen and reviewed by Mr. Jim Beaver and Dr. Winifred Curley. The efforts of Mr. Chris Hobbins (Technical Project Manager) from AFCEE and personnel at Carswell AFB are greatly appreciated.

John F. O'Brien
Project Manager

Winifred H. Curley, Ph.D.
Principal

Louis S. Karably, P.E.
Program Manager

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF TABLES

LIST OF ACRONYMS

AB	Ambient Condition Blank
ABB-ENV	ABB Environmental Services, Inc.
AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
ARAR	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
CA	Corrective Action
CCAS	Coast-to-Coast Analytical Services
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (PL-96-510) - SUPERFUND
CES	Civil Engineering Squadron
CEO	Chief Executive Officer
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
DC	Drill Cuttings
DOT	Department of Transportation
DQCR	Daily Quality Control Report
DQO	Data Quality Objectives
EB	Equipment Blank (Rinsate)
EMSL	Environmental Monitoring Systems Laboratory
FS	Feasibility Study
FSP	Field Sampling Plan
GC/MS	Gas Chromatography/Mass Spectrometry
GFAA	Graphite Furnace Atomic Absorption
HNu	Photoionization Detector (trade name)
ID	Sample Identification
ICP	Inductively Coupled Plasma
IRP	Installation Restoration Program
IRPIMS	Installation Restoration Program Information Management System
ITIR	Informal Technical Information Report
Law	Law Environmental, Inc., Government Services Division
LENL	Law Environmental National Laboratories

LIST OF ACRONYMS
(Continued)

LCS	Laboratory Control Standards
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
MITRE	MITRE Corporation
MQL	Method Quantitation Limit
MQC	Method Quantitation Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MW	Monitoring Well
NCP	National Contingency Plan
NTU	Nephelometric Turbidity Unit
OSWER	Office of Solid Waste and Emergency Response
PA	Preliminary Assessment
PARCC	Precision Accuracy Representativeness Completeness Comparability
PE	Professional Engineer
POC	Point of Contact
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAMS	Quality Assurance Management Staff
QCCS	Quality Control Check Samples
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RLS	Registered Land Surveyors
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
SAP	Sampling and Analysis Plan
SB	Soil Boring
SC	Specific Conductance

LIST OF ACRONYMS
(Continued)

SD	Surface Sediment
SI	Site Investigation
SOP	Standard Operating Procedures
SPT	Standard Penetration Test
SW	Surface Water
TB	Trip Blank
TC	Team Chief
TPM	Technical Project Manager
TWC	Texas Water Commission
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

1.0 INTRODUCTION

Law Environmental, Government Services Division (LEGS), Kennesaw, Georgia has prepared this Remedial Investigation/Feasibility Study (RI/FS) Work Plan in compliance with the United States Air Force (USAF) Installation Restoration Program (IRP). This Work Plan summarizes site characterization efforts performed at Carswell Air Force Base (Carswell AFB) as part of past IRP and non-IRP efforts relating to two problem sites/areas. The sites identified for continued investigation as part of the AFCEE Scope of Work for this project are the POL Tank Farm (ST-14) and the Unnamed Stream (SD-13).

The overall intent of this investigation is to obtain additional data necessary to more fully characterize the extent of contamination at each site, and identify appropriate remedial action measures necessary to bring each of these sites into compliance with environmental regulations.

1.1 DESCRIPTION OF THE AIR FORCE IRP

The United States Air Force Installation Restoration Program is designed to identify, confirm/quantify, and remediate problems caused by past management of hazardous wastes at Air Force facilities. It is the basis for assessment and response actions on USAF installations, under the provisions of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA).

1.1.1 Brief History of the IRP Program

The Installation Restoration Program of the United States Air Force (USAF) is a Department of Defense (DOD) program for assessing and

remediating hazardous waste problems on USAF installations. The IRP is designed to comply with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), and the recent Superfund Amendments and Reauthorization Act of 1986 (SARA). The program was formally designated as the DOD Superfund program on November 21, 1981.

The current DOD IRP policy is contained in the Defense Environmental Quality Program Policy Memorandum (DEQPPM 81-5), which reissues, amplifies, and consolidates all previous directives and memoranda on the IRP. DOD policy is to identify and evaluate suspected problems associated with past hazardous material disposal sites, to control migration of hazardous contamination from Air Force facilities, and to minimize hazards to health or welfare that resulted from past operations.

The IRP takes further program definition from Executive Orders (EO):

- EO 12088, which directs the DOD to comply with substantive and procedural statutes;
- EO 12316, which delegates responsibility for response actions at DOD sites to the Secretary of Defense; and
- EO 12580, which defines responsibilities of EPA and DOD under SARA for National Priority List (NPL) and non-NPL sites.

1.1.2 Program Objectives

The objectives of the Air Force IRP are to assess past hazardous waste disposal and spill sites on Air Force installations, and to

develop remedial actions consistent with the NCP for those sites which pose a threat to human health and welfare, or to the environment.

1.1.3 Program Organization

Prior to 1988, the basic USAF IRP comprised four phases:

Phase I - Installation Assessment/Records Search. This phase identified past disposal sites that might pose a hazard to public health or the environment. It also determined those sites requiring further action, such as confirming an environmental hazard (Phase II). If a site required immediate remedial action, the program could proceed directly to Phase IV.

Phase II - Confirmation/Quantification. This phase defined and quantified the extent of contamination, waste characteristics (when required by the regulatory agency), and sites or locations where remedial actions were required. Stage 1 of Phase II was an initial assessment to determine if contamination was present at a site. Sites found to be contaminated might require further investigation in subsequent stages of Phase II to assess the extent and significance of contamination. Sites warranting immediate remedial action could be transferred to Phase IV. Research requirements identified during Phase II were included in the Phase III effort of the program.

Phase III - Technology-Based Development. This phase developed new technologies for treating pollutants which have no currently available, or economically feasible, treatment. This phase included implementation of research requirements and technology development. A Phase III requirement could be identified at any time during the program.

Phase IV - Remedial Action. This phase involved the preparation and implementation of the remedial action plan.

In 1988, the phased approach of the IRP was superseded by an approach more closely approximating the Remedial Investigation and Feasibility Study (RI/FS) format used by the USEPA. The new IRP format combines the Phase II Confirmation/Quantification study and the Phase IV, Remedial Action Planning as outlined under the older version of the IRP to efficiently arrive at appropriate remedial actions in a timely matter.

Potential sites of concern are first identified through a preliminary assessment, including a literature/records search. If a release is suspected, an initial sampling and analytical program is recommended to identify target contaminants and confirm their presence. When a preliminary assessment has been completed, either an RI/FS program is recommended to further evaluate the site, or a Technical Document to Support No Further Action (TDSNFA) is prepared.

A remedial investigation is conducted in stages to collect information on the type and extent of contamination in the environment through field sampling. The results are evaluated in terms of public health and environmental criteria. A feasibility study, in which remedial alternatives are identified and ultimately recommended for selection, is conducted concurrently with the remedial investigation so that field data needed to select a remedy are collected during the field investigation.

The RI/FS is intended to systematically:

- Identify and prioritize contamination sources with respect to hazard

- Determine the nature and extent of contamination, or conclude that no significant adverse impact exists

- Determine the pathways and risks of the identified contamination to various human and environmental receptors

- Plan and conduct field activities that will support the selection and eventual design of appropriate remedial actions

- Develop appropriate remedial alternatives

The RI/FS program involves a preliminary sampling and analysis effort leading to the development of alternatives. If necessary, a more detailed sampling and analytical effort will be conducted to delineate contamination, and quantify pathways to aid in the selection of alternatives. The RI/FS encompasses several key elements necessary to select an appropriate remedial action. These include:

- Determination of the federal and state Applicable or Relevant and Appropriate Requirements (ARARs)

- Development of the Data Quality Objectives (DQOs) consistent with the ARARs and achievable with acceptable field and analytical procedures

- Performance of a field investigation in one or more stages to collect sufficient information to assess contamination movement and pathways, and to support development of potential alternatives, described in CERCLA and NCP as the RI

- Determination of the hazards by quantitatively determining the impact on receptors through the pathways of surface water, ground water, biota, and air; incorporating the exposure and risk assessment as

required under CERCLA, NCP, and SARA, and as defined in the Superfund Public Health Evaluation Manual (SPHEM)

- Determination of those sites where the results of the field investigation and risk assessment indicate no significant threat to human health or welfare, or to the environment, and preparation of a decision document identifying any necessary control measures, or no need for further action

- Development of a set of potential alternatives, consisting of appropriate technologies that can remove the contamination or control its migration, provide a range of reduction of the mobility, toxicity, or volume (MTV) associated with the contamination, and meet or exceed the ARARs.

Initial screening of alternatives is conducted using criteria of effectiveness, implementability, and cost. If necessary, additional studies are performed to support selection of technologies. A detailed analysis is then conducted to evaluate alternatives using a set of criteria that includes protectiveness, compliance with ARARs, reduction of MTV, schedule, reliability, and capital, operation, and maintenance costs.

After a remedial alternative is selected, a Record of Decision (ROD) is created, which documents the selection based on information and recommendations contained in the IRP Remedial Investigation (RI) and Feasibility Study (FS) reports. If an engineering solution is selected, the remedial design is specified and then implemented.

1.2 HISTORY OF PAST IRP WORK AT CARSWELL AFB

The IRP is a multidisciplinary, phased approach which is functionally equivalent to the EPA's Remedial Investigation/Feasibility Study Program. The IRP was developed as a four phase program:

- Phase I - Initial Assessment/Records Search
- Phase II - Confirmation and Quantification
- Phase III - Technology Base Development
- Phase IV - Operation/Remedial Actions

1.2.1 Previous Investigative Activities and Documentation

The Phase I Records Search study was conducted to identify past waste disposal activities at Carswell AFB which may have caused environmental contamination and the migration of contaminants off of the base (CH_2M Hill, 1984). After ranking each site for potential adverse environmental effects, further investigation was recommended for eleven sites on the base and the Weapons Storage Area west of the base.

The twelve sites were investigated in the Phase II Stage 1 confirmation and quantification study (Radian, 1986). These sites include landfills, fire department training areas, industrial areas, and spills. The on-base sites were concentrated in two areas, the Flightline Area and the East Area (Figure 1-1). The Phase II Stage 1 investigation was intended to determine the effect of past waste disposal activities at Carswell, including the magnitude and extent of contamination and its potential for further migration.

A Phase II Stage 2 Remedial Investigation was conducted to further detail the extent of existing contamination in the East Area

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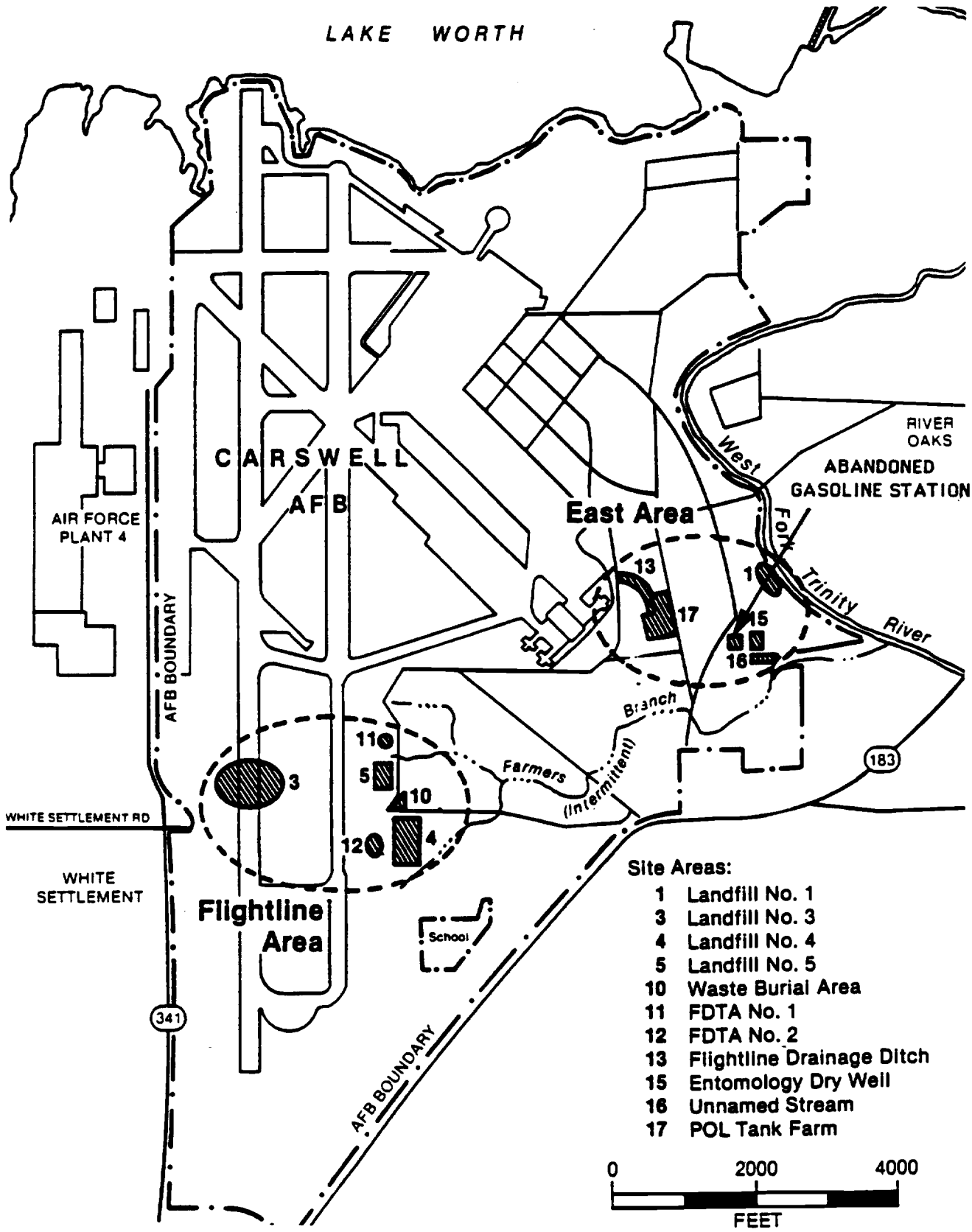
FIGURE 1-1

LOCATION OF PHASE II, STAGE 1 SITES

(AFTER RADIAN, 1986)

CARSWELL AIR FORCE BASE, TEXAS



(Radian, 1991a). This study focused on the hydrogeology and ground water quality at Landfill 1, Unnamed Stream, POL Tank Farm, and the Base Service Station.

Data from Radian's 1991 Remedial Investigation were used in the selection of alternatives in a Feasibility Study conducted for twenty-two sites suspected of containing hazardous waste. Sites classed in Category II (requiring additional monitoring or work to assess the extent of current or future contamination) included the POL Tank Farm and the Unnamed Stream (Radian, 1991b).

A non-IRP investigation was conducted prior to construction at Building 1337-White House Communication, to determine if pesticide contamination posed an environmental concern (Maxim, 1991). No significant pesticide contamination was detected in the soil or ground water at that time.

In 1991, the U.S. Army Corps of Engineers prepared a work plan for a RCRA Facility Assessment of SWMU No. 64 (French Underdrain System) and SWMU No. 67 (Bldg. 1340 - Oil-Water Separator). The tasks proposed in this work plan have yet to be implemented.

1.2.2. Existing Remedial Actions

Currently, there is a pilot test being conducted on-site at the POL Tank Farm site to test the effectiveness of bioventing on the petroleum-impacted soil. The test is currently on-going and is being conducted by Engineering Science and is expected to last one year in duration. (ES, 1993).

1.3 DESCRIPTION OF CURRENT STUDY

1.3.1 Project Objectives

The objective of this study is to conduct an RI/FS at two sites to identify and recommend appropriate remedial responses. This will involve the following site-specific approaches:

(1) Unnamed Stream

- Determine the types, quantities, and sources of contamination within the area of concern
- Determine the lateral and vertical extent of contamination

(2) POL Tank Farm ST-14

- Delineate the extent of ground-water contamination

1.3.2 Scoping Documents

Documents being prepared for this effort include:

- Work Plan
- Sampling and Analysis Plan (QAPP and FSP)
- Health and Safety Plan

1.3.2.1 Work Plan - Preparation of the Work Plan for the RI effort has been based on findings and recommendations in part from past investigations and also from observations of potential environmental concerns at Carswell AFB. The Work Plan details recommendations and the decision rationale for conducting field

investigations, developing and screening potential remedial responses, and determining applicable or relevant and appropriate requirements (ARARs) and Data Quality Objectives (DQOs). The format used for writing this Work Plan was provided in the Handbook to Support the Installation Restoration Program (IRP) Statements of Work for Remedial Investigation/Feasibility Studies (RI/FS), May 1991.

1.3.2.2 Sampling and Analysis Plan - A Sampling and Analysis Plan (SAP) has also been developed as a companion document to the Work Plan. The SAP consists of two parts, the Quality Assurance Project Plan (QAPP) and the Field Sampling Plan (FSP). The QAPP describes the policy, organization, functional activities, and quality assurance/quality control procedures which will be implemented in order to achieve the DQOs dictated by the intended use of the data. The FSP provides guidance for all field activities and defines, in detail, the sampling and data gathering methods to be used during the investigation.

1.3.2.3 Health and Safety Plan - A Health and Safety Plan (H&SP) has been prepared to comply with the Occupational Safety and Health Administration (OSHA) health and safety regulations regarding the work effort detailed in the Work Plan. The H&SP uses OSHA guidelines for designating the appropriate level of protection needed at the study sites.

1.3.3 Identity of Subcontractors and Their Roles

Law Environmental, Inc. Government Services Division (Law) will manage the project and provide services related to field samples, data analysis, site characterization, and reporting.

A state licensed drilling company will be subcontracted to perform

the drilling activities. Law Environmental National Laboratories (LENL) has been subcontracted to perform the chemical analysis of the soil and water samples. A surveying company, certified in the state of Texas, will survey the soil boring and sampling locations and prepare a site map. In addition, a subcontractor to be determined will perform a ground-water screening study at the POL Tank Farm (ST-14) in order to define the plume of contamination suspected to be located in association with that site. Details of project organization, personnel, and subcontractor responsibility are provided in the Quality Assurance Project Plan (QAPP).

2.0 SUMMARY OF EXISTING INFORMATION

The following discussion of the Carswell AFB environmental setting is derived primarily from the Installation Restoration Program Phase I Records Search Report (CH_2M Hill, 1984). Information from that report is supplemented by information from the literature and from the general findings of studies conducted by the U.S. Army Corps of Engineers (1991) Radian Corporation (Radian, 1986; 1991a).

2.1 CARSWELL AFB ENVIRONMENTAL SETTING

Carswell AFB is located in northeastern Texas in Tarrant County, six miles west of downtown Fort Worth (Figure 2-1). The installation 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 Plant 4 to the west.

The following information applies to the area of the base in general. Specific variations from this for the two sites being studied are presented in Section 2.2.

2.1.1 Physiography

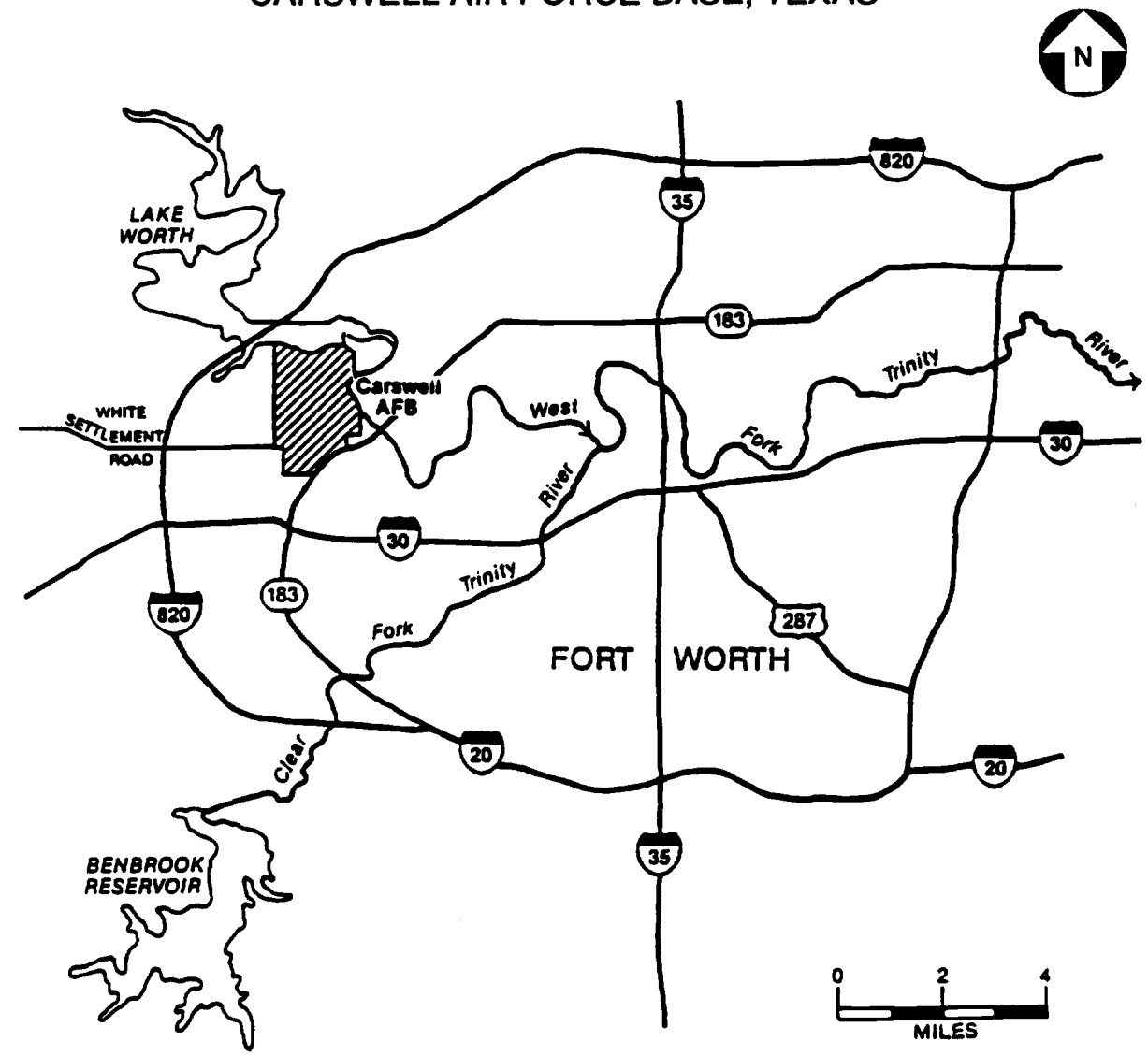
The majority of the Carswell AFB is located within the Grand Prairie section of the Central Lowlands Physiographic Province. This area is characterized by broad terraces sloping gently to the east, divided by westward-facing escarpments. The land is typically grass covered and treeless, except for isolated stands of upland timber. The northwestern portion of Carswell AFB is within the Western Cross Timbers Physiographic Province which is characterized by rolling topography and a heavy growth of post and black-jack oaks (U.S. Army Corps of Engineers, 1991).

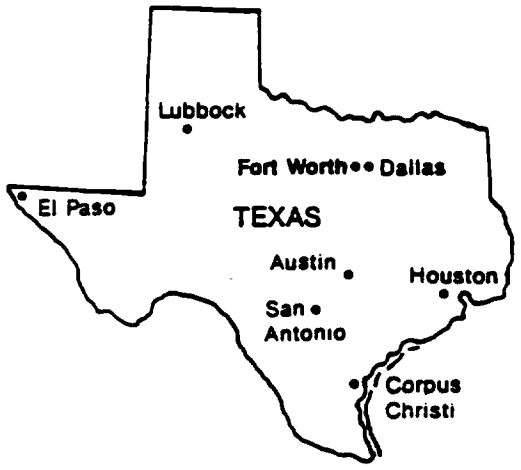
FIGURE 2-1

REGIONAL SETTING OF CARSWELL AFB

(AFTER RADIAN, 1986)

CARSWELL AIR FORCE BASE, TEXAS





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2.1.2 Geology

The following section summarizes the geological aspects of the study area which influence the environment at Carswell AFB.

2.1.2.1 Geomorphology - The topography of the installation 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 the installation range from a high of approximately 690 feet above mean sea level (msl) at the southwest corner of the installation to a low of approximately 550 feet MSL at the east side of the installation. The elevation of Lake Worth usually approximates the elevation of the dam spillway, 594 feet MSL (U.S. Army Corps of Engineers, 1991).

The principal drainage for Carswell AFB is the West Fork of the Trinity River. Farmer's Branch drains the southern portion of the installation and discharges into the Trinity. A small portion of the north end of the base drains into Lake Worth (U.S. Army Corps of Engineers, 1991).

2.1.2.2 Stratigraphy - The geology of Carswell AFB can be characterized as a blanket of Quaternary clastic units overlying Cretaceous bedrock. From youngest to oldest, the geologic units of interest are as follows:

- Quaternary Alluvium
- Cretaceous Goodland Limestone
- Cretaceous Walnut Formation
- Cretaceous Paluxy Formation
- Cretaceous Glen Rose Formation
- Cretaceous Twin Mountains Formation.

The areas where these units outcrop in the area of Carswell AFB are shown on Figure 2-2.

The majority of the installation is covered by alluvium deposited by the Trinity River. The alluvium is composed of gravel, sand, silt, and clay of variable thickness and lateral extent. The Goodland Limestone outcrops on the southern portion of the base, south of White Settlement road. The Goodland Formation is a chalky-white, fossiliferous limestone and marl. A small outcrop of the Walnut and Paluxy Formations occurs in the northwestern corner of the base along the shores of Lake Worth. The Walnut Formation is coquinoid limestone with variable quantities of clay and shale. The Paluxy Formation is primarily a fine to coarse-grained sand with minor quantities of clay, sandy clay, pyrite, lignite, and shale. Neither the Glen Rose Limestone, nor the Twin Mountains Formation outcrop at Carswell AFB (U.S. Army Corps of Engineers, 1991).

Carswell AFB is located on the relatively stable Texas shelf, west of the faulting associated with the Ouachita Structural Belt. No major faults or fracture zones have been mapped near the base. The regional dip of the rocks at Carswell AFB ranges from 35 and 40 feet per mile in an easterly to southeasterly direction. The stratigraphic and structural relationships of the shallow geologic units at Carswell AFB are illustrated in Figure 2-3. The geologic cross section extends from southwest to northeast across the southern portion of the installation (U.S. Army Corps of Engineers, 1991).

2.1.2.3 Soils - The U.S.D.A. Soil Conservation Service has identified four soil associations at Carswell AFB. The soils are described in Table 2-1 and their occurrences on the installation are shown on Figure 2-4. The surficial soils of the installation are primarily nearly level to gently sloping clayey soils of the

FIGURE 2-2

GEOLOGIC MAP

(AFTER RADIAN, 1986)

CARSWELL AIR FORCE BASE, TEXAS

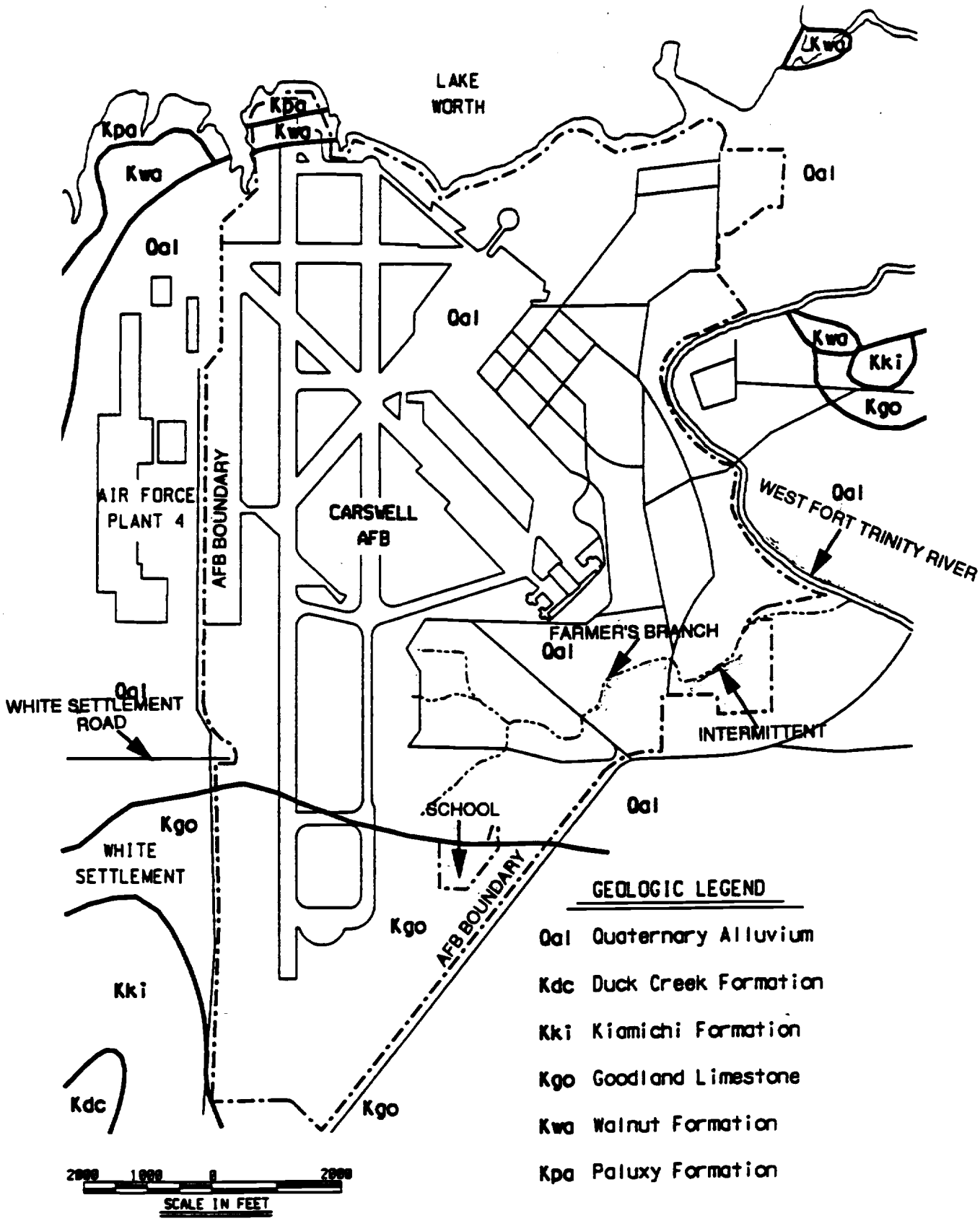

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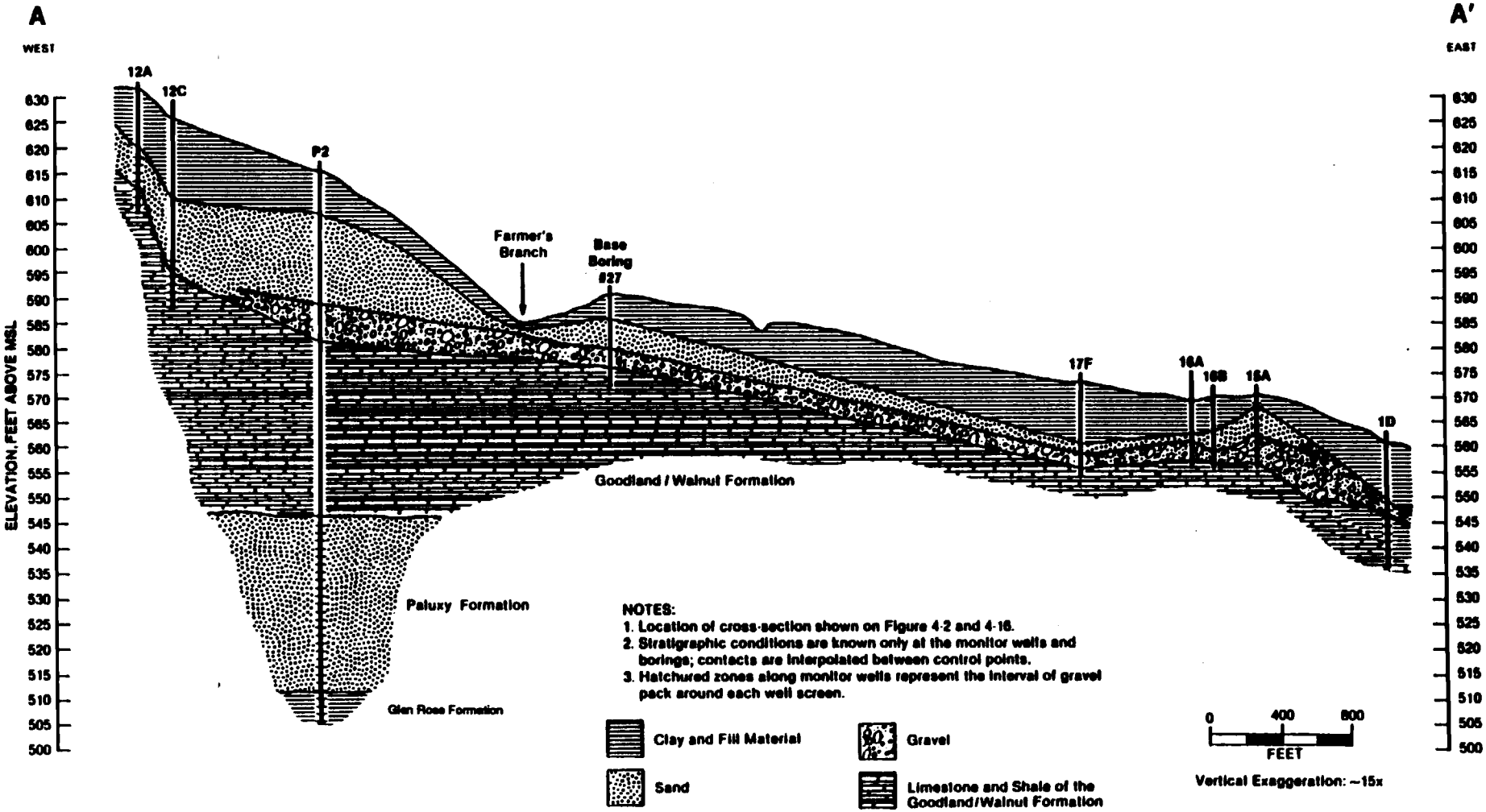
FIGURE 2-3

NE-SW GEOLOGIC CROSS-SECTION

(AFTER RADIAN, 1986)

CARSWELL AIR FORCE BASE, TEXAS



NOTE: THE TWIN MOUNTAINS AQUIFER UNDERLIES THE GLEN ROSE AQUITARD

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TABLE 2-1

SOIL CHARACTERISTICS
Carswell Air Force Base, Texas

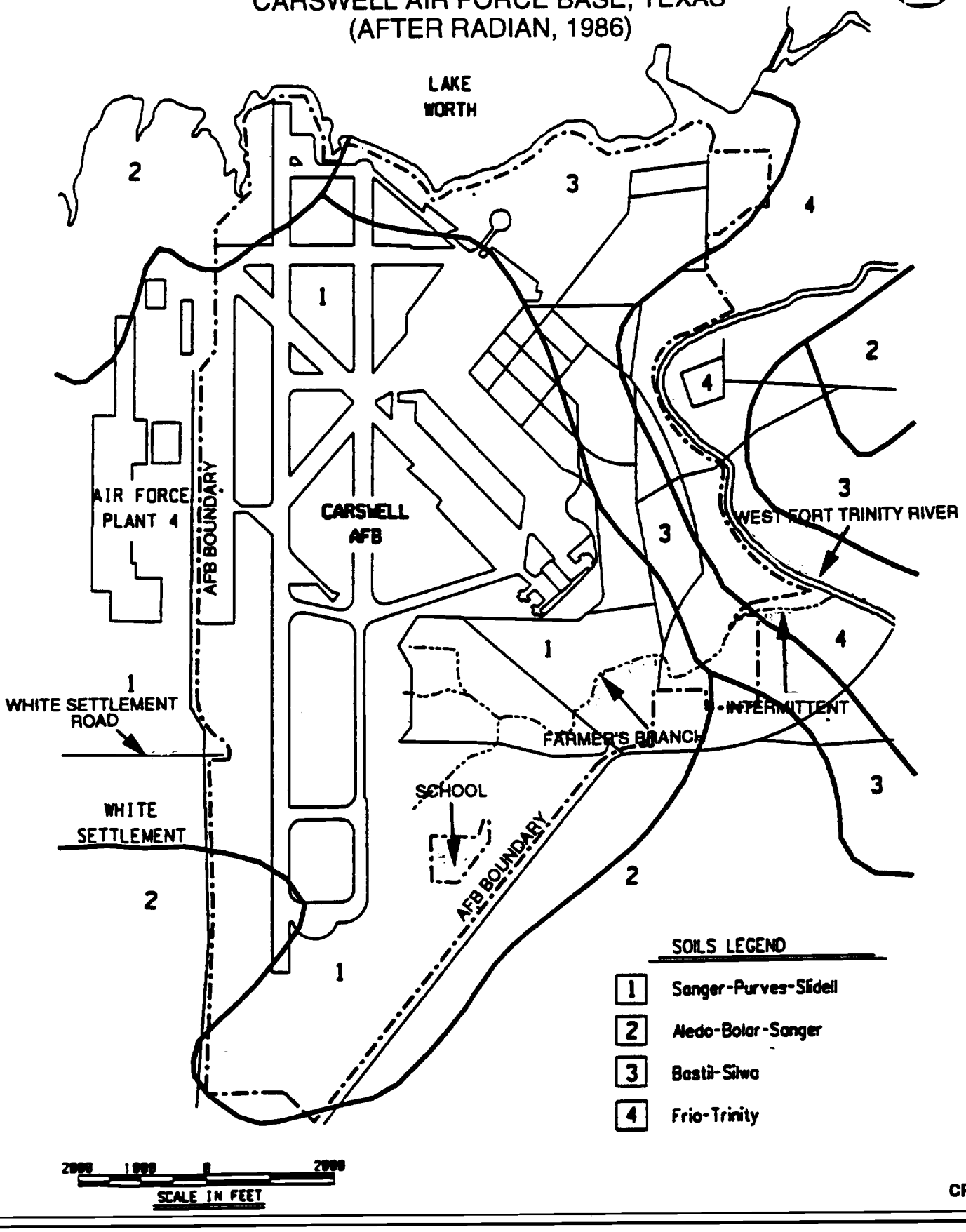
ASSOCIATION	DESCRIPTION	TEXTURE	THICKNESS	PERMEABILITY
Sanger-Purves-Slidell	Clayey soils of nearly level to gently sloping uplands	Clay loam Clay over bedrock Silty clay	8-80 inches	$<4.2 \times 10^{-5}$ to 3×10^{-4} cm/sec
Aledo-Bolar-Sanger	Loamy and clayey soils of gently sloping to moderately steep uplands	Clay loam over bedrock Clay loam	8-70 inches	$<4.2 \times 10^{-5}$ to 9×10^{-4} cm/sec
Frio-Trinity	Clayey soil on nearly level floodplains	Silty clay loam Clay	25-75 inches	$<4.2 \times 10^{-5}$ to 3×10^{-4} cm/sec
Bastil-Silawa	Loamy soils on nearly level to sloping stream terraces	Sandy clay loam	40-80 inches	9×10^{-4} to 3×10^{-3} cm/sec

Source: U.S. Dept. of Agriculture, Soil Conservation Service, 1981.

FIGURE 2-4

SOILS ASSOCIATION MAP

CARSWELL AIR FORCE BASE, TEXAS
(AFTER RADIAN, 1986)



Sanger-Purves-Slidell and Aledo-Bolar-Sanger Associations. Less widely distributed are the clayey soils of the Frio-Trinity Association and the loamy soils of the Bastil-Silawa Association occur on the floodplain and stream terraces of the West Fork of the Trinity River (U.S. Army Corps of Engineers, 1991).

2.1.3 Ground Water

Five hydrogeologic units have been identified at Carswell AFB. These units listed from most shallow to deepest are as follows:

- An upper perched-water zone occupying the alluvial terrace deposits of the Trinity River;
- An aquitard consisting of predominantly unsaturated limestone of the Goodland and Walnut Formations;
- The Paluxy sand;
- An aquitard of relatively impermeable limestone in the Glen Rose Formation; and
- A major aquifer in the sandstone of the Twin Mountains Formation

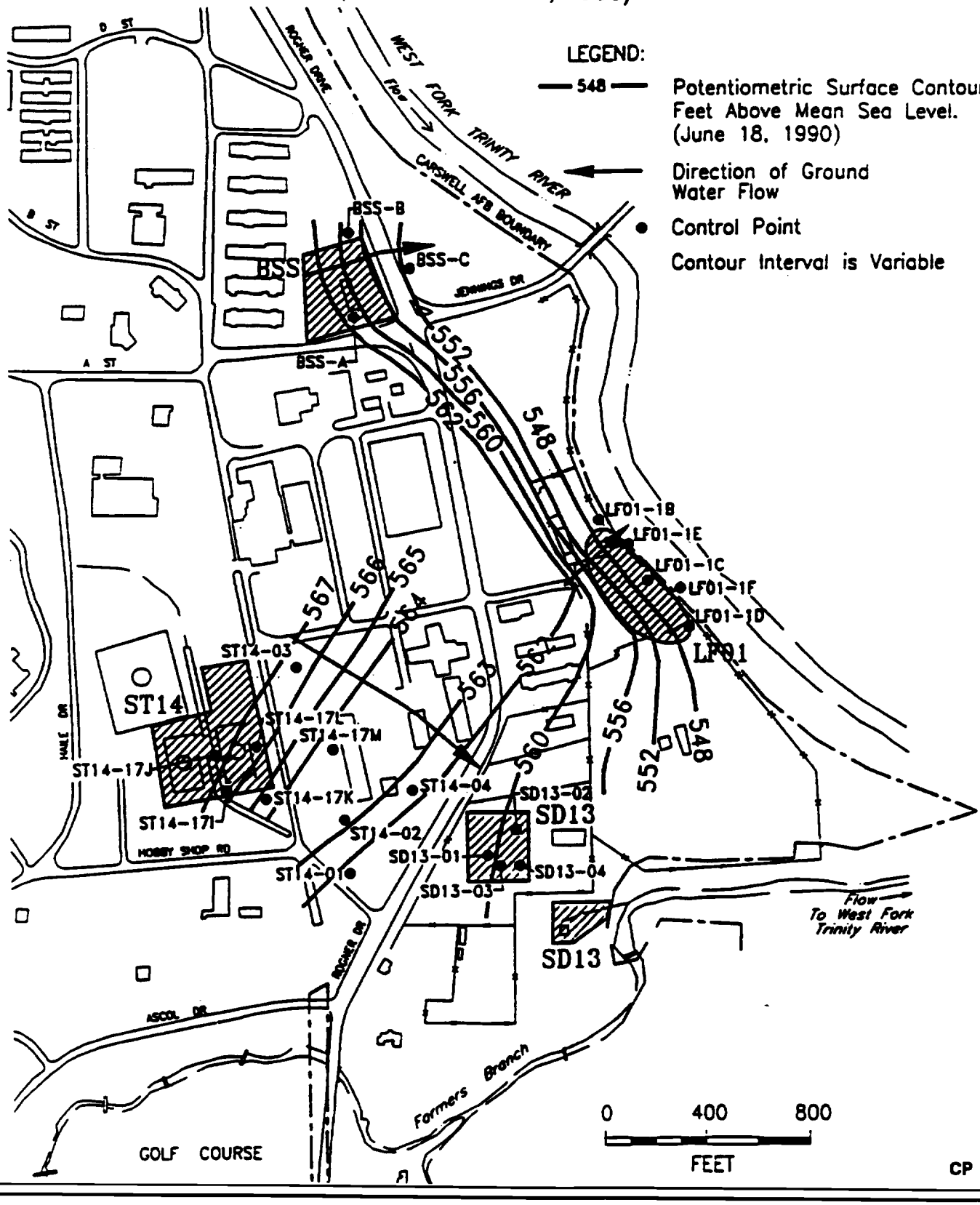
Upper Zone - Perched ground water occurs as lenses within the coarse alluvial sand and gravel deposits along the Trinity River. These lenses are limited in lateral extent and are surrounded by low-permeability clays and silts. Recharge to the water-bearing deposits is from rainfall and infiltration into stream channels and drainage ditches. Water flow in the alluvium is basically eastward, toward the West Fork of the Trinity River (U.S. Army Corps of Engineers, 1991) (Figure 2-5).

In parts of Tarrant County near the Trinity River, the upper zone is developed for irrigation and residential use. The community of River Oaks, immediately east of Carswell AFB, formerly utilized supply wells developed in alluvial deposits at a location near the

FIGURE 2-5

POTENTIOMETRIC SURFACE MAP OF THE UPPER ZONE EAST AREA,

CARSWELL AIR FORCE BASE, TEXAS
(AFTER RADIAN, 1986)



USAF hospital. The wells were abandoned when Carswell AFB purchased the property for hospital construction. In general, ground water in the upper zone is not economical to develop due to the zone's limited distribution and susceptibility to surface/storm water pollution (U.S. Army Corps of Engineers, 1991).

Goodland/Walnut Aquitard - The perched water present in the alluvium is separated from the underlying aquifers by the low permeability limestone and shale of the Goodland Limestone and Walnut Formation. The aquitard consists of moist clay and shale layers interbedded with dry limestone beds. Though primarily dry, drillers in the area have reported small amounts of water in the Walnut Formation, suggesting that ground water may move through the Walnut along bedding planes. 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 locally reduced the thickness of the limestone. In a soil boring at Air Force Plant 4, immediately west of Carswell AFB, the Goodland Limestone had been completely eroded and only 3 feet of the Walnut Formation was present. It is also reported that the upper zone and Paluxy formation are in contact at the eastern boundary of plant 4, where both the Goodland and Walnut formations have been removed by erosion. In areas of similarity extensive erosion, water in the upper zone could come in contact with water in the Paluxy aquifer (U.S. Army Corps of Engineers, 1991).

Paluxy Aquifer - The Paluxy aquifer is the shallowest bedrock aquifer beneath Carswell AFB. Water in the Paluxy normally occurs under confined conditions beneath the Goodland/Walnut aquitard except where the aquitard is absent due to erosion. Extensive pumping in the Fort Worth area has lowered the Paluxy potentiometric surface below the top of the formation, resulting in unconfined conditions beneath the installation. 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 while the lower sand is coarser; therefore, most wells are completed in the lower section (U.S. Army Corps of Engineers, 1991).

The Paluxy aquifer is recharged along outcrops west of Carswell AFB. Paluxy outcroppings also occur north of the base in the bed of Lake Worth. The lake bed represents a significant recharge source for the aquifer and creates a localized potentiometric high. Regional ground-water flow within the Paluxy is eastward, parallel with regional dip. Ground-water flow at Carswell AFB is influenced by the Lake Worth potentiometric high and by a potentiometric low induced by ground-water withdrawals of the community of White Settlement. This produces a generally southeasterly flow direction (U.S. Army Corps of Engineers, 1991).

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. In Tarrant County, the Paluxy Formation ranges in thickness from 140 to 190 feet, averaging 160 feet. 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 from the Paluxy aquifer range from 10 to 480 gallons per minute (gpm) averaging approximately 100 gpm (U.S. Army Corps of Engineers, 1991).

The Paluxy aquifer represents a significant source of potable ground water in the Fort Worth area. Communities adjacent to 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 extensive pumping, water levels in the Paluxy aquifer have declined significantly over the years. Water

levels in the immediate Carswell AFB vicinity have not lowered to the same degree as in the Fort Worth area because the base does not produce water from the Paluxy (U.S. Army Corps of Engineers, 1991).

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. Although the sands in the Glen Rose Formation yield small supplies to wells in Fort Worth and western Tarrant County, the relatively impermeable limestone behaves as an aquitard, restricting water movement between the overlying Paluxy aquifer and the underlying Twin Mountains aquifer (U.S. Army Corps of Engineers, 1991).

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 basal conglomerate of chert and quartz, grading upward into coarse to fine grained sand interbedded with shale. The formation varies in thickness from 250 and 430 feet. The Twin Mountains aquifer is recharged along outcrops west of Carswell AFB. Water movement is eastward in the direction of regional dip. Like water in the Paluxy aquifer, the Twin Mountains aquifer occurs under unconfined conditions in the recharge area, becoming progressively more confined in the downdip direction (U.S. Army Corps of Engineers, 1991).

The Twin Mountains aquifer is the principal aquifer in Tarrant County and yields large water supplies for municipal (including human consumptive) and industrial purposes. In Tarrant County, transmissivities in the Twin Mountains aquifer range from 1,950 to 29,700 gpd/ft averaging 8,450 gpd/ft. Permeabilities range from 8 to 165 gpd/ft^2 averaging 68 gpd/ft^2 (U.S. Army Corps of Engineers, 1991).

Ground-water 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 (U.S. Army Corps of Engineers, 1991).

2.1.4 Surface Water

Carswell AFB is located within the Trinity River Basin immediately south of Lake Worth, a man-made reservoir on the Trinity River. A portion of the installation is drained by Farmer's Branch which discharges into the West Fork of the Trinity River just south of the cantonment area. Farmer's Branch begins with the community of White Settlement and flows eastward. Immediately south of Air Force Plant 4, Farmer's Branch flows under the runway through two large culverts (U.S. Army Corps of Engineers, 1991).

Most of the installation's surface drainage is diverted through a series of storm drains and culverts. The water is in turn directed to oil/water separators and discharged to the West Fork downstream of Lake Worth. A small portion of the north end of the installation drains directly into Lake Worth.

2.1.5 Climatology/Air

Carswell AFB is located in north central Texas at approximately 33 degrees north latitude. 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 (U.S. Army Corps of Engineers, 1991).

The average annual temperature for Carswell AFB is 66 degrees F and monthly mean temperatures vary from 45 degrees F in January to 86 degrees F in July (Table 2-2). The average daily minimum temperature in January is 35 degrees F and the lowest recorded temperature is 2 degrees F. The average daily maximum temperature in July and August is 95 degrees F and the highest temperature recorded at the base was 111 degrees in the Month of June. On the average, freezing temperatures occur at Carswell AFB on 33 days per year (U.S. Army Corps of Engineers, 1991).

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, with an average, measurable snowfall 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 between average total precipitation and average lake evaporation or approximately minus 25 inches per year (U.S. Army Corps of Engineers, 1991).

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. The maximum precipitation recorded in a 24-hour period is 5.9 inches (U.S. Army Corps of Engineers, 1991).

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

TABLE 2-2

METEOROLOGICAL DATA SUMMARY
Carswell Air Force Base, Texas

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	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.

direction is predominately from the south during all months (U.S. Army Corps of Engineers, 1991).

2.1.6 Cultural Geography

2.1.6.1 Demographics - The total work force at Carswell AFB was approximately 6,100 persons, which includes about 1,000 civilian personnel (U.S. Army Corps of Engineers, 1991). Future demographics of Carswell AFB will be determined by the Final Base Realignment and Closure (BRAC) Policies.

The city of Fort Worth was estimated to have a population of 414,562 in 1984, with a population density of 1,617 people per square mile. The smaller suburbs of Forth Worth adjacent to Carswell AFB had 1980 population data as follows (U.S. Army Corps of Engineers, 1991):

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

2.1.6.2 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 installation. Commercial property is located to the south, while recreational property (Lake Worth) is north of the installation. Air Force Plant 4 is the industrial facility directly west of Carswell AFB (U.S. Army Corps of Engineers, 1991).

2.2 SITE SPECIFIC ENVIRONMENTAL SETTING

The following summaries of site specific environmental data are based on the results of previous IRP investigations at Carswell AFB (Radian, 1986; 1991a).

2.2.1 POL Tank Farm Site (ST-14)

The POL Tank Farm (Site ST-14) is located in the East Area of Carswell AFB, west of and adjacent to Knight's Lake Road and north of Hobby Shop Road (Figure 2-6). The Fuel Loading Area is east of Knight's Lake Road.

2.2.1.1 Contaminant Sources and Contamination - Three aboveground POL storage tanks currently are in place at this site and an additional three tanks have been removed from the site. Leaking underground POL lines are suspected to have released fuel products into the soil and ground water at and downgradient from the POL Tank Farm during the early 1960's. The leaking lines were reportedly located and replaced and no further fuel releases were documented after 1965. A french drain system was installed in 1965 east of Rogner Drive between the Abandoned Service Station and the Entomology Area to intercept fuel released either from this site or the Abandoned Service Station. Previous studies (Radian, 1986, 1991a) have found evidence of contamination by organic compounds, including ethylbenzene, benzene, chlorobenzene and total xylenes (Figure 2-7). Lead and chromium in excess of MCL's were also detected in the ground water at this site.

2.2.1.2 Geology - Geomorphology - The POL Tank Farm is located in a relatively flat area in the eastern part of the base. Elevations range from approximately 580 feet MSL west of the site to 572 feet

143017

FIGURE 2-6

LOCATION OF EAST AREA SITES

CARSWELL AIR FORCE BASE, TEXAS

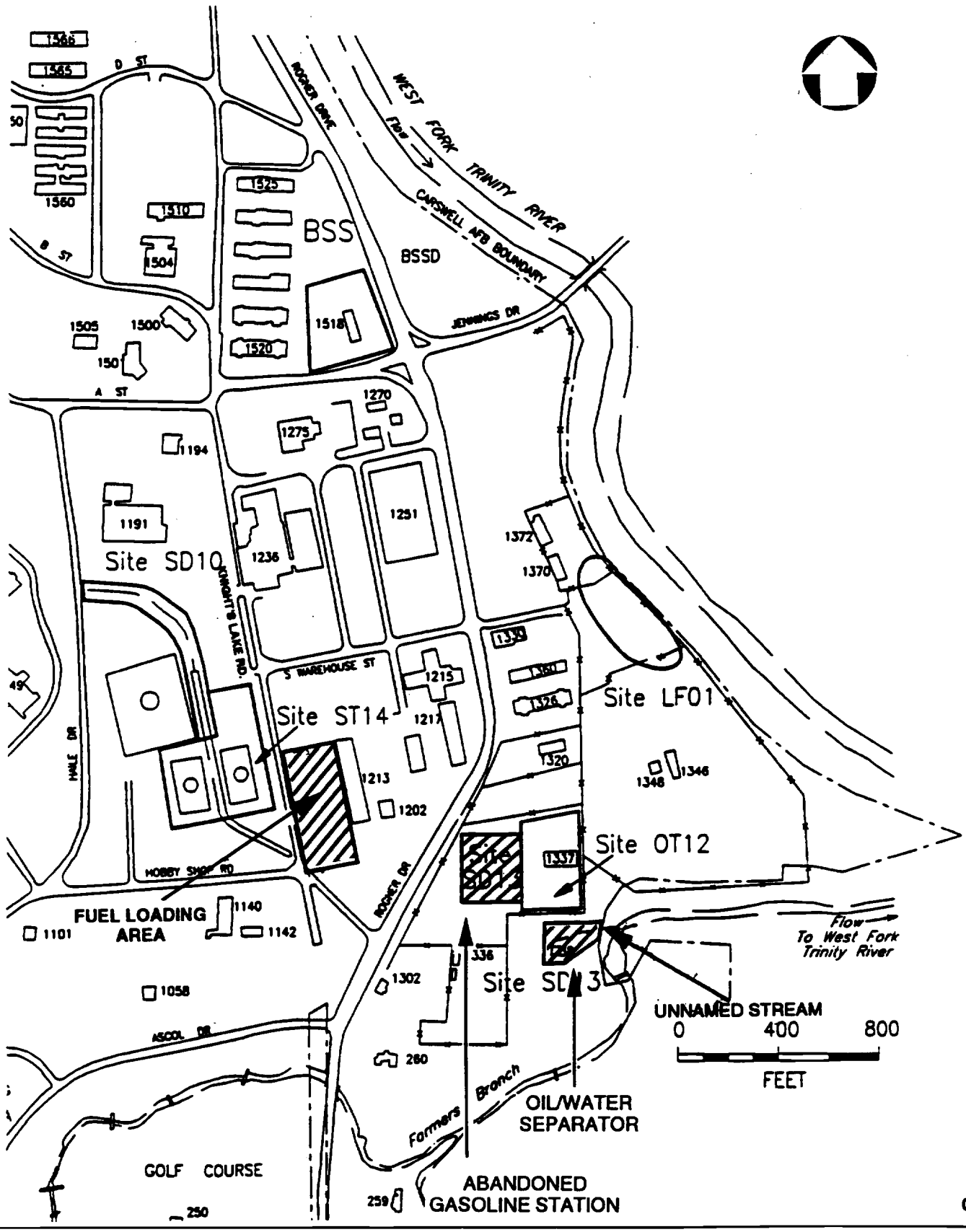
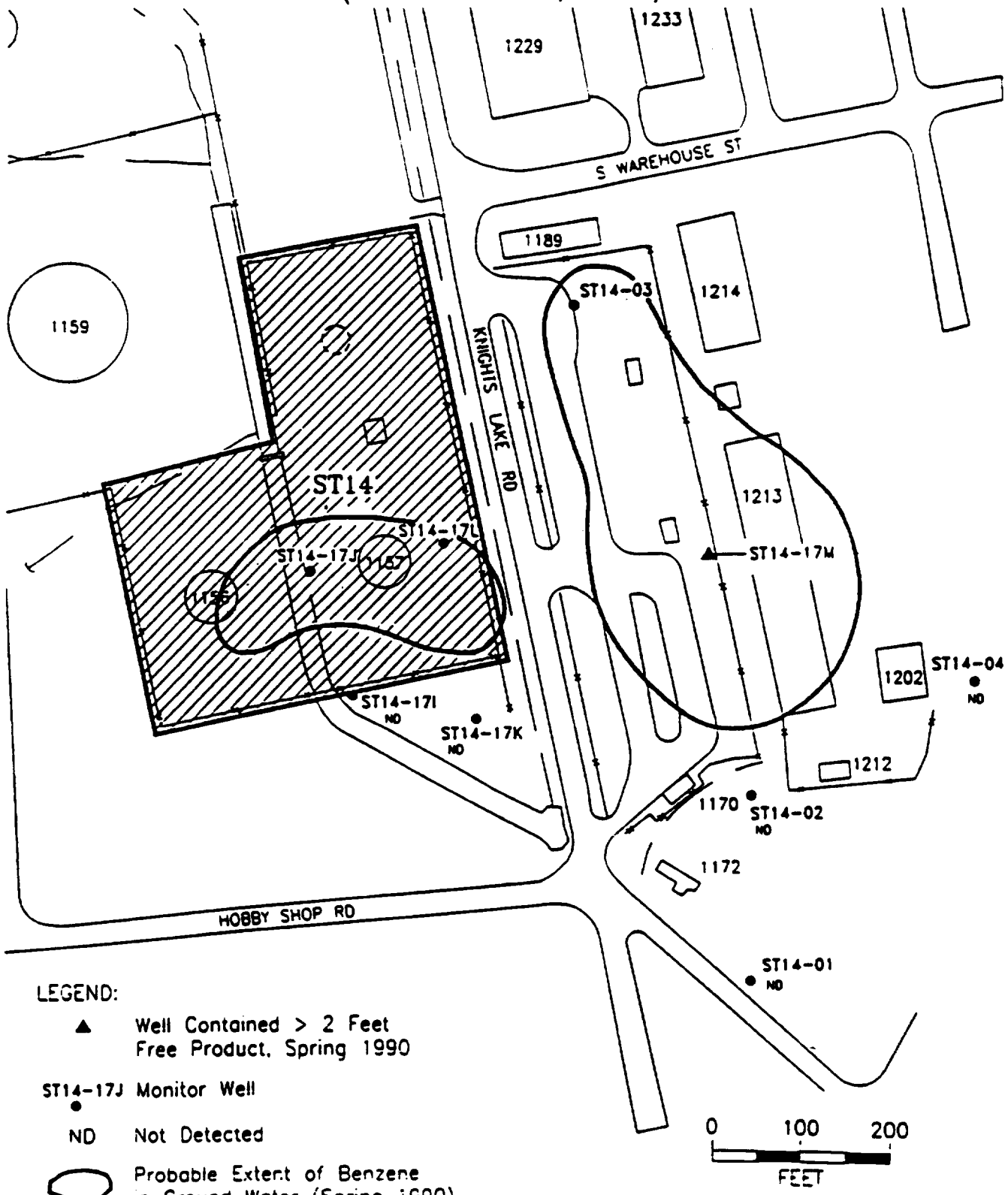


FIGURE 2-7

PROBABLE EXTENT OF BENZENE CONTAMINATION (SPRING 1990), CARSWELL AIR FORCE BASE, TEXAS (AFTER RADIAN, 1991a)



DATA COMPILED FROM STAGE 1 AND STAGE 2 RI REPORTS PREPARED BY RADIAN CORPORATION

MSL to the east of the site. The ground surface slopes gently to the south southeast.

Stratigraphy - Previous investigations at the POL Tank Farm (Radian, 1986; Radian, 1991a) have revealed that sixteen to more than twenty feet of Quaternary alluvium overlie the Cretaceous Goodland Limestone at this site (Figure 2-8; 2-9). Elevation data from wells and borings that were drilled to the top of the Goodland indicate that the contact of the Limestone with the Quaternary clastic units forms a gently sloping, uniform surface that dips to the southwest.

Quaternary alluvial strata in this area typically contain basal units of sand and gravel five to ten feet thick that overlie the Goodland. The sand units are generally fine grained and vary in color from gray, tan to brown, to pink. The gravel clasts range from pea sized to over an inch in diameter.

Approximately ten feet of gray to tan clay overlies the basal units. Limonite staining, pebbles and freshwater gastropod shells are frequently found in the clay unit. Hydrocarbon odor was observed emanating from the clay during drilling operations (Radian, 1991a).

Soil Properties

Soils at Site ST-14 POL Tank Farm are of the Sanger-Purves-Slidell Association. This association is characterized by clayey soils found on nearly level to gently sloping uplands. Textures include clay loam and silty clay. Thickness of the soil varies from eight to eighty inches. Permeability values range from $< 4.2 \times 10^{-5}$ to 3×10^{-4} cm/sec.

Soil Geochemistry - Review of existing reports did not reveal site specific data background or naturally occurring analytes in environmental media. Soil samples collected at this site during

FIGURE 2-8

POL TANK FARM AND UNNAMED STREAM CROSS-SECTION LOCATION MAP

CARSWELL AIR FORCE BASE, TEXAS

(AFTER RADIAN, 1991a)

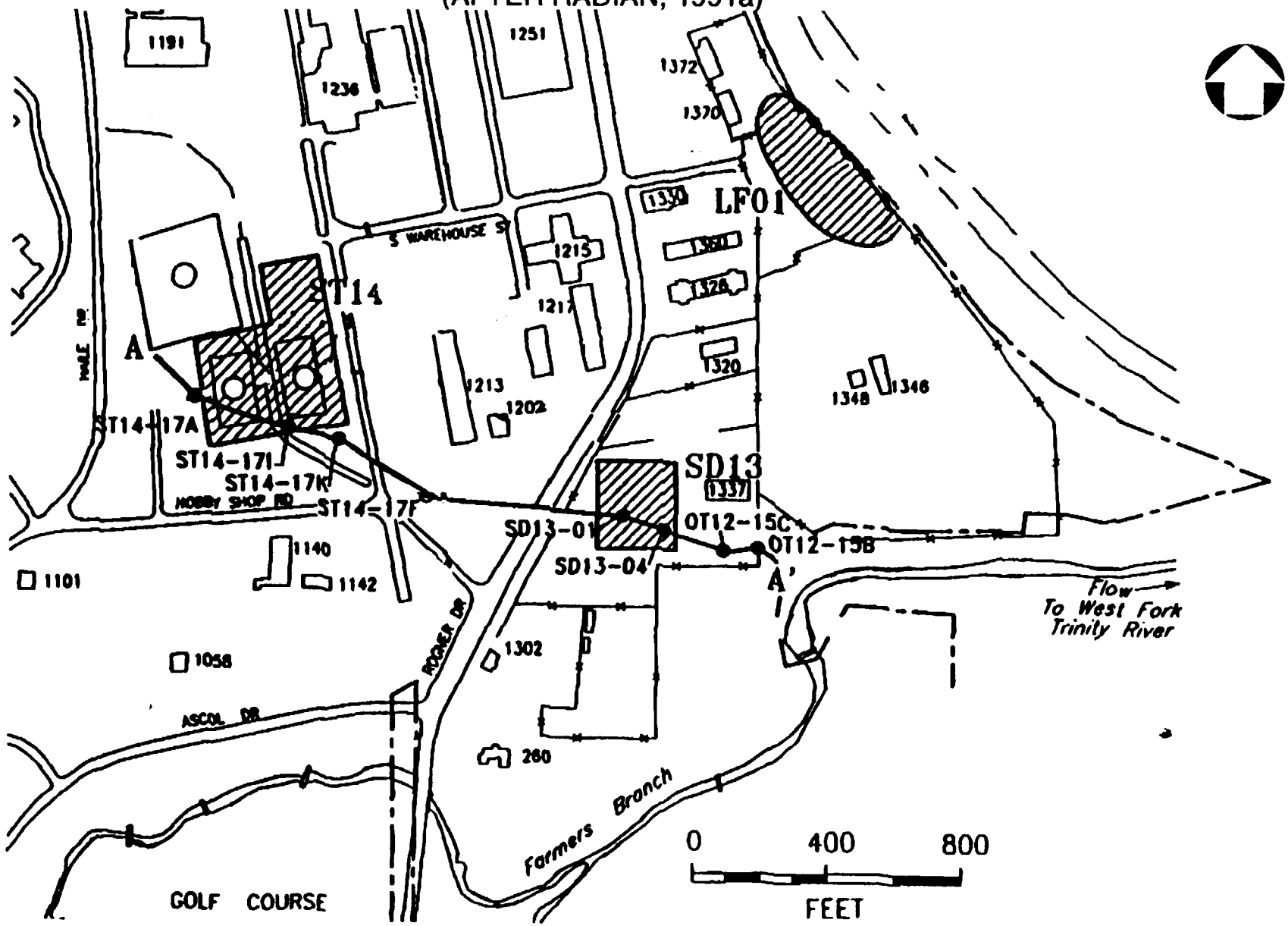
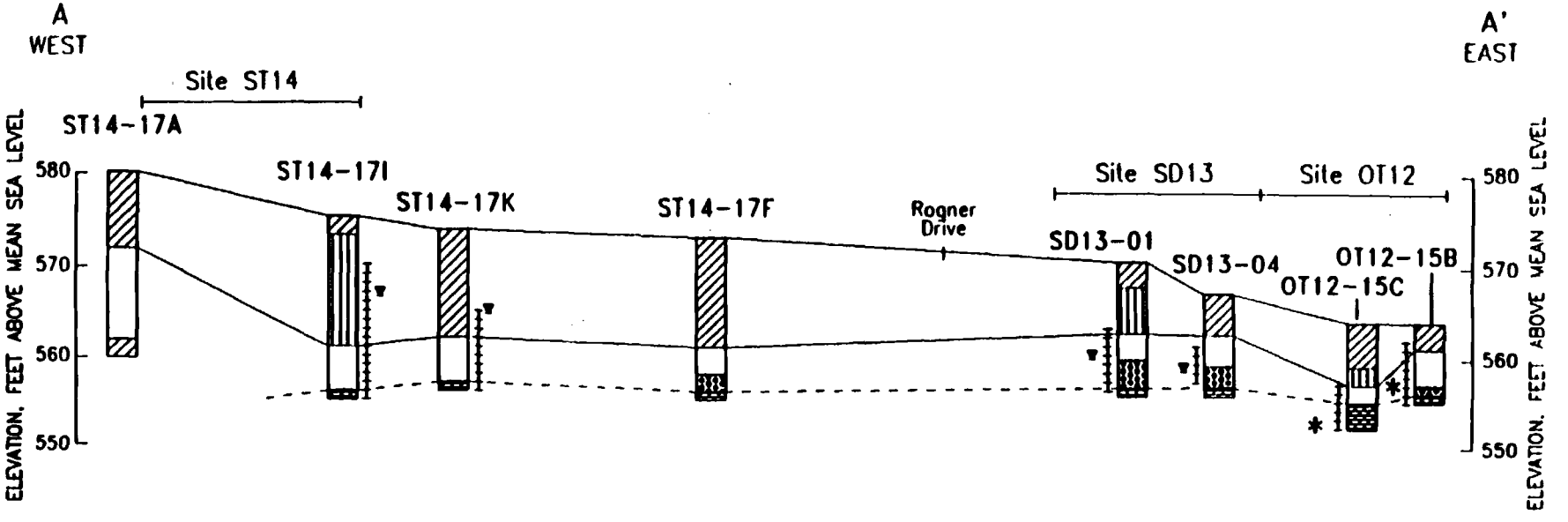


FIGURE 2-9

CROSS-SECTION A-A'

CARSWELL AFB, TEXAS

(AFTER RADIAN, 1991a)



LEGEND:

- Clay and Fill Material
- Silt
- Sand
- Sand and Gravel
- Limestone and Shale
- Top of Bedrock
- Soil Contact
- Water Level, June/1990
- Screened Interval
- Water Level Not Taken

0 100 200 400

FEET

Vertical Exaggeration: 12.5x

DATA COMPILED FROM STAGE 1 AND STAGE 2 RI REPORTS PREPARED BY RADIAN CORPORATION

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the Phase II stage 1 investigation (Radian, 1986) were analyzed only for oil and grease. No soil samples were submitted for chemical analysis in conjunction with the Phase II stage 2 study (Radian, 1991a).

2.2.1.3 Ground Water - The water bearing unit of concern at this site is the upper zone aquifer in the Quaternary alluvium overlying the Goodland formation. No wells have been drilled at this site into the Paluxy Aquifer under the Goodland Aquiclude. Depth to ground water at this site ranges from eight to sixteen feet. The upper zone aquifer is under watertable conditions and water level is effected by precipitation recharge. Hydraulic conductivity values ranging from 2.5×10^{-4} to 1.2×10^{-2} cm/sec were calculated from slug tests performed by Radian on wells installed in the Carswell AFB "East Area" during previous investigations. The hydraulic gradient at the time of the June 1990 measurement was on average 0.007 feet/foot (Radian, 1991a). Ground water velocities calculated from this gradient and an assumed porosity of 20% average about 0.3 ft/day to the southeast (Figure 2-10).

Ground-Water quality - No data are available to assess background or naturally occurring levels of analytes for this site.

Ground Water use - The upper zone aquifer is not currently used as a water source. The only wells completed in the aquifer at this site are monitoring wells installed during prior IRP investigations.

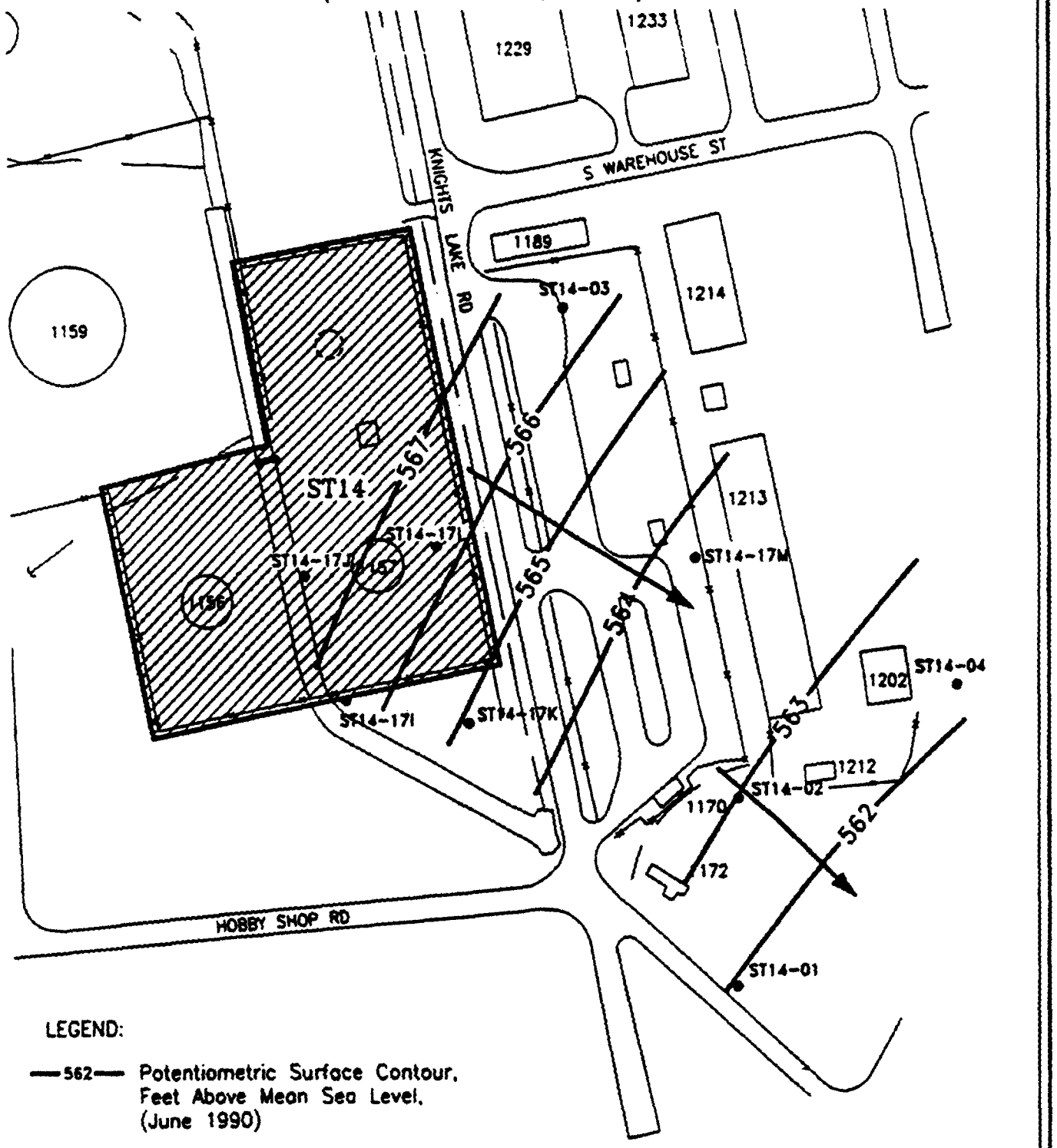
2.2.1.4 Surface Water - The only surface water present at the site is found in the concrete lined portion of the Flightline Drainage Ditch that bisects the site. Presence of water in this ditch depends on precipitation. Surface runoff at the site is to the south and east.

FIGURE 2-10

POTENTIOMETRIC SURFACE, POL TANK FARM (SPRING 1990)

CARSWELL AIR FORCE BASE, TEXAS
(AFTER RADIAN, 1991a)

143053



DATA COMPILED FROM STAGE 1 AND STAGE 2 RI REPORTS PREPARED BY RADIAN CORPORATION

2.2.1.5 Air - No data is available on air quality at this site.

2.2.1.6 Biology - Review of existing information identified this area of the base to be highly developed and paved. No known endangered species or sensitive communities were documented to be present at this site.

2.2.2 Unnamed Stream Site (SD-13)

The Unnamed Stream site area is located near the eastern boundary of the base east of Rogner Drive and north of Farmer's Branch. This site consists of two locations, the paved area around the Abandoned Service Station and the intermittent stream flowing from an Oil/Water separator to Farmer's Branch (Figure 2-11). This stream is approximately 200 ft. long before it enters Farmers Branch (see Figure 2-12).

2.2.2.1 Contaminant Sources and Contamination - The Abandoned Service Station area may contain one or more USTs that may have leaked petroleum products. The Unnamed Stream flows from the oil/water separator that is the terminus of a french drain system installed in 1965 to recover fuel leaking from either the Abandoned Service Station UST(s) or the POL Tank Farm. Previous studies (Radian, 1986, 1991a) detected low levels of organic contamination in the ground water at this site. Surface water samples with lead and arsenic in excess of MCL's were collected from the Unnamed Stream downstream from the oil/water separator (Figure 2-12).

2.2.2.2 Geology - Geomorphology - The Abandoned Service Station is located in a fairly flat area in the eastern part of the base. There is approximately fifteen to twenty feet of topographic relief between the location of the Abandoned Service Station on the upper

143055

FIGURE 2-11

LOCATION OF EAST AREA SITES

(AFTER RADIAN, 1986)

CARSWELL AIR FORCE BASE, TEXAS

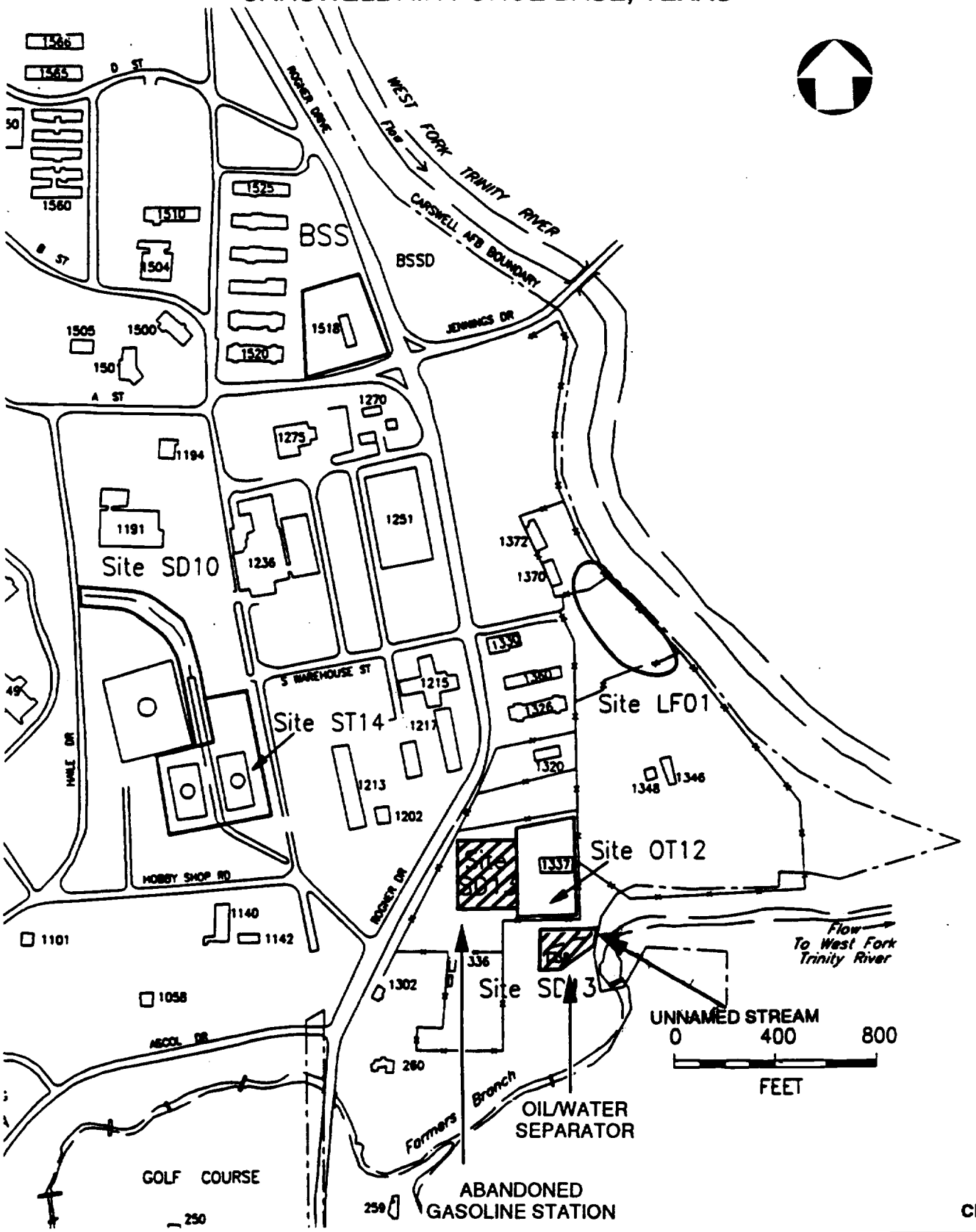
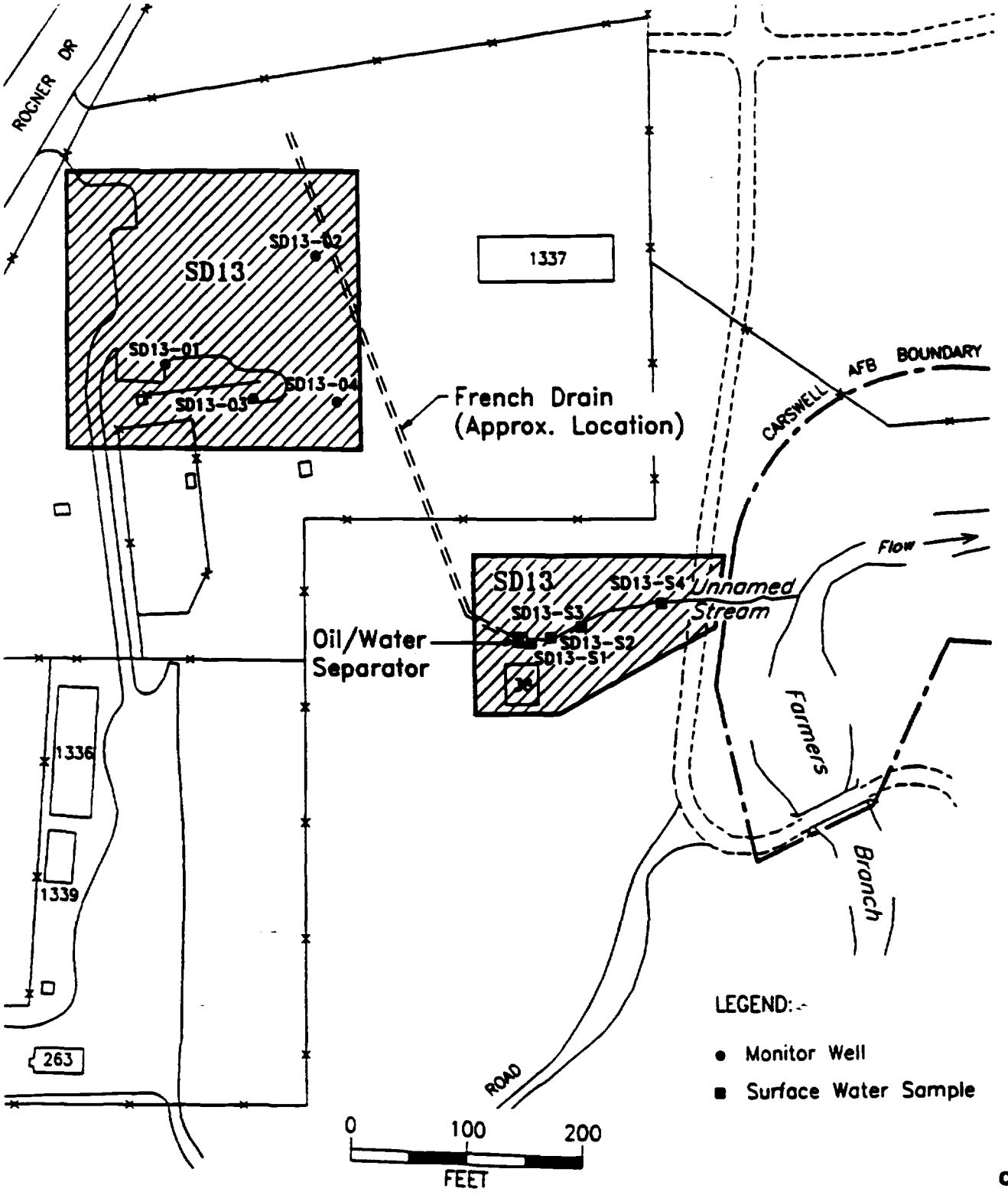


FIGURE 2-12

LOCATION OF WELLS AND SURFACE WATER SAMPLING LOCATIONS AND APPROXIMATE LOCATIONS OF FRENCH DRAIN AND OIL/WATER SEPARATOR, SITE SD13,

(AFTER RADIAN, 1991a)

CARSWELL AIR FORCE BASE, TEXAS



terrace deposits and the Unnamed Stream which is located on the lower floodplain of Farmer's Branch.

Stratigraphy - Previous investigations found ten to fifteen feet of Quaternary alluvium overlying the Goodland Formation in the vicinity of the Abandoned Service Station (Figure 2-8; 2-9). Elevation data from wells and borings that were drilled to the top of the Goodland indicate that the upper surface of the limestone dips slightly to the southwest towards Farmer's Branch. No subsurface data is available for the vicinity of the Unnamed Stream.

Quaternary alluvial strata in the area of the Abandoned Service Station contain from two to five feet of gravel in unconformable contact with the weathered surface of the Goodland. The gravel generally consists of subrounded chert and larger limestone clasts. Medium grained sand is usually a component of these units (Radian, 1991).

The gravel unit is overlain by three to five feet of fine to medium grained sand. Most of the sand in this area is green gray, fine to medium grained and contains minor amounts of clay. Some of the sand is orange to tan, coarser grained and lacking in fines. The uppermost sediments at this site are orange to orange brown clays and silts ranging in thickness from four to eight feet. Roots, calcareous nodules and oxidation staining are frequently observed in these fine grained clastic units.

Soil Properties - Soils at the Unnamed Stream site are of the Bastil - Silawa Association. This association is characterized by loamy soils on nearly level to sloping stream terraces. Soil texture is predominantly sandy clay loam. Soil thickness ranges from forty to eighty inches. Permeability values range from 9×10^{-4} to 3×10^{-3} cm/sec. (U.S. Department of Agriculture, Soil Conservation Service, 1981).

Soil Geochemistry - Soil samples collected along the Unnamed Stream had high levels of oil and grease that increased with proximity to the oil/water separator (Radian, 1986).

2.2.2.3 Ground Water - The water bearing unit of concern at this site is the upper zone aquifer in the Quaternary alluvium overlying the Goodland Formation. No wells at this site have been drilled into the Paluxy Aquifer. Depth to ground water at this site ranges from seven to twelve feet. No aquifer tests were performed to determine the hydraulic characteristics of the upper zone at this site. The hydraulic gradient at the time of June 1990 water level measurements was approximately 0.01 ft/ft. Based on the interpreted potentiometric surface, ground-water flow was determined to be to the north-northeast towards the french drain and the Trinity River, instead of to the southwest in the direction of dip at the top of the Goodland (Figure 2-13).

Ground-water quality - No data is available for background or naturally occurring analyte concentrations.

Ground Water use - The upper zone aquifer is not used as a water source in the vicinity of this site. The only wells completed in the upper zone in this area are monitoring wells.

2.2.2.4 Surface Water - The Unnamed Stream is a intermittent stream that flows via the oil/water separator from the french drain system. Surface runoff at the Abandoned Service Station is to the south and east.

2.2.2.5 Air - No data is available on air quality at this site.

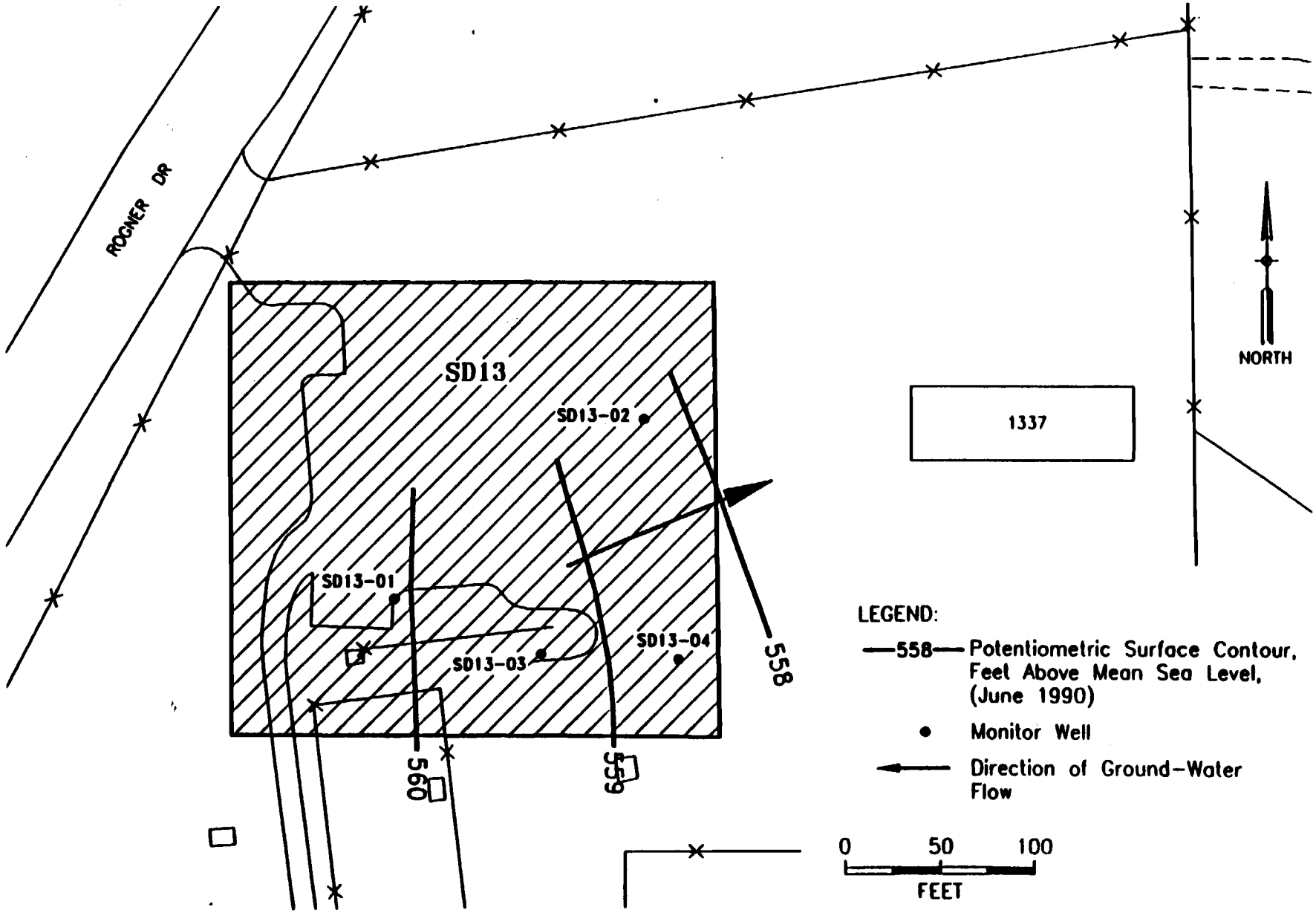
2.2.2.6 Biology - Based on review of available data, no endangered species or environmentally sensitive communities are known to exist

FIGURE 2-13

UPPER ZONE POTENTIOMETRIC SURFACE, SITE SD13

(AFTER RADIAN, 1991a)

CARSWELL AFB, TEXAS



at this site or the surrounding area. The area is highly developed which would discourage most nonhuman habitation.

2.3 CONCEPTUAL SITE MODEL

Information obtained during previous environmental investigations and site visits to Carswell AFB concerning the waste sources, pathways, and receptors at each site was used to develop a conceptual understanding of the two sites in order to evaluate potential risks to human health and the environment. Radian Corporation conducted a staged investigation under the Installation Restoration Program. These investigations, Phase II Stage I and Phase II Stage 2 are discussed in Sections 1.0 and 2.0, above. This information was compiled to produce a preliminary conceptual site model for the POL Tank Farm (ST-14) and the Unnamed Stream site area (SD-13).

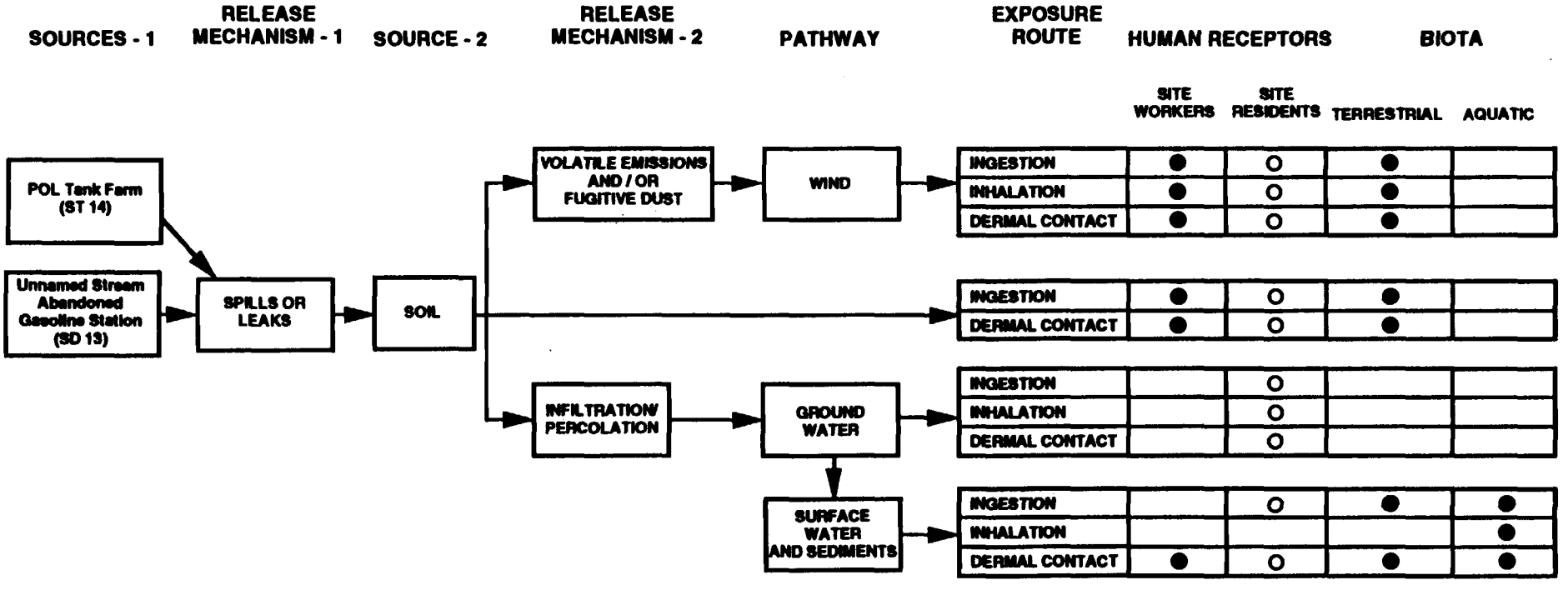
The conceptual site model includes known and suspected sources of contamination and affected media, known and potential routes of migration, and known and potential human and environmental receptors. The preliminary conceptual site model for the two sites under investigation is presented graphically as Figure 2-14. The Conceptual Site Model Summaries, which identify sources, pathways, and receptors are provided as Tables 2-3 and 2-4. The geologic and hydrogeologic data for each site are presented in Figures 2-15 through 2-19. The summary provides the basis for development of the baseline risk assessment and evaluation of the remedial action alternatives. The data presented in the table have been obtained through the review of existing reports (Radian, 1986 and 1991a).

It should be noted that data for background concentrations of constituents have not been identified in the previous reports reviewed to date. Effort is underway to determine if background has been established during studies of other areas at Carswell.

FIGURE 2-14

CONCEPTUAL SITE MODEL

CARSWELL AIR FORCE BASE



3517-0111.02

TABLE 2-3

CONCEPTUAL SITE MODEL SUMMARY
Site ST14 - POL Tank Farm
Carswell Air Force Base, Texas

SITE IDENTIFICATION	SITE DESCRIPTION	BACKGROUND CONC.	SOURCE			MIGRATION PATHWAY	RECEPTOR/ EXPOSED POPULATION
			Contaminants	Maximum Concentration	Media		
Site ST14 - POL Tank Farm	Nearly level, with a slight gradient to the west. Two above-ground fuel storage tanks are located at the site. Three tanks that were previously in use have been removed.	No data	PHASE II STAGE 1 DATA[d]				
			Organic Indicators	µg/g		Primary:	
			Oil and grease	1,300	Soil	Ground Water	Site Residents; potential future use.
			PHASE II STAGE 2 DATA[d]				
			No soil samples analyzed.			Surface Water/ Sediments	Humans: dermal contact and ingestion of fish from Farmer's Branch
							Local fauna: Possible biological uptake - vegetation
						Surface Soil (future use, soils are currently covered with gravel)	Humans: ingestion, dermal contact
							Local fauna: ingestion, dermal contact
						Air-fugitive dust (future use, soils are currently covered with gravel)	Humans: ingestion, inhalation, and/or dermal contact
							Local fauna: ingestion, inhalation, and/or dermal contact

[a] Concentrations were determined from surface and subsurface soil samples and reported in Radian Corporation, 1986.
[b] Samples collected from oil/water separator and reported in Radian Corporation, 1986.
[c] Samples collected from Unnamed Stream and data reported by Radian, 1991.
[d] Radian Corporation, 1986
[e] Radian Corporation, 1991

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Carswell Air Force Base, Texas

SITE IDENTIFICATION	SITE DESCRIPTION	BACKGROUND CONC.	SOURCE			MIGRATION PATHWAY	RECEPTOR/ EXPOSED POPULATION
			Contaminants	Maximum Concentration	Media		
Site ST14 - POL Tank Farm	Nearly level, with a slight gradient to the west. Two above-ground fuel storage tanks are located at the site. Three tanks that were previously in use have been removed.	No data	PHASE II STAGE 1 DATA[a]				
			Organic Indicators	mg/L		Primary:	
			Oil and grease	31,000	Ground Water	Ground Water	Site residents, potential future use: ingestion, inhalation and dermal contact
			TOC	190	Ground Water		
			TOX	0.12	Ground Water	Surface Water/ Sediments	Humans; dermal contact and ingestion of fish from Farmer's Branch
			Purgeable Aromatics				
			Not analyzed.				Local fauna; Possible biological uptake - vegetation
			Purgeable Hydrocarbons				
			Not Detected			Air (volatile emissions)	Local residents; potential future use
			PHASE II STAGE 2 DATA[a]				
			Metals	mg/L			
			Aluminum	36.0	Ground Water		
			Arsenic	0.039	Ground Water		
			Barium	0.58	Ground Water		
			Beryllium	0.007	Ground Water		
			Boron	3.8	Ground Water		
			Cadmium	0.007	Ground Water		
			Calcium	550.0	Ground Water		
			Chromium	0.066	Ground Water		
			Cobalt	0.029	Ground Water		
			Copper	0.07	Ground Water		
			Iron	0.72	Ground Water		
			Lead	0.69	Ground Water		

[a] Concentrations were determined from surface and subsurface soil samples and reported in Radian Corporation, 1986.
[b] Samples collected from oil/water separator and reported in Radian Corporation, 1986.
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[e] Radian Corporation, 1991

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Carswell Air Force Base, Texas

SITE IDENTIFICATION	SITE DESCRIPTION	BACKGROUND CONC.	SOURCE			MIGRATION PATHWAY	RECEPTOR/ EXPOSED POPULATION
			Contaminants	Maximum Concentration	Media		
Site ST14 - POL Tank Farm	Nearly level, with a slight gradient to the west. Two above-ground fuel storage tanks are located at the site. Three tanks that were previously in use have been removed.	No data	PHASE II STAGE 2 DATA[a] (Continued)			Primary:	
			Magnesium	14.0	Ground Water		
			Manganese	0.73	Ground Water		
			Nickel	0.072	Ground Water		
			Potassium	7.3	Ground Water		
			Silicon	75.0	Ground Water		
			Silver	0.036	Ground Water	Ground Water	Site residents; potential future use; ingestion, inhalation and dermal contact
			Sodium	32.0	Ground Water		
			Strontium	0.71	Ground Water	Surface Water/ Sediments	Humans; dermal contact and ingestion of fish from Farmer's Branch
			Vanadium	0.17	Ground Water		
			Zinc	0.12	Ground Water		Local fauna; ingestion, inhalation and/or dermal contact
			Volatile Organics	µg/L			
			Benzene	16.0	Ground Water	Air (volatile emissions)	Local Residents; potential future use
			Chlorobenzene	38.0	Ground Water		
			Ethylbenzene	35.0	Ground Water		
			Toluene	22.0	Ground Water		
			Xylenes	300	Ground Water		
			Water Quality Indicators				
			Chloride	35.0			
			Fluoride	0.3			
			Nitrate as N	1.1			
			Sulfate	37.0			
			Total Dissolved solids	1200.0			

[a] Concentrations were determined from surface and subsurface soil samples and reported in Radian Corporation, 1986.
[b] Samples collected from oil/water separator and reported in Radian Corporation, 1986.
[c] Samples collected from Unnamed Stream and data reported by Radian, 1991.
[d] Radian Corporation, 1986
[e] Radian Corporation, 1991

TABLE 2-4

CONCEPTUAL SITE MODEL SUMMARY
Site SD13 - Unnamed Stream and abandoned gas station
Carswell Air Force Base, Texas

SITE IDENTIFICATION	SITE DESCRIPTION	BACKGROUND CONC.	SOURCE			MIGRATION PATHWAY	RECEPTOR/ EXPOSED POPULATION
			Contaminants	Maximum Concentration	Media		
Site SD13 - Unnamed Stream and abandoned gas station	The Unnamed Stream is a small tributary of Farmer's Branch. It receives its perennial flow from an oil/water separator at the end of a french underdrain system. The abandoned gas station is a nearly level, paved area where a base gasoline station was formerly located.	No data	PHASE II STAGE 1 DATA[a]				
			Metals	µg/g		Primary:	
			Arsenic	11	Soil	Ground Water	Site Residents; potential future use; ingestion, inhalation of volatiles, and dermal contact
			Barium	85	Soil		
			Cadmium	0.89	Soil	Surface Water/ Sediments	Humans; dermal contact and ingestion of fish from Farmer's Branch
			Chromium (total)	13	Soil		
			Lead	20	Soil		Local fauna: ingestion, inhalation, and/or dermal contact
			Mercury	0.10	Soil		
			Selenium	41	Soil	Surface Soil (future use, site is currently paved)	Human: ingestion, dermal contact
			Silver	1.2	Soil		
			Organics	µg/g			Local fauna: ingestion, dermal contact
			Oil and grease	240	Soil		
			Purgeable Aromatics				
			Toluene	0.54	Soil		
			Purgeable Halocarbons	Not Detected	Soil		

[a] Concentrations were determined from surface and subsurface soil samples and reported in Radian Corporation, 1986.
[b] Samples collected from oil/water separator and reported in Radian Corporation, 1986.
[c] Samples collected from Unnamed Stream and data reported by Radian, 1991.
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			Contaminants	Maximum Concentration	Media		
Site SD13 - Unnamed Stream and abandoned gas station	The Unnamed Stream is a small tributary of Farmer's Branch. It receives its perennial flow from an oil/water separator at the end of a french underdrain system. The abandoned gas station is a nearly level, paved area where a base gasoline station was formerly located.	No data	PHASE II STAGE 1 DATA[b]				
			Metals	mg/L		Primary:	
			Arsenic	0.16	Surface Water	Ground Water	Site residents; potential future use; ingestion, inhalation of volatiles, and dermal contact
			Barium	0.29	Surface Water		
			Cadmium	0.007	Surface Water	Surface Water/ Sediments	Humans: dermal contact and ingestion of fish from Farmer's Branch
			Chromium	0.017	Surface Water		
			Lead	0.081	Surface Water		Local fauna: ingestion, inhalation and/or dermal contact
			Mercury	0.0004	Surface Water		
			Organic Indicators	mg/L		Air (volatile emissions)	Site workers (current and future use) and on-site residents (potential future use); via inhalation
			Oil and grease	640	Surface Water		Local fauna: inhalation
			Total organic carbon (TOC)	200	Surface Water		
			Total Halocarbons (TOX)	0.01	Surface Water		
			Purgeable Aromatics	Not Detected	Surface Water		
			Purgeable Halocarbons	mg/L			
			Trichlorofluoromethane	2.9	Surface Water		

[a] Concentrations were determined from surface and subsurface soil samples and reported in Radian Corporation, 1986.
[b] Samples collected from oil/water separator and reported in Radian Corporation, 1986.
[c] Samples collected from Unnamed Stream and data reported by Radian, 1991.
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			Contaminants	Maximum Concentration	Media		
Site SD13 - Unnamed Stream and abandoned gas station	The Unnamed Stream is a small tributary of Farmer's Branch. It receives its perennial flow from an oil/water separator at the end of a french underdrain system. The abandoned gas station is a nearly level, paved area where a base gasoline station was formerly located.	No data	PHASE II STAGE 2 DATA[a]				
			Metals	mg/L		Primary:	
			Arsenic	0.086	Surface Water	Ground Water	Site residents; potential future use; ingestion, inhalation of volatiles, and dermal contact
			Barium	0.29	Surface Water		
			Calcium	130	Surface Water	Surface Water/ Sediments	Humans: dermal contact and ingestion of fish from Farmer's Branch
			Cobalt	0.011	Surface Water		
			Iron	26.0	Surface Water		Local fauna: possible biological uptake - vegetation
			Lead	0.066	Surface Water		
			Magnesium	6.4	Surface Water	Air (volatile emissions)	Site workers (current and future use) and on-site residents (potential future use); via inhalation
			Manganese	0.21	Surface Water		Local fauna: inhalation
			Selenium	30.0	Surface Water		
			Volatile Organics	µg/L			
			1,3-Dichlorobenzene	1.2	Surface Water		
			1,4-Dichlorobenzene	1.7	Surface Water		
			Benzene	0.31	Surface Water		
			Chlorobenzene	2.8	Surface Water		
			Ethylbenzene	0.97	Surface Water		
			Toluene	0.59	Surface Water		
			Xylenes	0.53	Surface Water		
			Water Quality Indicators	mg/L			
			Chloride	26.0	Surface Water		
			Fluoride	0.29	Surface Water		
			Nitrate as N	0.56	Surface Water		

[a] Concentrations were determined from surface and subsurface soil samples and reported in Radian Corporation, 1986.
[b] Samples collected from oil/water separator and reported in Radian Corporation, 1986.
[c] Samples collected from Unnamed Stream and data reported by Radian, 1991.
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			Contaminants	Maximum Concentration	Media		
Site SD13 - Unnamed Stream and abandoned gas station	The Unnamed Stream is a small tributary of Farmer's Branch. It receives its perennial flow from an oil/water separator at the end of a french underdrain system. The abandoned gas station is a nearly level, paved area where a base gasoline station was formerly located.	No data	PHASE II STAGE 1 DATA[d]				
			Metals	mg/L		Primary:	
			Barium	1.3	Ground Water	Ground Water	Site residents; potential future use; ingestion, inhalation of volatiles, and dermal contact
			Mercury	0.0006	Ground Water		
			Organic Indicators	mg/L		Surface Water/ Sediments	Humans: dermal contact and ingestion of fish from Farmer's Branch
			Oil and grease	7,100	Ground Water		
			TOC	420	Ground Water		Local fauna: Possible biological uptake - vegetation
			TOX	0.04	Ground Water		
			Purgeable Halocarbons	µg/L		Air (volatile emissions)	Local residents; potential future use
			Trichlorofluoromethane	4.2	Ground Water		
			1,1,1-trichloroethane	2.9	Ground Water		
			trans-1,2-dichloroethene	0.1	Ground Water		
			Purgeable Aromatics	µg/L			
			1,4-Dichlorobenzene	no data; reported as "very high"			
			1,2-Dichlorobenzene	no data; reported as "very high"			

[a] Concentrations were determined from surface and subsurface soil samples and reported in Radian Corporation, 1986.
[b] Samples collected from oil/water separator and reported in Radian Corporation, 1986.
[c] Samples collected from Unnamed Stream and data reported by Radian, 1991.
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Site SD13 - Unnamed Stream and abandoned gas station
Carswell Air Force Base, Texas

SITE IDENTIFICATION	SITE DESCRIPTION	BACKGROUND CONC.	SOURCE			MIGRATION PATHWAY	RECEPTOR/ EXPOSED POPULATION
			Contaminants	Maximum Concentration	Media		
Site SD13 - Unnamed Stream and abandoned gas station	The Unnamed Stream is a small tributary of Farmer's Branch. It receives its perennial flow from an oil/water separator at the end of a french underdrain system. The abandoned gas station is a nearly level, paved area where a base gasoline station was formerly located.	No data	PHASE II STAGE 2 DATA[a]				
			Metals	mg/L		Primary:	
			Aluminum	12.0	Ground Water	Ground Water	Site residents; potential future use; ingestion and dermal contact
			Arsenic	0.042	Ground Water		
			Barium	0.63	Ground Water	Surface Water/ Sediments	Humans: dermal contact and ingestion of fish
			Boron	1.1	Ground Water		
			Calcium	270.0	Ground Water		Local fauna: Possible biological uptake - vegetation
			Chromium	0.024	Ground Water		
			Cobalt	0.017	Ground Water	Air (volatile emissions)	
			Copper	0.023	Ground Water		
			Iron	44.0	Ground Water		
			Lead	0.031	Ground Water		
			Magnesium	9.5	Ground Water		
			Manganese	0.46	Ground Water		
			Nickel	0.041	Ground Water		
			Potassium	3.6	Ground Water		
			Silicon	36.0	Ground Water		
			Silver	0.012	Ground Water		
			Sodium	29.0	Ground Water		
			Strontium	0.56	Ground Water		
			Vanadium	0.058	Ground Water		
			Zinc	0.13	Ground Water		

[a] Concentrations were determined from surface and subsurface soil samples and reported in Radian Corporation, 1986.
[b] Samples collected from oil/water separator and reported in Radian Corporation, 1986.
[c] Samples collected from Unnamed Stream and data reported by Radian, 1991.
[d] Radian Corporation, 1986
[e] Radian Corporation, 1991

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Carswell Air Force Base, Texas

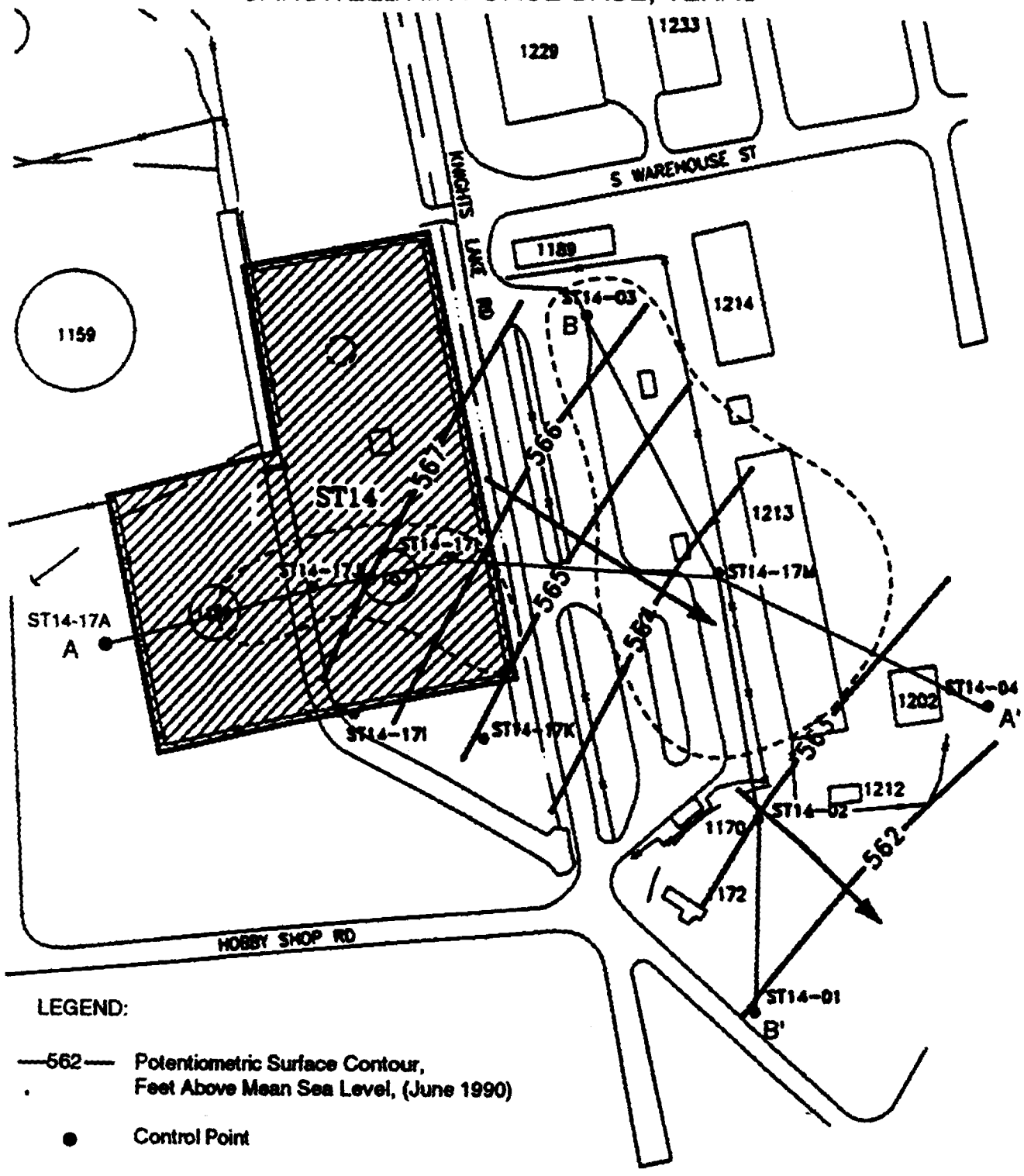
SITE IDENTIFICATION	SITE DESCRIPTION	BACKGROUND CONC.	SOURCE			MIGRATION PATHWAY	RECEPTOR/ EXPOSED POPULATION
			Contaminants	Maximum Concentration	Media		
Site SD13 - Unnamed Stream and abandoned gas station	The Unnamed Stream is a small tributary of Farmer's Branch. It receives its perennial flow from an oil/water separator at the end of a french underdrain system. The abandoned gas station is a nearly level, paved area where a base gasoline station was formerly located.	No data	PHASE II STAGE 2 DATA[a] (continued)				
			Volatile Organics	µg/L			
			Benzene	2.0	Ground Water		Site residents; potential future use; ingestion, inhalation of volatiles, and dermal contact
			Chlorobenzene	3.6	Ground Water		
			Toluene	59.0	Ground Water		Humans: dermal contact and ingestion of fish from Farmer's Branch
			Water Quality Indicators	mg/L			
			Chloride	26.0	Ground Water		Local Fauna: Possible biological uptake-vegetation
			Fluoride	0.29	Ground Water		
			Nitrate	0.14	Ground Water		Local residents; potential future use
			Sulfate	13.0	Ground Water		
			Total Dissolved Solids	460.0	Ground Water		

[a] Concentrations were determined from surface and subsurface soil samples and reported in Radian Corporation, 1986.
[b] Samples collected from oil/water separator and reported in Radian Corporation, 1986.
[c] Samples collected from Unnamed Stream and data reported by Radian, 1991.
[d] Radian Corporation, 1986
[e] Radian Corporation, 1991

FIGURE 2-15

SITE CHARACTERIZATION PLAN VIEW, SITE ST-14
BENZENE DETECTION AND POTENTIOMETRIC CONTOURS

CARSWELL AIR FORCE BASE, TEXAS

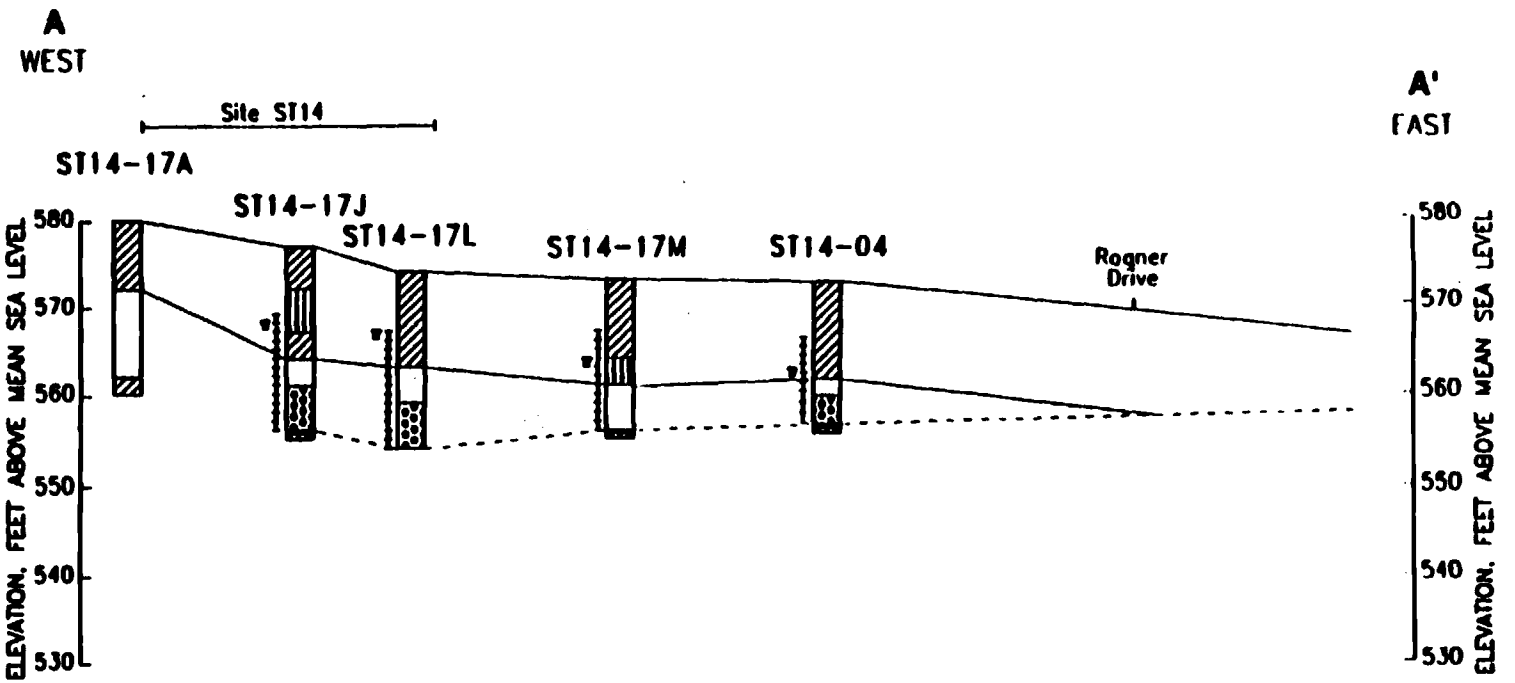


DATA COMPILED FROM STAGE 1 AND STAGE 2 RI REPORTS PREPARED BY RADIAN CORPORATION

FIGURE 2-16

CROSS SECTION A-A', SITE ST-14

CARSWELL AFB, TEXAS



LEGEND:

- Clay and Fill Material
- Silt
- Sand
- Sand and Gravel
- Limestone and Shale
- Top of Bedrock
- Soil Contact
- Water Level, June/1990
- Screened Interval

0 100 200 400

FEET

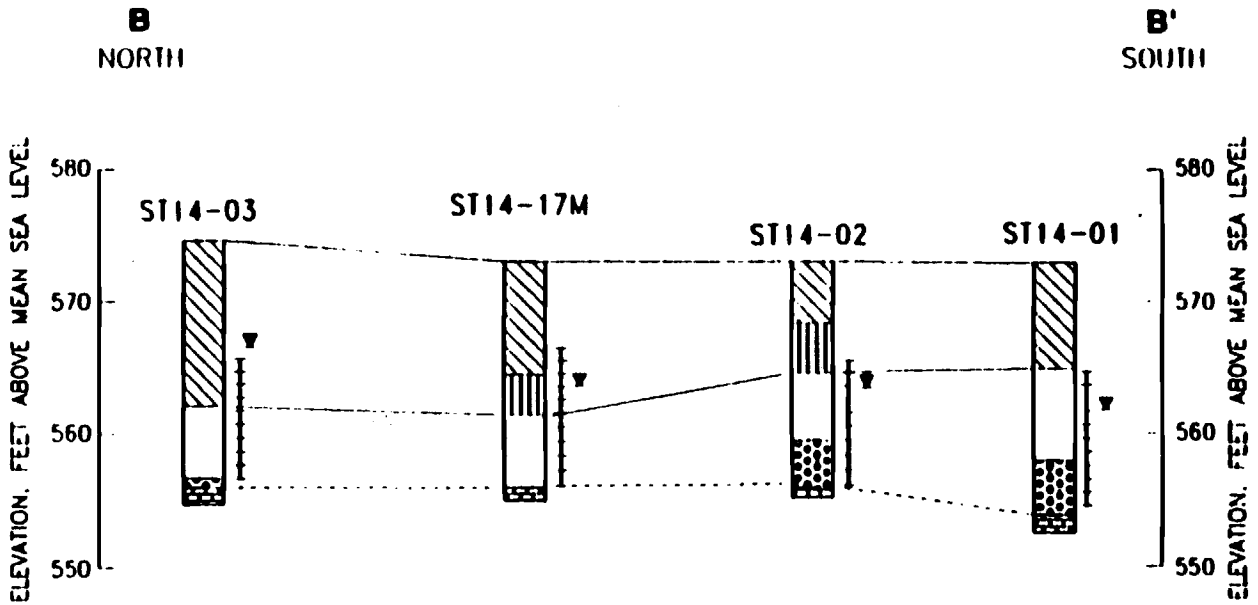
Vertical Exaggeration: 12.5x

DATA COMPILED FROM STAGE 1 AND STAGE 2 RI REPORTS
PREPARED BY RADIAN CORPORATION

FIGURE 2-17

CROSS-SECTION B-B', SITE ST-14

CARSWELL AFB, TEXAS



LEGEND:

- Clay and Fill Material
- Silt
- Sand
- Sand and Gravel
- Limestone and Shale
- Top of Bedrock
- Soil Contact
- Water Level, June/1990
- Screened Interval

0 100 200 400

FEET

Vertical Exaggeration: 12.5x

(DATA COMPILED FROM STAGE 1 AND STAGE 2 RI REPORTS PREPARED BY RADIAN CORP.)

CP

FIGURE 2-18

SITE CHARACTERIZATION PLAN VIEW, SITE SD-13 GROUND-WATER CONTOURS

CARSWELL AIR FORCE BASE, TEXAS

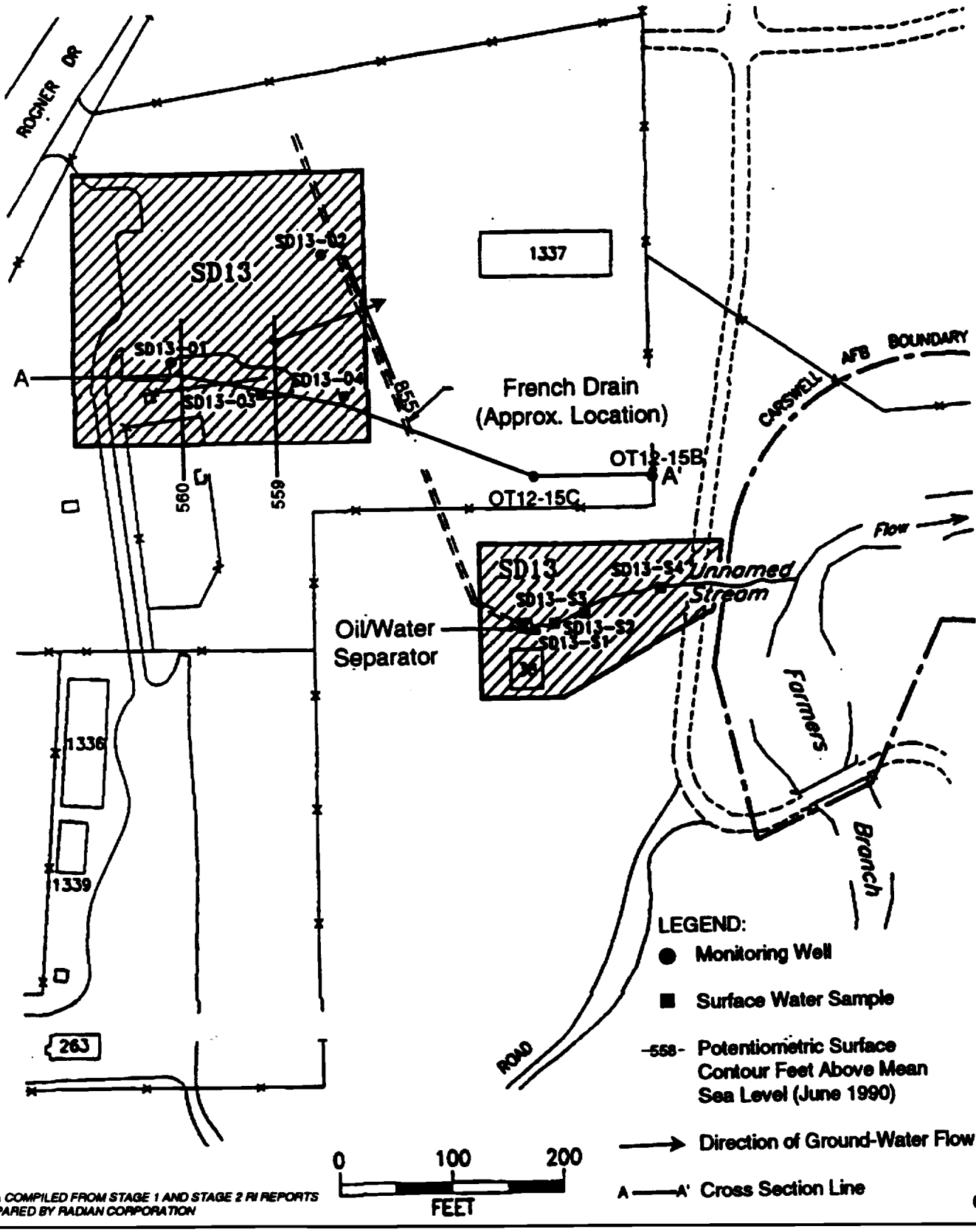
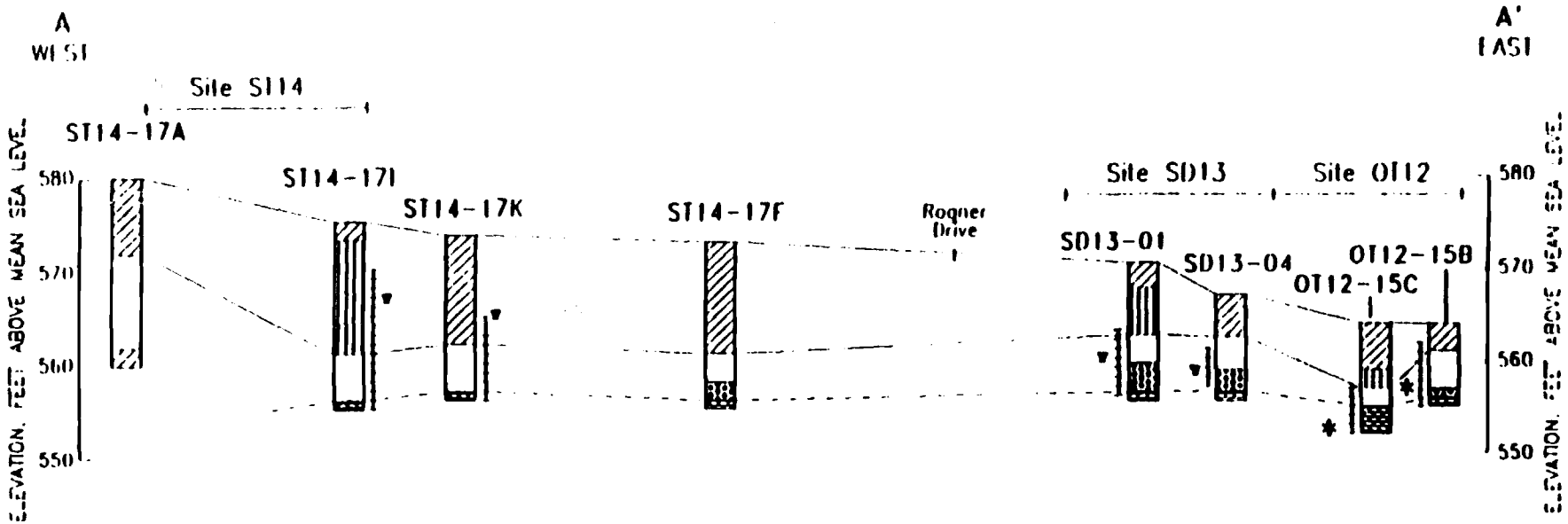


FIGURE 2-19

CROSS-SECTION A-A', SITE SD-13

CARSWELL AFB, TEXAS



LEGEND:

- Clay and Fill Material
- Silt
- Sand
- Sand and Gravel
- Limestone and Shale
- Top of Bedrock
- Soil Contact
- Water Level, June/1990
- Screened Interval
- Water Level Not Taken

0 100 200 400

FEET

Vertical Exaggeration 12.5x

(DATA COMPILED FROM STAGE 1 AND STAGE 2 RI REPORTS PREPARED BY RADIAN CORP.)

CP

Since no background sampling has been identified in the current scope, this could be a data gap.

2.3.1 Potential Sources

There are two potential sources of constituents of concern for the sites of concern. The potential sources are:

- leaks and/or spills from above ground tanks or a pipeline that previously existed at the POL Tank Farm
- leaks and/or spills from the abandoned gas station at site SD-13

According to Radian, fuel was discovered in the 1960s in the ground at the POL Tank Farm and downgradient. The report does not state whether fuel was originally discovered by observation, or by collection of soil or ground water samples. Following the discovery, a french drain collection system was reportedly installed in 1965 (Radian, 1986) downgradient of the Tank Farm. The french drain has its outlet at an underground oil/water separator which discharges to the Unnamed Stream. Reports by previous investigators do not establish the source of the constituents collected by the French drain system. Information on the leaks or spills from the abandoned gas station was also unavailable.

The potential sources of contamination may be affecting the following media:

Ground Water: The upper zone aquifer, which may flow to surface water in Farmers Branch and/or West Fork Trinity River.

Surface Water:	Unnamed Stream and Farmer's Branch (tributary of the West Fork of the Trinity River).
Sediment:	Unnamed Stream and Farmer's Branch.
Soil:	Surface, which may provide an exposure pathway under future use conditions.
	Subsurface, which may serve as a source of contamination to the upper zone ground-water aquifer.

2.3.2 Exposure Routes and Receptors

In areas of surface soil contamination, inhalation exposure to fugitive dust or volatile organic vapors must be considered as a potential exposure route for employees and future site residents on Carswell AFB, including terrestrial animals. Current residents are at a distance from the two sites which would not be likely to be impacted by fugitive dust or volatiles. According to previous reports, surface soil along the Unnamed Stream may be contaminated with low levels of lead and selenium (Radian, 1986).

Infiltration through contaminated subsurface soils may have resulted in contamination of the upper zone aquifer. Underlying aquifers at the Base may be protected by the presence of the Goodland/Walnut Aquitard. Since ground water in the upper zone aquifer is not currently a source of potable water for residents in the area, potential ground-water exposure pathways for local residents and employees of Carswell AFB are not complete.

According to a previous investigation, shallow ground water from sites ST-14 and SD-13 may migrate to Farmer's Branch (Radian,

1991). Surface runoff from sites ST-14 is not a concern, because the ground surface is level and is covered with gravel and rocks or is vegetated. The source area at SD-13 is paved, and therefore, would not contribute contaminated runoff. Shallow ground water that migrates to Farmer's Branch would be diluted considerably by the time flow enters the West Fork of the Trinity. The West Fork of the Trinity may be used for recreation (swimming, wading or fishing) by local (off-site) residents, and as a source of water and food for local wildlife. Therefore, recreation exposures such as ingestion of contaminated fish, dermal exposure and incidental ingestion though contact with surface water may be considered. Interviews with local officials and a review of available documentation on classification of the waterways will be conducted to determine if recreational use is plausible. Terrestrial and aquatic wildlife may be exposed to constituents present in surface waters by ingestion, inhalation of volatile emissions and dermal contact.

2.3.3 Summary of Previous Baseline Risk Assessment

The Phase II, Stage 2 RI report prepared by Radian included a preliminary baseline risk assessment using the Superfund Public Health Evaluation Manual (EPA, 1986). Radian conducted a quantitative risk assessment based on the selection of indicator chemicals. Indicator chemicals selected include benzene, methylene chloride, toluene, trichloroethene, and vinyl chloride.

2.3.3.1 Site SD-13 Unnamed Stream and Abandoned Gasoline Station - The migration pathways identified by Radian for this site were:

- Volatilization to air
- Fugitive dust generators
- Leachate from soil to ground water

- Surface runoff
- Discharge of Unnamed Stream to Farmer's Branch

Human exposure pathways considered to be complete in the Radian report were:

- By persons residing and/or working nearby
- Inhalation of constituents volatilized from soil
- Uptake by fish and other aquatic organisms/ingestion of aquatic organisms;
- Human ingestion of meat and diary products from animals that ingest contaminated surface water
- Dermal contact during recreational use of surface water.

Exposure pathways to ecological receptors considered to be complete were:

- Ingestion of surface water by terrestrial and aquatic fauna
- Inhalation of ambient air by aquatic fauna

Pathways considered to be incomplete were:

- Inhalation of fugitive dust by persons residing and/or working nearby,
- Leaching from soil to ground water and domestic or agricultural use of ground water,
- Use of surface water (West Fork of the Trinity River) as a potable source.

Risk was quantified for inhalation of volatile chemicals. Receptors were defined as persons living or working downwind of the site; footnotes in Radian's tables indicate that adult residential exposure scenarios were used. "Day care" refers to adults residing at the location of a proposed day care center. Other pathways were not quantified. Radian estimated noncarcinogenic and carcinogenic risks due to inhalation of chemicals released from Site SD-13. The Hazard Indices (HI) attributed to systemic toxicants were as follows:

On-site maximum HI: 2.33×10^{-6}
Off-site maximum HI = 2.60×10^{-7}
Individuals exposed at Day Care Facility HI = 4.90×10^{-9}

Because these levels are significantly less than one (1), the calculated HIs are acceptable.

Estimated total incremental excess cancer risks attributable to inhalation exposure were:

On-site Maximum Exposed Individuals	1.4×10^{-8}
Off-site Maximum Exposed Individuals	1.5×10^{-9}
Individuals Exposed at Day Care Facility	2.8×10^{-11}

These risk levels were described as inconsequential.

Potential exposures via ingestion of meat and diary products, contaminated surface water and contaminated fish were judged by Radian to be minimal,and risks were not quantified. Potential exposures via dermal contact with surface water were also judged to be minimal and risks were not quantified (Radian, 1991a).

Radian stated that contaminants in surface water at Unnamed Stream or Farmers Branch "pose some risk" to terrestrial wildlife that use

these sources for drinking water. Species of wildlife that could be exposed to surface water were not identified.

2.3.3.2 Site ST-14 POL Tank Farm - Potential transport of ground-water contaminants in the upper zone to surface water in Farmer's Branch, and the release of volatiles from soil to the air were the primary fate and transport mechanisms identified for Site ST-14. Exposure pathways identified as complete by Radian were:

- Inhalation of volatile emissions from soil;
- Inhalation of volatiles (released from soil) by animals: Ingestion of meat and dairy products;
- Uptake by fish and other aquatic organisms: Ingestion of aquatic organisms;
- Ground-water migration to surface water, ingestion of surface water by farm animals: Ingestion of meat and diary products by humans;
- Ground-water migration to surface water: Dermal contact with surface water during recreation; and
- Inhalation of volatile emissions released from surface water (Radian, 1991a).

Pathways determined to be incomplete for the POL Tank farm were:

- Inhalation of fugitive dust;
- Leaching from soil to ground water and domestic or agricultural use of ground water;

- Discharge of surface runoff to surface water, and exposure to surface water.

Risk characterization was only conducted for the inhalation of volatiles pathway. Risk for other pathways were not quantified. Receptors were assumed to be the same as for Site SD-13. The Hazard Indices attributable to exposure to multiple systemic toxicants were:

On-site maximum HI = 6.30×10^{-6}
Off-site maximum HI = 1.43×10^{-6}
Individuals Exposed at Day Care Facility HI = 1.20×10^{-7}

Estimated total incremental individual excess cancer risks for exposures associated with the inhalation of volatile emissions were:

On-site Maximum Exposed Individual	5.7×10^{-8}
Off-site Maximum Exposed Individual	1.1×10^{-8}
Individual Exposed at Day Care Facility	9.4×10^{-10}

2.3.3.4 Conclusion - Based on the data available at the time, Radian Corporation prepared risk estimates for inhalation of volatile chemicals released from the sites. Law Environmental will use the data generated by the current investigation to quantify risk using the latest USEPA risk assessment guidance (EPA, 1989). The baseline risk assessment prepared by Law will address exposures to the receptors/exposed populations defined in the Conceptual Site Model Summaries, Tables 2-3 and 2-4. Quantification of risks will include only data collected by Law. If risks identified by Law differ significantly from risks estimated by Radian, further evaluation of risk and consolidation of data will be recommended.

2.4 PRELIMINARY REMEDIAL ACTION ALTERNATIVES

The objective of preliminary identification of remedial action alternatives is to identify remediation options that insure maximum protectiveness of human health and the environment. For the Carswell AFB sites, identification of remedial action alternatives is preliminary and will be refined based on additional data generated during the RI. Site-specific conditions, which will be further elucidated during the RI/FS, will dictate the final selection and sequence of remedial alternatives and technologies.

2.4.1 Selection Criteria for Remedial Alternatives

After each site has been completely characterized, remedial alternatives will be selected in a two phase manner and evaluated against nine specific criteria. The first stage of the selection process is an Initial Screening step, during which time the number of proposed remedial options will be reduced, but the range of options will be retained. As a portion of the Initial Screening process, remedial alternatives will be assessed to investigate interactions among the various contaminated media in terms of both the evaluation of technologies and sitewide protectiveness. The Initial Screening will evaluate each alternative with respect to the following criteria:

- Implementability
- Effectiveness
- Cost

The effectiveness of an alternative refers to its ability to adequately protect human health and the environment. Short-term effectiveness refers to protection during the construction and implementation period; long-term effectiveness refers to protection

during the period after remedial action is complete. Remedial options will be evaluated on a cost basis to determine which options are prohibitively costly prior to the Detailed Analysis step. Only the alternatives shown to be viable in terms of these criteria will be subjected to further consideration in the Detailed Analysis step of the selection process.

During the Detailed Analysis phase of remedial action selection, those alternatives that were shown to be implementable, effective, and cost-effective during the Initial Screening phase will be examined in further detail. As outlined by EPA (EPA, 1988), there are nine criteria that will be used as standards against which remedial alternatives will be judged during the Detailed Analysis phase of selection. These are:

Short-term Effectiveness Emphasizes the effects of the alternative during construction and implementation phase, until remedial response objectives have been met.

Long-term Effectiveness Addresses the magnitude of residual risk and the adequacy and reliability of controls for residual management, if required.

Overall Protection Of Human Health And The Environment Considers how site risks can be minimized, eliminated or controlled relative to human health and the environment.

Reduction Of Toxicity, Mobility Or Volume Estimates toxicity, mobility or volume reduction of contaminates as a consequence of treatment.

Implementability Evaluates implementability from a technical standpoint (ease of installation and start-up, difficulty of operation, reliability,...) and from an administrative perspective (permitting, availability of services and materials,...).

Cost Compares each alternative's capital costs, annual operations and maintenance, and costs of future actions in the event of remedial action failure.

Compliance With ARARs Judges compliance with chemical-specific, location-specific and action-specific ARARs.

State Acceptance Evaluates concerns the state (or support agency) may have regarding implementation of each alternative.

Community Acceptance Evaluates issues or concerns the public may have concerning alternative implementation.

2.4.2 Media-Specific Remedial Action Objectives

Early development of remedial action objectives is important for protection of human health and the environment. Protection of human health includes the prevention of inhalation, ingestion, or dermal contact with contaminants present in impacted media. Protection of the environment includes the prevention of contaminant migration and the prevention of contaminant contact with receptors. Remedial action goals stress the restoration of ground water and soils to environmentally safe contaminant levels.

There are two sites of concern at Carswell AFB identified for this effort; these sites are the POL Tank Farm Site (Site ST-14) and the Unnamed Stream Site (Site SD-13). Based on the currently available information pertaining to these two sites at Carswell AFB, it has been hypothesized that soils and ground water are the only impacted media present at both of these sites. Also, at the Unnamed Stream site, the potential exists for contamination of sediment and surface water. Therefore, remedial action objectives and alternatives for all of the media listed above are addressed by this document.

2.4.2.1 Ground Water - Remedial action objectives for human health are designed to prevent ingestion/direct contact with ground water having carcinogens in excess of MCLs or a total excess cancer risk greater than 10^{-4} to 10^{-6}. Objectives are also designed to prevent ingestion of water containing non-carcinogens in excess of MCL(s) or their reference doses. Remedial action objectives for environmental protection are to restore ground-water quality to acceptable concentrations.

2.4.2.2 Soils - Remedial action objectives for human health are developed to prevent ingestion/direct contact with soil having non-carcinogen(s) in excess of reference doses. Objectives also are designed to prevent direct contact/ingestion with soil having 10^{-4} to 10^{-6} excess cancer risk levels, and to prevent inhalation of carcinogens posing excess cancer risk levels of 10^{-4} to 10^{-6}. Remedial action objectives for protection of the environment are developed to contain and/or remove potential sources from pathways which contribute to potential ground-water contamination.

2.4.2.3 Sediments - Response action objectives for human health are as follows: prevent ingestion/direct contact with soil having non-carcinogen(s) in excess of reference doses, and prevent direct contact/ingestion with soil having 10^{-4} to 10^{-6} excess cancer risk levels. Response action objectives for protection of the environment are to prevent releases of contaminants contained in sediments that would result in surface water levels in excess of ambient water quality criteria.

2.4.2.4 Surface Water - Response action objectives for human health are as follows: prevent ingestion/direct contact with ground water having carcinogens in excess of MCLs and a total excess cancer risk greater than 10^{-4} to 10^{-6}. Objectives are also

intended to prevent ingestion of water containing non-carcinogens in excess of MCL(s) or reference doses. Response action objectives for environmental protection are developed to restore ground-water quality to acceptable concentrations. Surface water containing unacceptable concentrations of constituents may be diverted and treated using varying treatment technologies.

2.4.3 Preliminary Remedial Action Alternatives

Preliminary remedial response actions and technologies are summarized by affected medium for each site in Table 2-5. These response actions have been developed based on the current level of knowledge available for each site. Remedial alternatives for each site are conceptually described in this section and incorporate the response actions outlined in Table 2-5. As more data are generated during the RI/FS procedure, these alternatives will be modified to reflect changes in the existing knowledge base for each site. Also presented below are brief synopses of existing or hypothesized contamination at each site. A conceptual identification of preliminary remedial alternatives is also provided.

2.4.3.1 POL Tank Farm (Site ST-14) - This site has not been fully characterized with respect to contaminant type, concentration, or areal extent. Previous investigations conducted at this site (Radian, 1991a) have revealed contamination of the ground water with benzene, toluene, ethylbenzene, xylene (BTEX), and chlorobenzene. Ethylbenzene was the most commonly encountered constituent; benzene was the only volatile organic compound detected at a concentration which exceeded its MCL. Two separate plumes of benzene have been identified. Over two feet of free product were detected at one monitoring well during a 1990 sampling event. Lead was detected at concentrations exceeding MCLs in three separate wells; chromium was detected in concentrations exceeding MCLs in one well. The RI report (Radian, 1991a), concluded that

TABLE 2-5

PRELIMINARY REMEDIAL RESPONSE ACTIONS AND REMEDIAL TECHNOLOGY TYPES FOR SITES AT CARSWELL AIR FORCE BASE
Carswell Air Force Base, Texas

SITE NAME	ENVIRONMENTAL MEDIA	PRELIMINARY REMEDIAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPES	POTENTIAL PROCESS OPTIONS
POL Tank Farm (ST-14)	Ground Water	No Action/Institutional Actions: No action Institutional controls Monitoring Containment Actions: Containment Collection/Treatment Actions: Collection, treatment, and discharge In-situ ground-water treatment	No Action/Institutional Options: Fencing Deed restrictions Containment Technologies: Capping Vertical barriers Horizontal barriers Extraction Technologies: Extraction wells Interception trenches Enhanced recovery Treatment Technologies: Physical treatment Chemical treatment Biological treatment In-situ treatment Disposal Technologies: Discharge to POTW (after treatment) Discharge to surface water (after treatment) Discharge to aquifer (after treatment) Off-site treatment (in a RCRA-permitted facility, if hazardous waste)	Capping: Clay cap, soil, concrete, synthetic membranes Vertical Barriers: Slurry wall, sheet piling, vibrating beam, hydraulic barriers Horizontal Barriers: Liners, grout injection, hydraulic barriers Ground-Water Collection: Wells (subsurface or leachate collection), interception trenches, pumping Enhanced Removal: Oil recovery by skimming Physical Treatment: Coagulation/ flocculation, oil/water separation, carbon adsorption, sand filtration, steam stripping Chemical Treatment: Ion exchange, oxidation reduction reactions, precipitation/ sedimentation, reverse osmosis In-Situ Treatment: In-situ bioremediation Biological Treatment: Above-ground bioreactors

TABLE 2-5

PRELIMINARY REMEDIAL RESPONSE ACTIONS AND TECHNOLOGY TYPES FOR SITES AT CARSWELL AIR FORCE BASE
Carswell Air Force Base, Texas

SITE NAME	ENVIRONMENTAL MEDIA	PRELIMINARY REMEDIAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPES	POTENTIAL PROCESS OPTIONS
POL Tank Farm (ST-14)	Soil	No Action/Installation Actions: No action Access restrictions Institutional controls Containment Actions: Containment Excavation/Treatment Actions: Excavation and disposal In-situ treatment Excavation and treatment/disposal	No Action/Institutional Options: Fencing Deed restrictions Containment Technologies: Capping Vertical barriers Horizontal barriers Grading Revegetation Diversion and Collection Removal Technologies: Soil excavation Treatment Technologies: Physical treatment Chemical treatment Biological treatment In-situ treatment Thermal treatment Disposal Technologies: Backfill (after treatment, if non-hazardous waste) Off-site landfill (Subtitle C or D, depending on the type of waste) Off-site treatment (in a RCRA-permitted facility, if hazardous waste)	Capping: Clay cap, concrete cap, soil, synthetic membranes Vertical Barriers: Slurry wall, sheet piling, vibrating beam, hydraulic barriers Horizontal Barriers: Liners, grout injection, hydraulic barriers Physical Treatment: Water/solids leaching (with liquids treatment), dewatering, soil shredding Chemical Treatment: Soil washing In-Situ Treatment: In-situ bioremediation, in-situ vapor extraction, in-situ soil flushing Biological Treatment: Above-ground bioreactors, landfarming Thermal Treatment: Incineration, pyrolysis, asphalt batching, low temperature thermal desorption

TABLE 2-5

PRELIMINARY REMEDIAL RESPONSE ACTIONS AND TECHNOLOGY TYPES FOR SITES AT CARSWELL AIR FORCE BASE
Carswell Air Force Base, Texas

SITE NAME	ENVIRONMENTAL MEDIA	PRELIMINARY REMEDIAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPES	POTENTIAL PROCESS OPTIONS
Unnamed Stream (SD-13)	Ground Water	No Action/Institutional Actions: No action Institutional controls Monitoring Containment Actions: Containment Collection/Treatment Actions: Collection, treatment, and discharge In-situ ground-water treatment	No Action/Institutional Options: Fencing Deed restrictions Containment Technologies: Capping Vertical barriers Horizontal barriers Extraction Technologies: Extraction wells Interception trenches Existing French Drain system Treatment Technologies: Physical treatment Chemical treatment Biological treatment In-situ treatment Disposal Technologies: Discharge to POTW (after treatment) Discharge to surface water (after treatment) Discharge to aquifer (after treatment) Off-site treatment (in a RCRA permitted facility, if hazardous waste)	Capping: Clay cap, soil, concrete, synthetic membranes Vertical Barriers: Slurry wall, sheet piling, vibrating beam, hydraulic barriers Horizontal Barriers: Liners, grout injection, hydraulic barriers Ground-Water Collection: Wells (subsurface or leachate collection), interception trenches, pumping Physical Treatment: Coagulation/ flocculation, oil/water separation, carbon adsorption, sand filtration, steam stripping Chemical Treatment: Ion exchange, oxidation reduction reactions, precipitation/sedimentation, reverse osmosis In-Situ Treatment: In-situ bioremediation Biological Treatment: Above-ground bioreactors

TABLE 2-5

PRELIMINARY REMEDIAL RESPONSE ACTIONS AND TECHNOLOGY TYPES FOR SITES AT CARSWELL AIR FORCE BASE
Carswell Air Force Base, Texas

SITE NAME	ENVIRONMENTAL MEDIA	PRELIMINARY REMEDIAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPES	POTENTIAL PROCESS OPTIONS
Unnamed Stream (SD-13)	Soil	No Action/Installation Actions: No action Access restrictions Institutional controls Containment Actions: Containment Source removal Excavation/Treatment Actions: Excavation and disposal In-situ treatment Excavation and treatment/disposal	No Action/Institutional Options: Fencing Deed restrictions Containment Technologies: Capping Vertical barriers Horizontal barriers Grading Revegetation Diversion and Collection Removal Technologies: Soil excavation Treatment Technologies: Physical treatment Chemical treatment Biological treatment In-Situ treatment Thermal treatment Disposal Technologies: Backfill (after treatment, if nonhazardous waste) Off-site landfill (Subtitle C or D, depending on the type of waste) Off-site treatment (in a RCRA-permitted facility, if hazardous waste)	Capping: Clay cap, concrete cap, soil, synthetic membranes Vertical Barriers: Slurry wall, sheet piling, vibrating beam, hydraulic barriers Horizontal Barriers: Liners, grout injection,hydraulic barriers Physical Treatment: Water/solids leaching (with liquids treatment), dewatering, soil shredding Chemical Treatment: Soil washing In-Situ Treatment: In-situ bioremediation, in-situ vapor extraction, in-situ soil flushing Biological Treatment: Above-ground bioreactors, landfarming Thermal Treatment: Incineration, pyrolysis, asphalt batching, low temperature thermal desorption

TABLE 2-5

PRELIMINARY REMEDIAL RESPONSE ACTIONS AND TECHNOLOGY TYPES FOR SITES AT CARSWELL AIR FORCE BASE

Carswell Air Force Base, Texas

SITE NAME	ENVIRONMENTAL MEDIA	PRELIMINARY REMEDIAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPES	POTENTIAL PROCESS OPTIONS
Unnamed Stream (SD-13)	Surface Water	No Action/Institutional Actions: No action Access restrictions Monitoring Collection/Treatment Actions: Surface water diversion/interception, collection, treatment, and discharge	No action/Institutional Options: Fencing Collection Technologies: Surface controls Treatment Technologies: Physical treatment Chemical treatment Biological treatment (Organics only) In-situ treatment Disposal Technologies: Discharge to POTW (after treatment) Discharge to surface water (after treatment) Off-site treatment (in a RCRA permitted facility, if hazardous waste)	Surface Controls: Grading, diversion, and collection trenches Physical Treatment: Coagulation/ flocculation, oil/water separation, air stripping, carbon adsorption, sand filtration, steam stripping Chemical Treatment: Ion exchange, precipitation/sedimentation, oxidation/reduction, lime softening, reverse osmosis In-Situ Treatment: In-situ bioremediation Biological Treatment: Above-ground bioreactors

TABLE 2-5

PRELIMINARY REMEDIAL RESPONSE ACTIONS AND TECHNOLOGY TYPES FOR SITES AT CARSWELL AIR FORCE BASE
Carswell Air Force Base, Texas

SITE NAME	ENVIRONMENTAL MEDIA	PRELIMINARY REMEDIAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPES	POTENTIAL PROCESS OPTIONS
Unnamed Stream (SD-13)	Sediments	No Action/Installation Actions: No action Access restrictions Monitoring Removal/Treatment Actions: Dredging and disposal In-situ treatment Dredging and treatment/disposal	No Action/Institutional Options: Fencing Containment Technologies: Capping Vertical barriers Horizontal barriers Sediment control barriers Removal Technologies: Excavation Dredging Treatment Technologies: Physical treatment Chemical treatment Biological treatment (Organics only) In-situ treatment Thermal treatment (Organics only) Solidification/Fixation treatment Disposal Technologies: Off-site landfill (Subtitle C or D, depending on the type of waste) Off-site treatment (in a RCRA-permitted facility, if hazardous waste)	Capping: Clay cap, synthetic membranes Vertical Barriers: Slurry wall, sheet piling Horizontal Barriers: Liners, grout injection Sediment Control Barriers: Coffer dams, curtain barriers, capping barriers Physical Treatment: Freeze crystallization, dewatering Chemical Treatment: Neutralization, dechlorination, oxidation/reduction In-Situ Treatment: In-situ bioremediation, in-situ fixation/ stabilization Biological Treatment: Above-ground bioreactors, composting, landfarming Thermal Treatment: Asphalt kilns (low temperature), incineration, pyrolysis Solidification/Fixation Technologies: Encapsulation, fixation with cementacious material, fixation using kaolinitic materials, sorption

ground-water contamination is principally due to organic compound contamination resulting from fuel related sources.

The objective of the current field effort is better delineate the existing plume(s) of contamination known to exist at this site and also to further characterize the nature and extent of the soil and ground-water contamination. Based on currently available information, the contamination at this site appears to be confined to soil and ground water and is consistent with releases of petroleum fuels, with the possibility of association of fuel-related metals (e.g. - lead) contamination of soil and ground water as well.

The potential remedial alternatives for contaminated ground water at this site all include, as a component, the initiation of a ground-water monitoring program. Specific potential remedial alternatives for ground water at this site include the following:

1. No action
2. In-situ bioremediation (for organics only)
3. Extraction, pretreatment using oil/water separation (for the free product) followed by primary treatment for organics and metals (if required), and discharge to either the POTW, the aquifer, or to surface water. Extraction and primary treatment technologies that could be utilized are summarized in Table 2-5.

Potential remedial alternatives for contaminated soil at this site are listed below.

1. No action
2. In-situ soil vapor extraction (for organics only)
3. Excavation and aboveground treatment using bioremediation, vapor extraction, or thermal treatment (for organics only).

4. In-situ bioremediation (bioventing - for organics only)
5. Excavation and off-site disposal (landfilling)

Based on currently available information concerning this site, it is not anticipated that either soil or ground water will be contaminated with a listed hazardous waste. The above referenced alternatives assume disposal of non-hazardous waste only. If hazardous waste is encountered, the above alternatives are still applicable to soil and ground water, with the additional option for ground water treatment of off-site shipment to an industrial wastewater treatment facility. Furthermore, if hazardous waste is detected, on-site treatment of the waste may require a RCRA permit, off-site landfilling must be in a Subtitle C landfill (with the possibility of potential pretreatment to comply with Land Disposal Restrictions), and off-site treatment of the waste must occur in a RCRA permitted facility.

2.4.3.2 Unnamed Stream (SD-13) - This site is comprised of two areas: a paved lot near an abandoned gasoline station, the French drain system and associated oil/water separator that leads into the Unnamed Stream, and the Unnamed Stream itself. Previous investigations at this site have demonstrated the presence of organic compounds in ground water (probably originating from fuels), but the former service station was not implicated as a potential source. It has not yet been determined whether USTs still exist at the site.

No metals were detected above MCLs in ground water from this site. No volatile organic compounds were detected in the surface water from the Unnamed Stream, although low levels of aromatic compounds were previously detected (Radian, 1991). The areas where volatile organics were detected are localized upstream, around the oil/water separator, with levels declining further downstream. Current data indicates that metals in the Unnamed Stream will preferentially adsorb and be bound to sediments in the stream, thus creating a

metals sink. A probable source of the fuel contamination was speculated to be the POL Tank Farm in the previous FS report (Radian, 1991b).

Potential environmental media of concern for Carswell AFB include ground water, soil, sediment, and surface water. Site ground water and surface water appear to be somewhat impacted by petroleum fuel contamination, based on the Radian RI report (Radian, 1991a). Soil may also be impacted, as may sediments. Potential remedial alternatives for all four matrices are presented in this report and are based on currently available information concerning this site. These alternatives are based on currently available information concerning each site and may be revised as more data is received. The objective of the current field effort is to better define the nature and extent of contamination across applicable environmental media at this site.

There may be buried USTs on site from the abandoned service station. If detected, these USTs will need to be removed or closed in accordance with federal (40 CFR 280) and state (Texas Water Commission) closure regulations. Soil and/or ground water that has become contaminated as a result of leaking USTs (if the USTs are leaking) can be addressed as described below. The existing French Drain System and oil/water separator do not appear to be a source of contamination. These systems could be incorporated into the final remedial alternatives selected for ground water remediation at this site if it is necessary. Some modification/enhancement of the current system's efficiency and/or capacity may be required for future use for remediation purposes.

All potential remedial alternatives for ground water at this site include the initiation of a ground-water monitoring program. Specific remedial alternatives are listed below:

1. No action
2. In-situ bioremediation (for organics only)

3. Extraction, treatment for organics and metals (if required), and discharge to either the POTW, the aquifer, or to surface water (Unnamed Stream). Extraction and primary treatment technologies that can be utilized are summarized in Table 2-5.

Potential remedial alternatives for soils (if contaminated) are summarized below:

1. No action
2. Excavation and aboveground treatment using bioremediation or thermal treatment (for organics only).
3. In-situ bioremediation (bioventing - for organics only).
4. Excavation and off-site disposal (landfilling).
5. Source removal (i.e. - remediation of the POL Tank Farm).

Potential remedial alternatives for sediments (if contaminated) are listed below:

1. No action
2. Dredging, dewatering, on-site treatment for metals (and/or organics, if required), and on- or off-site disposal. Specific treatment technologies are described in Table 2-5.

3. Dredging, dewatering, and off-site disposal.

Potential remedial alternatives for surface water (if contaminated) are listed below:

1. No action
2. Diversion, treatment for organics and metals (if required), and discharge to either the POTW or the stream bed. Diversion and treatment technologies that can be utilized are summarized in Table 2-5.

Based on currently available information concerning this site, it is not anticipated that either soil or ground water will be contaminated with a listed hazardous waste. The above referenced alternatives assume disposal of non-hazardous waste only. If hazardous waste is encountered, the above alternatives are still applicable to soil, ground-water, sediment, and surface water. The additional option for ground-water and surface water treatment followed by off-site shipment to an industrial wastewater treatment facility may be necessary if material is hazardous. Furthermore, if hazardous waste is detected, on-site treatment of waste may require a RCRA permit, off-site landfilling must be in a Subtitle C landfill (with the possibility of potential pretreatment to comply with Land Disposal Restrictions), and off-site treatment of waste must occur in a RCRA permitted facility.

2.5 SUMMARY OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) AND TO BE CONSIDERED (TBC) REQUIREMENTS

A basic objective under the Installation Remediation Program (IRP) is that all remedial response actions must comply with environmental regulations or requirements which are determined to be "applicable or relevant and appropriate," or ARARs. This section identifies potential ARARs for the sites of concern at Carswell AFB based on the preliminary conceptual site model and preliminary remedial action alternatives. In general, the identification process involves comparing a number of site-specific factors with statutory or regulatory requirements. These factors may include:

- hazardous substances present
- types of remedial actions considered
- physical circumstances of the site

Three types of ARARs exist: chemical-, location-, and action-specific. Chemical-specific ARARs provide quantitative limits on contaminants in the environment. Location-specific ARARs limit activities in environmentally sensitive areas. Action-specific ARARs provide design and performance standards for remedial activities.

In addition to the ARARs, requirements "to be considered" (TBCs) are also identified during the determination of remedial response objectives. The TBC requirements are non-promulgated advisory or guidance measures issued by state or federal government. They are not legally binding and do not carry the same weight as potential ARARs. However, the TBC requirements are used in conjunction with a site risk assessment to aid in determining the necessary level of cleanup for the protection of human and environmental health. Examples of TBC requirements are health advisories, reference doses (RfDs), and guidance policy documents developed to implement regulations.

Actions taken under the IRP may have to comply with several different types of requirements. The types of requirements are reflected in the classification of ARARs and TBC requirements discussed in the following sections. According to the Federal Facility Agreement, "with respect to releases of hazardous substances, pollutants, or contaminants, RCRA shall be considered an ARAR." However, only specific RCRA requirements are included in the proposed ARAR and TBC requirements list, as summarized in Table 2-6.

2.5.1 Chemical-Specific ARARs and TBC Requirements

Chemical-specific ARARs are usually health- or risk-based numerical action values or methodologies. When applied to site-specific conditions, they establish numerical action values, which are

TABLE 2-6

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) - FEASIBILITY STUDY
Carswell Air Force Base, Texas

TYPE OF ARAR	ARARs	DESCRIPTION	COMMENT
Chemical-Specific	Maximum Contaminant Levels (SDWA 40 CFR 141 Subpart B)	Establishes maximum contaminant levels (MCLs) which are health-based standards for public water systems.	The MCLs for organic and inorganic contaminants may be relevant and appropriate for ground-water cleanup.
	MCLs - Texas Drinking Water Standards (TAC 31, Part IX, Chapter 290)	Establishes state MCLs for public water systems.	The MCLs for organic and inorganic contaminants may be state ARARs.
	Alternate Cleanup Levels (RCRA 40 CFR 246.94)	Establishes alternate cleanup levels (ACLs) for public water systems.	Alternate cleanup levels may be applicable where it is not feasible to meet MCLs.
	Texas Cleanup Criteria of Releases from Petroleum Storage Tanks (TAC 31 Part 334)	Establishes cleanup standards for releases of petroleum products from storage tanks.	Provides different criteria based on ground-water quality.
Location-Specific	Flood Plain Management (Executive Order 11988 16 USE 661 et seq 40 CFR% 6.302, Appendix A)	Regulates action that will occur in a floodplain and relatively flat areas adjoining inland and coastal waters and other floodplain areas to avoid adverse effects due to flooding.	If the site is located in a floodplain, the order will be applicable.
	Protection of Wetlands (Executive Order 11990 40 CFR 6.302, Appendix A)	Regulates action involving construction of facilities or management of property in sc to avoid adverse effects, minimize potential harm, and preserve and enhance sc, to the extent possible.	Although no wetland areas appear to be present at the site; additional information is needed on classification of some areas.
	Endangered Species Act of 1973 (16 USE 1531-1544	Action to conserve or provide a program to conserve endangered or threatened species.	If species identified at the site are on the federal and state threatened and/or endangered lists, the Act will be relevant.
	Fish and Wildlife Protection (16 USE 661-usn; 16 USE 2901 et seq 33 CFR 320-330; 40 CFR 6.302)	Action to conserve fish and wildlife, particularly those species which are indigenous to the state. Wildlife conservation will be coordinated with other features of water resource development programs.	Several different species of animals are likely to occur in nearby surface water.
	Stormwater Discharge Requirements National Pollutant Discharge Elimination System (CWA 40 CFR 122.26)	Requirements under the storm water discharge including permitting and standards program.	Will be applicable if the site has storm water that comes in contact with elements of industrial activity or if selected remedy involves discharge of treated water to surface water.

TABLE 2-6

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) - FEASIBILITY STUDY
Carswell Air Force Base, Texas

TYPE OF ARAR	ARARs	DESCRIPTION	COMMENT
	Historic Site Protection (Executive Order 11593; 16 USC 461 et seq; 16 USC 469 et seq; 16 USC 470 et seq; 40 CFR 6.301)	Provides for the protection, enhancement, and preservation of sites of archaeological or historic significance.	Relevant if any structure or area at the site is designated as an Historic District or is listed on the National Register of Historic Places
	Texas Water Quality Standards (TAC 31 Part 307.6)	Regulates water for exiting aquatic life. Specifies that water should not be toxic to aquatic life.	Surface waters have been identified downgradient of the site.
	Texas Underground Storage Tanks Rules (TAC 31 Part 334)	Provides for the registration, removal from service, corrective action, and other applicable requirements associated with UST systems.	USTs may be located at Site SD13 and a pipeline may have been located at Site ST14.
Action-Specific			
No Action	None Identified		
Institutional Controls	Releases from Solid Waste Management Units (RCRA 40 CFR 264 Subpart F)	Regulations apply to owners and operators of facilities that treat, store or dispose of hazardous waste.	Will be applicable if hazardous waste is stored at the site.
Containment Actions	Occupational Safety and Health Standards for Air Contaminants (OSHA) (29 CFR 1910.1000)	Provides national standards of worker exposure to listed air contaminants.	Will be applicable if there is a potential for workers at the site to come in contact with listed air contaminants.
	National Ambient Air Quality Standards (NAAQS) (CAA 40 CFR Part 50)	Defines levels of air quality which are necessary to protect the public health.	Will be applicable if work at the site affects ambient air quality for such pollutants as particulate matter and carbon monoxide.
	Texas Clean Air Act (TAC 5, Subtitle C, Chapter 382)	Provides state emission standards for listed hazardous air pollutants and state air quality standards to protect the public health.	Will be applicable if remedy results in emission of any listed pollutants.
Treatment In-Situ Vapor Extraction	General Pretreatment Regulations for Existing and New Sources of Pollution for Publicly-Owned Treatment Works (POTW) (40 CFR Parts 401 and 403)	Provides effluent limitations guidelines for existing sources, standards of performance for new sources, and pre-treatment standard for new and existing sources.	Will be applicable if wastewater from remedy is discharged to a POTW.

TABLE 2-6

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) - FEASIBILITY STUDY
Carswell Air Force Base, Texas

TYPE OF ARAR	ARARs	DESCRIPTION	COMMENT
	National Pollutant Discharge Elimination System (NPDES) (CWA 40 CFR 122)	Regulates discharges of pollutants from any point source into waters of the U.S.	Will be applicable if water from the site is discharged into surface waters.
	Texas Water Effluent Limits and Standards	Limits the amounts of pollutants which can be discharged into state waterways.	Will be applicable if water is to be discharged to state waterways.
	Texas Water Quality Standards TAC (31-307.6)	Establishes water quality standards for protection of aquatic life.	Will be applicable if water is to be discharged to state waterways.
	Standards for Owners and Operators of Hazardous Treatment, Storage and Disposal Facilities (RCRA 40 CFR 264)	Regulations apply to owners or operators of facilities that treat, store, or dispose of hazardous waste.	Will be applicable if site activities are analogous to hazardous waste facility activities.
	National Ambient Air Quality Standards (NAAQS) (CAA 40 CFR Part 50)	Defines levels of air quality which are necessary to protect the public health.	Will be applicable if work at the site affects ambient air quality for such pollutants as particulate matter and carbon monoxide.
	National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 CFR 61)	Provides national emission standards for listed hazardous air pollutants.	Will be applicable if the remedy results in emission of any listed pollutants.
	Occupational Safety and Health Standards for Air Contaminants (OSHA) (29 CFR 1910.1000)	Provides national standards of worker exposure to listed air contaminants.	Will be applicable if there is a potential for workers at the site to come in contact with listed air contaminants.
Precipitation	General Pretreatment Regulations for Existing and New Sources of Pollution for Publicly-Owned Treatment Works (POTW) (40 CFR Parts 401 and 403)	Provides effluent limitations guidelines for existing sources, standards of performance for new sources, and pre-treatment standard for new and existing sources.	Will be applicable if wastewater for soil flushing is discharged to a POTW.
	National Pollutant Discharge Elimination System (NPDES) Requirements (CWA 40 CFR 122)	Regulates discharges of pollutants from any point source into waters of the U.S.	Will be applicable if water from the site is discharged to surface waters.
	Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities (RCRA 40 CFR 264)	Regulations apply to owners or operators of facilities that treat, store, or dispose of hazardous waste.	Will be applicable if the site activities are analogous to hazardous waste facility activities.

TABLE 2-6

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) - FEASIBILITY STUDY
Carswell Air Force Base, Texas

TYPE OF ARAR	ARARs	DESCRIPTION	COMMENT
	Texas Consolidated Permit Rules (TAC 31, Part IX, Chapter 290)	Limits the amounts of pollutants which can be discharged into state waterways.	Will be applicable if water is to be discharged to state waterways.
Neutralization	General Pretreatment Regulations for Existing and New Sources of Pollution for Publicly-Owned Treatment Works (POTW) (40 CFR Parts 401 and 403)	Provides effluent limitations guidelines for existing sources, standards of performance for new sources, and pre-treatment standard for new and existing sources.	Will be applicable if wastewater for soil flushing is discharged to a POTW.
	National Pollutant Discharge Elimination System (NPDES) Requirements (CWA 40 CFR 122)	Regulates discharges of pollutants from any point source into waters of the U.S.	Will be applicable if water from the site is discharged into surface waters.
	Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities (RCRA 40 CFR 264)	Regulations apply to owners or operators of facilities that treat, store, or dispose of hazardous waste.	Will be applicable if the site activities are analogous to hazardous waste facility activities.
	Texas Consolidated Permit Rules (TAC 31, Part IX, Chapter 290)	Limits the amounts of pollutants which can be discharged into state waterways.	Will be applicable if water is to be discharged to state waterways.
Sedimentation	General Pretreatment Regulations for Existing and New Sources of Pollution for Publicly-Owned Treatment Works (POTW) (40 CFR Parts 401 and 403)	Provides effluent limitations guidelines for existing sources, standards of performance for new sources, and pre-treatment standard for new and existing sources.	Will be applicable if wastewater for soil flushing is discharged to a POTW.
	National Pollutant Discharge Elimination System (NPDES) Requirements (CWA 40 CFR 122)	Regulates discharges of pollutants from any point source into waters of the U.S.	Will be applicable if water from the site is discharged into surface waters.
	Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities (RCRA 40 CFR 264)	Regulations apply to owners or operators of facilities that treat, store, or dispose of hazardous waste.	Will be applicable if the site activities are analogous to hazardous waste facility activities.
	Texas Consolidated Permit Rules (TX Title 311, Part IX, Chapter 305)	Limits the amounts of pollutants which can be discharged into state waterways.	Will be applicable if water is to be discharged to state waterways.

TABLE 2-6

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) - FEASIBILITY STUDY
Carswell Air Force Base, Texas

TYPE OF ARAR	ARARs	DESCRIPTION	COMMENT
Coagulation/Flocculation	General Pretreatment Regulations for Existing and New Sources of Pollution for Publicly-Owned Treatment Works (POTW) (40 CFR Parts 401 and 403)	Provides effluent limitations guidelines for existing sources, standards of performance for new sources, and pre-treatment standard for new and existing sources.	Will be applicable if wastewater for soil flushing is discharged to a POTW.
	National Pollutant Discharge Elimination System (NPDES) Requirements (CWA 40 CFR 122)	Regulates discharges of pollutants from any point source into waters of the U.S.	Will be applicable if water from the site is discharged into surface waters.
	Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities (RCRA 40 CFR 264)	Regulations apply to owners or operators of facilities that treat, store, or dispose of hazardous waste.	Will be applicable if the site activities are analogous to hazardous waste facility activities.
	Texas Consolidated Permit Rules (TAC 311, Part IX, Chapter 305)	Limits the amounts of pollutants which can be discharged into state waterways.	Will be applicable if water is to be discharged to state waterways.
Filtration	General Pretreatment Regulations for Existing and New Sources of Pollution for Publicly-Owned Treatment Works (POTW) (40 CFR Parts 401 and 403)	Provides effluent limitations guidelines for existing sources, standards of performance for new sources, and pre-treatment standard for new and existing sources.	Will be applicable if wastewater for soil flushing is discharged to a POTW.
	National Pollutant Discharge Elimination System (NPDES) Requirements (CWA 40 CFR 122)	Regulates discharges of pollutants from any point source into waters of the U.S.	Will be applicable if water from the site is discharged into surface waters.
	Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities (RCRA 40 CFR 264)	Regulations apply to owners or operators of facilities that treat, store, or dispose of hazardous waste.	Will be applicable if the site activities are analogous to hazardous waste facility activities.
	Effluent Limits and Standards Regulations	Limits the amounts of pollutants which can be discharged into state waterways.	Will be applicable if water is to be discharged to state waterways.
Absorption/Filtration	General Pretreatment Regulations for Existing and New Sources of Pollution for Publicly-Owned Treatment Works (POTW) (40 CFR Parts 401 and 403)	Provides effluent limitations guidelines for existing sources, standards of performance for new sources, and pre-treatment standard for new and existing sources.	Will be applicable if wastewater for soil flushing is discharged to a POTW.

TABLE 2-6

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) - FEASIBILITY STUDY
Carswell Air Force Base, Texas

TYPE OF ARAR	ARARs	DESCRIPTION	COMMENT
	National Pollutant Discharge Elimination System (NPDES) Requirements (CWA 40 CFR 122)	Regulates discharges of pollutants from any point source into waters of the U.S.	Will be applicable if water from the site is discharged into surface waters.
	Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities (RCRA 40 CFR 264)	Regulations apply to owners or operators of facilities that treat, store, or dispose of hazardous waste.	Will be applicable if the site activities are analogous to hazardous waste facility activities.
	Texas Consolidated Permit Rules (TAC 31, Part IX, Chapter 305)	Limits the amounts of pollutants which can be discharged into state waterways.	Will be applicable if water is to be discharged to state waterways.
Air Stripping	General Pretreatment Regulations for Existing and New Sources of Pollution for Publicly-Owned Treatment Works (POTW) (40 CFR Parts 401 and 403)	Provides effluent limitations guidelines for existing sources, standards of performance for new sources, and pre-treatment standard for new and existing sources.	Will be applicable if wastewater for soil flushing is discharged to a POTW.
	National Pollutant Discharge Elimination System (NPDES) Requirements (CWA 40 CFR 122)	Regulates discharges of pollutants from any point source into waters of the U.S.	Will be applicable if water from the site is discharged into surface waters.
	Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities (RCRA 40 CFR 264)	Regulations apply to owners or operators of facilities that treat, store, or dispose of hazardous waste.	Will be applicable if the site activities are analogous to hazardous waste facility activities.
	Effluent Limits and Standards Regulations	Limits the amounts of pollutants which can be discharged into state waterways.	Will be applicable if water is to be discharged to state waterways.
	National Ambient Air Quality Standards (NAAQS) (CAA 40 CFR Part 50)	Defines levels of air quality which are necessary to protect the public health.	Will be applicable if work at the site affects ambient air quality for such pollutants as particulate matter and carbon monoxide.
	National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 CFR 61)	Provides national emission standards for listed hazardous air pollutants.	Will be applicable if the remedy results in emission of any listed pollutants.
	Occupational Safety and Health Standards for Air Contaminants (OSHA 29 CFR 1910.1000)	Provides national standards of worker exposure to listed air contaminants.	Will be applicable if there is potential for workers at the site to come in contact with listed air contaminants.

TABLE 2-6

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) - FEASIBILITY STUDY
Carswell Air Force Base, Texas

TYPE OF ARAR	ARARs	DESCRIPTION	COMMENT
	Texas Clean Air Act (TAC 5 Subtitle C Chapter 382)	Provides state emission standards for listed hazardous air pollutants and state air quality standards to protect the public health.	Will be applicable if the remedy results in emission of any listed pollutants.
	Control of Air Pollution from Volatile Organic Compounds (TAC 31, Part III, Chapter 115)	Provides emission standards for volatile organic compounds.	May be applicable, if the remedy releases volatile organic compounds.
Collection/Treatment/Discharge	General Pretreatment Regulations for Existing and New Sources of Pollution for Publicly-Owned Treatment Works (POTW) (40 CFR Parts 401 and 403)	Provides effluent limitations guidelines for existing sources, standards of performance for new sources, and pre-treatment standard for new and existing sources.	Will be applicable if wastewater for soil flushing is discharged to a POTW.
	National Pollutant Discharge Elimination System (NPDES) Requirements (CWA 40 CFR 122)	Regulates discharges of pollutants from any point source into waters of the U.S.	Will be applicable if water from the site is discharged into surface waters.
	Texas Consolidated Permit Rules (TAC 31, Part IX, Chapter 305)	Limits the amounts of pollutants which can be discharged into state waterways.	Will be applicable if water is to be discharged to state waterways.
	Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities (RCRA 40 CFR 264)	Regulations apply to owners or operators of facilities that treat, store, or dispose of hazardous waste.	Will be applicable if hazardous waste remains at the site.
	Standards Applicable to Generators of Hazardous Waste (RCRA 40 CFR 262 Subparts B, C and F)	Regulates the manifesting, pre-transport requirements, and recordkeeping and reporting for hazardous waste.	Will be applicable if the waste is removed from the site for treatment and/or disposal.
Excavation with on and off-site disposal	Standards Applicable to Transporters of Hazardous Waste (RCRA 40 CFR 263)	Establishes the standards which apply to persons transporting hazardous waste within the U.S. if the transportation requires a manifest under RCRA.	Will be applicable if the waste is disposed of off site.
	RCRA Land Disposal Restrictions (RCRA 40 CFR 268)	Identifies hazardous wastes that are restricted from land disposal and defines those limited circumstances under which an otherwise prohibited waste may continue to be land disposed	Will be applicable depending on the type of waste generated at the site.

TABLE 2-6

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) - FEASIBILITY STUDY
Carswell Air Force Base, Texas

TYPE OF ARAR	ARARs	DESCRIPTION	COMMENT
	RCRA - Manifesting, Recordkeeping, and Reporting Requirements (RCRA 40 CFR 264 Subpart E)	These standards apply to owners and operators of all facilities which treat, store, or dispose of hazardous waste.	Will be applicable if the site activities are analogous to hazardous waste facility activities.
	RCRA - Standards for Identification and Listing of Hazardous Waste (RCRA 40 CFR 261)	Lays out the criteria of hazardous versus solid wastes. It also lists characteristics of hazardous waste.	Will be applicable when identifying hazardous wastes.
	Industrial Waste Management Regulations (TAC Title 31, Part IX, Chapter 335)	Provides state regulations on hazardous waste management including all aspects of storage, transport, and treatment.	May be applicable at the site if the presence of hazardous waste is determined.
	Occupational Safety and Health Standards for Air Contaminants (OSHA 29 CFR 1910.1000)	Provides national standards of worker exposure to listed air contaminants.	Will be applicable if workers at the site will come in contact with listed air contaminants.
	DOT Rules for Transportation of Hazardous Materials (DOT 40 CFR 107)	Provides regulations for transport of hazardous waste on the highway system, rail system, by water, or by air.	Will be applicable if the waste from the site is to travel on any federal transportation system.
	National Ambient Air Quality Standards (NAAQS) (CAA 40 CFR Part 50)	Defines levels of air quality which are necessary to protect the public health.	Will be applicable if work at the site effects ambient air quality for such pollutants as particulate matter and carbon monoxide.

acceptable concentrations of constituents that may be found in the environment.

Using EPA methodology for establishing Preliminary Remediation Goals (EPA, 1991), chemical-specific soil action levels could be calculated for some of the specific compounds.

ARARs have been identified at the State and Federal level. The Texas Water Commission (TWC) has guidance that is relevant to the clean-up of underground storage tank sites. This guidance (TWC Petroleum Storage Tank Guidance Manual for LPST Cleanups in Texas) contains clean-up criteria for petroleum products. The TWC has also established criteria for the projection of ground water and surface water from toxic chemicals regardless of the source of the release.

Federal cleanup standards for ground water that is, or may be, a useable drinking water aquifer are established by the USEPA under the Safe Drinking Water Act (SDWA). The SDWA establishes Maximum Contaminant Levels (MCLs) as the national primary drinking water standards.

The Texas State Drinking Water Standards also has established state MCLs for public water systems. If ground water is not used by the public, TWC criteria apply. These criteria are based on:

- level of total dissolved solids (TDS)
- potential for impact to utility trenches
- whether off-site migration has occurred
- whether water wells and/or surface water is threatened or impaired
- whether there is a potential vapor impact to buildings,
- whether wells are located within a ½ mile radius.

2.5.2 Location-Specific ARARs and TBC Requirements

Location-specific ARARs are restrictions placed on the concentrations of constituents or activities that may be conducted when sites occur in special locations such as floodplains, wetlands, historic places, and fragile ecosystems or habitats. The potential requirements which have been evaluated are listed below:

- Fish and Wildlife Protection
- National Historic Preservation Act
- Historic Site, Building and Antiquities Act
- Endangered Species Act
- Flood Plains Management Executive Order 11988
- Classification for Surface Water
- Wetlands Executive Order 11990
- Stormwater Discharge Requirements-National Pollutant Discharge Elimination System (NPDES)

Federally protected species of migratory birds may pass through or nearby the site, so the Endangered Species Act of 1973 is a potential ARAR. The Fish and Wildlife Coordination Act is also a potential ARAR and is designed to protect fish and wildlife when federal actions result in the modification of a body of water. The Historic Site Buildings and Antiquities Act and The National Historic Preservations Act are included to preserve the history of the site. The stormwater discharge requirements under the National Pollutant Discharge Elimination System (NPDES) will also be considered. If any of the sites are located in a floodplain or wetland area, the Flood Plain Management or Protection of Wetlands will apply.

2.5.3 Action-Specific ARARs and TBC Requirements

Action-specific ARARs are technology- or activity-based requirements or limitations on proposed remedial actions at the

site. By definition, action-specific ARARs depend on the proposed remedial actions at the site. General ARARs for any remedial actions conducted at the site include Occupational Safety and Health Administration (OSHA) requirements for Hazardous Waste Operations and Emergency Response, Permissible Exposure Limits for air contaminants, and the OSHA construction standards. Potential action-specific ARARs for various remediation activities are listed in Table 2-6.

TBC requirements identified for remedial activities at the site may include concentration guidelines for contaminants in air published by the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) and the Recommended Exposure Limits (RELs) published by the National Institute for Occupational Safety and Health. The TLVs and REL values are recommended maximum air concentrations to protect workers from adverse health effects associated with exposure during the proposed remedial actions.

Additional TBCs may include maximum air concentrations for fugitive dust established by the Clean Air Act, or the Texas air pollution control regulations.

2.6 DATA NEEDS

Information required to characterize the site, better define ARARs, perform an analysis of alternatives, and complete the conceptual site model include the following:

- Characterization of human receptors including the number and location of potentially exposed populations such as Air Force employees and off-site residential or recreational receptors;

- Characterization of ecological receptors including common biotic communities, endangered/threatened species, the presence of sensitive habitats or environments;

- The location and use of ground-water wells within a one-half-mile radius of the sites;

- The uses of local surface water, (i.e., recreational, fishing, water source) and the distances to downstream water bodies; and

- Upstream and downstream levels of constituents currently detectable in site surface water (the adjacent stream) and sediment;

- Physical characteristics of surface soil; particle size distribution, bulk density, porosity and moisture content;

- Meteorological data, including wind speed and prevailing direction, and seasonal average temperature.

- Data which characterize levels of naturally occurring or "background" metals in environmental media.

3.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY TASKS

3.1 SITE OBJECTIVES

Previous sections of this plan have identified waste management practices and investigative activities at Carswell AFB. The objectives of these investigations are intended to improve site characterizations that would ultimately lead to remediation of the sites. The purpose of this RI/FS at Carswell AFB is to collect assessment data on soils and ground water at two sites on the base. The focus of this work will be to characterize the spatial distribution of contamination at each site and its potential for transport. The findings of this RI/FS will be used to complete a feasibility study to define and evaluate remedial action alternatives.

Field work will be conducted at two sites at Carswell AFB. The primary objectives of the field work are as follows:

- Develop the data base at each site
- Confirm the presence/absence of any previously-detected contaminants
- Improve understanding of spatial distribution of contaminants
- Improve understanding of contaminant migration
- Assess variations in shallow subsurface stratigraphy

3.2 FIELD INVESTIGATION

Field tasks to be performed at each of the sites during this RI/FS are discussed in subsequent sections of this plan and are discussed

in detail in the Sampling and Analysis Plan. The field tasks are also summarized in Table 3-1. These tasks include:

- Geophysical Survey
- Ground-water Screening
- Monitoring Well Installation and Subsurface Soil Sampling
- Ground-Water Sampling
- Aquifer Testing (In-Situ Hydraulic Conductivity)
- Surface Water/Sediment Sampling

All previously installed monitoring wells and borings name designations will remain the same. Ground-water samples will be identified with the monitoring well from which they are collected.

3.2.1 Field Tasks

The following section summarizes specific field operations at each RI/FS site, included in this study. Details of the execution of the field tasks are presented in the SAP.

3.2.1.1. Geophysical Survey - A surface geophysical survey will be performed at both sites to help characterize the near surface conditions and to locate utilities and abandoned tanks and pipechases. Ground Penetrating Radar (GPR) is a geophysical technique which can provide high resolution data on surficial geology. The technique is used to map shallow bedrock, soil and water table features, and locate underground pipes and tanks. The GPR technique is not subject to interference from power lines or fences found at both sites. The depth of penetration is dependent upon the types of soil and the electrical properties of the subsurface. In silts and clays the depth of penetration may be on the order of only a few feet, while in dry sands the depth of penetration may extend to tens of feet. Typically in geologic

TABLE 3-1

FIELD TASKS FOR REMEDIAL INVESTIGATION
Carswell Air Force Base, Texas

SITE	FIELD TASKS	RATIONALE
Unnamed Stream	1. Perform geophysical survey.	1. Determine locations of USTs, piping and utilities.
	2. Install three new monitoring wells (MW-01 through MW-03). Screen soils with HNU. Collect two soil samples per boring for lab analyses, one from the ground-water interface and one from the sample interval exhibiting the highest head space analysis. Install 4-inch PVC screen and riser. Screen length will be 10 feet, slotted: slot size .010.	2. Assess hydrocarbon impact to native soil. Determine nature and extent of ground-water contamination and expand ground-water database.
	4. Sample three new monitoring wells and eight existing wells, during two separate sampling events.	4. Determine nature and extent of ground-water contamination and expand ground-water data base.
	5. Aquifer testing. (Slug testing)	5. Determine hydraulic characteristics of Upper Zone Aquifer.
	6. Surface water/sediment sampling.	6. Determine extent of contamination released from the oil/water separator.
POL Tank Farm	1. Perform geophysical survey.	1. Determine the location of any pipechases or utilities.
	2. Perform ground-water screening, collect 25 upper zone ground-water samples with Hydropunch and screen for contamination.	2. Determine the nature and extent of ground-water contamination and expand ground-water database.

materials, the lower the frequency range of the radar the greater the penetration range, assuming the transmitter output power and receiver sensitivity are not varied. The ability to resolve variations in electrical properties which have small spatial extent increases as the frequency increases, assuming a constant center-frequency to system-bandwidth ratio. It is necessary, therefore, to use antennas having the optimum frequency range and bandwidth characteristics to see the desired electrical variations in the particular geologic medium.

A GEODAR-I, Model-2441, or equivalent GPR unit, will be used at the Carswell sites. A typical radar unit consists of a timing control unit which synchronizes all timing for the transmitter, receiver, data recorder, and data display. The transmitter and receiver electronics are located in the respective antenna modules. They are connected to the control unit through cables. Only the timing signals, the audio frequency facsimile of the received signal, and the DC voltage are carried on this cable.

The received radar signals are filtered before recording using audio frequency analog filters located in the control unit. Analog filtering helps to remove some of the equipment-generated noise.

For a routine reconnaissance map of reflections in the ground, the antennas are mounted rigidly at a known separation and moved along the profile line. The resultant trace shows reflection travel time versus position along the profile. In the profile mode, the travel time is related to the reflector depth and signal propagation velocity.

3.2.1.2 Ground-water Screening - A ground-water screening survey will be performed at the POL Tank Farm. The survey is intended to delineate the extent of ground-water contamination. Up to twenty-five upper zone ground-water samples will be collected with ground-

water sampling equipment, at the POL Tank Farm. Sampling technologies to be considered include direct-push technology (DPT) or HydroPunch®. The ground-water samples will be analyzed with a gas chromatograph to characterize contamination extent at the site.

3.2.1.3 Monitoring Well Installation and Subsurface Soil Sampling - Three shallow monitoring wells will be installed at the Unnamed Stream site. These wells will be drilled to the base of the overburden/top of bedrock using hollow-stem auger techniques. Subsurface soil samples will be collected every five feet from ground surface to total depth using procedures outlined in the Sampling and Analysis Plan (SAP). Ten-foot screens will be installed, along with 4-inch interior diameter (I.D.) polyvinyl chloride (PVC) casing.

3.2.1.4 Ground-water Sampling - Two rounds of ground-water sampling will be conducted after the wells are properly developed as specified in the Field Sampling Plan of the SAP. Sampling from eight existing wells will be included in each of the sampling events.

3.2.1.5 Aquifer Testing (Slug Tests) - An in-situ permeability test will be performed on each new monitoring well following well development. The permeability tests to be performed are known as the "falling head" and "rising head" tests. The "falling head" test involves inserting a slug (solid PVC rod) into the water column in the well to raise the water level. The water level recovery to static water level is recorded over time using a pressure transducer and Hermit 2000C Datalogger. Readings will be taken continuously and recorded until the static water level is reached. The slug is removed for the "rising head" test and the water level recovery back to static water level is recorded over

time. Because the monitoring wells will be constructed with a portion of the well screen situated above the water level, only the results of the rising head tests will be used.

The data results of the permeability test are then plotted on semi-logarithmic paper. The following formula (Bouwer and Rice, 1976) is utilized to calculate hydraulic conductivity (K):

$$K\ (ft/sec) = \frac{r^2_c \ln (R_e/r_w)}{2\ L_e} * \frac{1}{t} * \frac{\ln Y_0}{Y_t}$$

Where:
- r_c (ft) = well radius
- R_e (ft) = effective radial distance over which the head difference is dissipated
- r_w (ft) = radial distance between well center and undisturbed aquifer
- L_e (ft) = height of saturated screen
- Y_0 (ft) = water level Y at time zero
- Y_t (ft) = water level Y at time t
- t (sec) = time since Y_0

The formation permeability will be computed using appropriate predictive equations.

3.2.1.6 Surface Water/Sediment Samples - Samples of surface water and sediments will be collected from the Unnamed Stream between the oil/water separator and Farmer's Branch. Three samples of surface water and sediment will be taken at this site. However, no surface water will be obtained if it is not present during the sampling event. The surface water will be collected in a Pyrex beaker in high flow areas of running water. VOA samples will be collected directly in the VOA sampling jar. The sediment samples will be collected with a stainless-steel spoon or hand auger in low flow

(eddy type) areas. A Wildco sediment sampler will be kept on site in case conditions preclude the use of the stainless-steel spoon or hand auger for sample collection. At each sample location, the surface water samples will be collected first, then the sediment samples will be obtained. Sample collections will begin downstream and proceed upstream to avoid cross contamination by upstream disturbed sediments.

3.2.2 Sampling and Analysis Activities

The samples and analyses to be performed for each of the two sites considered under this RI/FS are summarized in Tables 3-2 through 3-6.

3.3 LITERATURE SEARCH

A literature search will be conducted as part of the Remedial Investigation to ensure that all information pertinent to the study is collected and integrated into the investigation. Sources for historical records include the base engineering office, interviews with base personnel, municipal and state records, and publications. A summary of major publications used in the literature search is listed below.

Installation Restoration Program - IRP RI/FS Stage 1, Carswell AFB, Forth Worth, Texas, Final Radian Report, 1986

Installation Restoration Program - IRP RI/FS Stage 2, Carswell AFB, Forth Worth, Texas, Final RI Report, Radian, 1991

Installation Restoration Program - IRP RI/FS Stage 2, Carswell AFB, Forth Worth, Texas, Final FS Report, Radian, 1991

TABLE 3-2

SAMPLING AND ANALYSIS PLAN SUMMARY: SUB-SURFACE SOIL FROM BORINGS
Remedial Investigation Feasibility Study – Carswell Air Force Base, Texas

PARAMETER	TOTAL NO. FIELD LOCATIONS	SAMPLES PER LOCATION	FIELD QC SAMPLES					TOTAL NO. FIELD SAMPLES	LAB QC SAMPLES					2ND COLUMN CONFIRM. ANALYSES	TOTAL NO. LAB SAMPLES
			Field Duplicate	Equipment Blank	Amb Cond Blank	Blind QC	Trip Blank (a)		MS	MSD	Lab Duplicate	Spiked Blank (b)	Hold Blank (a)		
Volatile Organics															
Unnamed Stream	3	2	1	1	1	0	1	10	1	1	0	1	0	0	13
TOTALS	3	2	1	1	1	0	1	10	1	1	0	1	0	0	13
Aromatic Volatiles															
Unnamed Stream	3	2	1	1	1	0	1	10	1	1	0	1	0	1	13
TOTALS	3	2	1	1	1	0	1	10	1	1	0	1	0	1	13
Total Recoverable Petroleum Hydrocarbons															
Unnamed Stream	3	2	1	1	0	0	0	8	1	1	0	1	0	0	11
TOTALS	3	2	1	1	0	0	0	8	1	1	0	1	0	0	11
Toxicity Characteristic Leaching Procedure															
Unnamed Stream	3	1	0	0	1	0	0	4	1	1	0	1	0	0	5
TOTALS	3	1	0	0	1	0	0	4	1	1	0	1	0	0	5

Note: Analytical methodologies are presented in the Sampling and Analysis Plan.
(a) Volatile Organics only; number to be initiated will depend upon number of shipments.
(b) Estimated; number to be determined by batch preparation.

TABLE 3–3

SAMPLING AND ANALYSIS PLAN SUMMARY: GROUND WATER – MONITORING WELLS
Remedial Investigation Feasibility Study – Carswell Air Force Base, Texas

PARAMETER	TOTAL NO. FIELD LOCATIONS	ROUNDS OF SAMPLING	FIELD QC SAMPLES					TOTAL NO. FIELD SAMPLES	LAB QC SAMPLES					2ND COLUMN CONFIRM. ANALYSES	TOTAL NO. LAB SAMPLES
			Field Duplicate	Equipment Blank	Ambient Blank	Blind QC	Trip Blank (a)		MS	MSD	Lab Duplicate	Spiked Blank (b)	Hold Blank (a)		
Volatile Organics															
Unnamed Stream	11	2	2	2	1	0	1	28	2	2	0	2	0	0	34
TOTALS	11	2	2	2	1	0	1	28	2	2	0	2	0	0	34
Total Recoverable Petroleum Hydrocarbons															
Unnamed Stream	11	2	2	2	0	0	0	26	2	2	0	2	0	0	32
TOTALS	11	2	2	2	0	0	0	26	2	2	0	2	0	0	32
Oil and Grease															
Unnamed Stream	11	2	2	2	0	0	0	26	2	2	0	2	0	0	32
TOTALS	11	2	2	2	0	0	0	26	2	2	0	2	0	0	32
Screen for 24 Metals															
Unnamed Stream Total	11	2	2	2	0	0	0	26	2	2	0	2	0	0	32
Total Dissolved	11	2	2	2	0	0	0	26	2	2	0	2	0	0	32
TOTALS	22	4	4	4	0	0	0	52	4	4	0	4	0	0	64
Arsenic															
Unnamed Stream Total	11	2	2	2	0	0	0	26	2	2	0	2	0	0	32
Total Dissolved	11	2	2	2	0	0	0	26	2	2	0	2	0	0	32
TOTALS	22	4	4	4	0	0	0	52	4	4	0	4	0	0	64
Mercury															
Unnamed Stream Total	11	2	2	2	0	0	0	26	2	2	0	2	0	0	32
Total Dissolved	11	2	2	2	0	0	0	26	2	2	0	2	0	0	32
TOTALS	22	4	4	4	0	0	0	52	4	4	0	4	0	0	64
Selenium															
Unnamed Stream Total	11	2	2	2	0	0	0	26	2	2	0	2	0	0	32
Total Dissolved	11	2	2	2	0	0	0	26	2	2	0	2	0	0	32
TOTALS	22	4	4	4	0	0	0	52	4	4	0	4	0	0	64
Lead															
Unnamed Stream Total	11	2	2	2	0	0	0	26	2	2	0	2	0	0	32
Total Dissolved	11	2	2	2	0	0	0	26	2	2	0	2	0	0	32
TOTALS	22	4	4	4	0	0	0	52	4	4	0	4	0	0	64
Toxicity Characteristic Leaching Procedure															
Unnamed Stream	5	1	1	0	0	0	0	6	1	1	0	0	0	0	6
TOTALS	5	1	1	0	0	0	0	0	0	0	0	0	0	0	0

Note: Analytical methodologies are presented in the Sampling and Analysis Plan.
(a) Volatile Organics only; number ot be initiated will depend upon number of shipments.
(b) Estimated; number to be determined by preparation batch.

TABLE 3-4

SAMPLING AND ANALYSIS PLAN SUMMARY: GROUND WATER – HYDROPUNCH SURVEY
Remedial Investigation Feasibility Study – Carswell Air Force Base, Texas

PARAMETER		TOTAL NO. FIELD LOCATIONS	FIELD QC SAMPLES					TOTAL NO. FIELD SAMPLES	LAB QC SAMPLES					2ND COLUMN CONFIRM. ANALYSES	TOTAL NO. LAB SAMPLES
			Field Duplicate	Equipment Blank	Ambient Blank	Blind QC	Trip Blank (a)		MS	MSD	Lab Duplicate	Spiked Blank (b)	Hold Blank (a)		
Aromatic Volatiles															
POL Tank Farm		9	3	2	2	0	2	18	1	1	0	1	0	10	31
Reserve (c)		1	0	0	0	0	0	1	0	0	0	0	0	1	2
	TOTALS	10	3	2	2	0	2	19	1	1	0	1	0	11	33
Petroleum Hydrocarbons															
POL Tank Farm		22	2	0	0	0	0	24	2	2	0	1	0	20	49
Reserve (c)		3	1	0	0	0	0	4	1	1	0	1	0	0	7
	TOTALS	25	3	0	0	0	0	28	3	3	0	2	0	20	56
Lead															
POL Tank Farm		9	4	3	0	0	0	16	1	1	0	1	0	0	19
Reserve (c)		1	1	0	0	0	0	2	0	0	0	0	0	0	2
	TOTALS	10	5	3	0	0	0	18	1	1	0	1	0	0	21

Note: Analytical methodologies are presented in the Sampling and Analysis Plan.
(a) Volatile Organics only; number to be initiated will depend upon number of shipments.
(b) Estimated; number to be determined by preparation batch.
(c) Three Hydropunch sampling locations will be reserved for discretionary use during the implementation of the field work.

TABLE 3-5

SAMPLING AND ANALYSIS PLAN SUMMARY: SURFACE WATER
Remedial Investigation Feasibility Study – Carswell Air Force Base, Texas

PARAMETER	TOTAL NO. FIELD LOCATIONS	SAMPLES PER LOCATION	FIELD QC SAMPLES					TOTAL NO. FIELD SAMPLES	LAB QC SAMPLES					2ND COLUMN CONFIRM. ANALYSES	TOTAL NO. LAB SAMPLES
			Field Duplicate	Equipment Blank	Ambient Blank	Blind QC	Trip Blank (a)		MS	MSD	Lab Duplicate	Spiked Blank (b)	Hold Blank (a)		
Volatile Organics															
Unnamed Stream	3	1	1	1	1	0	1	7	1	1	0	1	0	0	10
TOTALS	3	1	1	1	1	0	1	7	1	1	0	1	0	0	10
Total Recoverable Petroleum Hydrocarbons															
Unnamed Stream	3	1	1	1	0	0	0	5	1	1	0	1	0	0	8
TOTALS	3	1	1	1	0	0	0	5	1	1	0	1	0	0	8
Oil and Grease															
Unnamed Stream	3	1	1	1	0	0	0	5	1	1	0	1	0	0	8
TOTALS	3	1	1	1	0	0	0	5	1	1	0	1	0	0	8

Note: Analytical methodologies are presented in the Sampling and Analysis Plan.
(a) Volatile Organics only; number to be initiated will depend upon number of shipments.
(b) Estimated; number to be determined by preparation batch.

TABLE 3-6

SAMPLING AND ANALYSIS PLAN SUMMARY: SEDIMENT
Remedial Investigation Feasibility Study – Carswell Air Force Base, Texas

PARAMETER	TOTAL NO. FIELD LOCATIONS	FIELD QC SAMPLES					TOTAL NO. FIELD SAMPLES	LAB QC SAMPLES					2ND COLUMN CONFIRM. ANALYSES	TOTAL NO. LAB SAMPLES
		Field Duplicate	Equipment Blank	Amb Cond Blank	Blind QC	Trip Blank (a)		MS	MSD	Lab Duplicate	Spiked Blank (b)	Hold Blank (a)		
Screen for 24 Metals														
Unnamed Stream	3	1	1	0	0	0	5	1	1	0	0	0	0	7
TOTALS	3	1	1	0	0	0	5	1	1	0	0	0	0	7

Note: Analytical methodologies are presented in the Sampling and Analysis Plan.
(a) Volatile Organics only; number to be initiated will depend upon number of shipments.
(b) Estimated; number to be determined by preparation batch.

In addition to the above described literature search, historical maps and aerial photographs (if available) will be reviewed to determine site features and conditions. This information will be utilized to direct field activities, specifically with respect to underground storage tank areas.

3.4 RECORD KEEPING

3.4.1 Field Record Keeping

Field records will be maintained in order to document all field work, sampling events, and personnel at the site. This information will be used to assist in the Remedial Investigation report document. A summary of field record documents that will be used during field work follows.

Field Log Book

A field log book will be maintained during operations at Carswell AFB. The log book will be hard bound and the pages will be sequentially numbered. The log book will be completed by the site manager and notes will be kept throughout the day, recording pertinent events and time of occurrence.

Daily Quality Control Reports

Figure 3-1 illustrates the Daily Quality Control Report form used to summarize daily activity. The report summarizes work performed, sampling activities, and personnel working or visiting the sites. The Daily Quality Control Reports will be forwarded to the AFCEE Technical Project Manager on a weekly basis during field operations.

FIGURE 3-1

DAILY QUALITY CONTROL REPORT

REPORT No. _____ CONTRACT No. _____ DATE _____

LOCATION OF WORK _____

DESCRIPTION OF WORK _____

WEATHER _____ RAINFALL (INCHES) _____ TEMPERATURE _____ MIN _____MAX

WIND DIRECTION _____

1. WORK PERFORMED _____

2. SAMPLES COLLECTED _____

3. PERSONNEL AND VISITORS AT SITE _____

SITE MANAGER: _____

HF

Soil Test Boring Records

Figure 3-2 illustrates the Soil Test Boring Record form used to record boring activities. Each monitoring well boring will be logged by a qualified geologist or engineer, and all relevant intrusive data will be recorded.

Monitoring Well Installation Diagrams

Figure 3-3 illustrates the Type II Monitoring Well Installation Diagram form that will be used upon completion of shallow monitoring wells. To ensure a quality well installation and completion, the field geologist/engineer will record all information pertaining to drilling, materials used, and actual well construction for each well.

Well Development Data

Figure 3-4 illustrates the Well Development Data form used to record the well development process. The form includes information about well construction and the processes used in development of each well. During well development, specific conductivity, temperature, and pH will be recorded approximately every 15 minutes and turbidity will be measured upon completion of well development.

Chain of Custody Record

Figure 3-5 illustrates the Chain of Custody Record form used to transfer custody of the samples from Law Environmental, Inc. to the shipping agent, and ultimately to the analyzing laboratory. All sample identification names and required signatures will be recorded on this form prior to shipment.

FIGURE 3-2

SOIL TEST BORING RECORD

JOB NO. _____ BORING NO. _____
JOB NAME _____ G.S. ELEV. _____
DATE: _____ HOURS MOVING _____
WEATHER _____ HOURS DRILLING _____
DRILLER _____ PAGE _____ OF _____

DEPTH (FEET)	STRATA DESCRIPTION	#	"N" 1	2	3	4	N	PID	REC	SOIL CLASSIFICATON AND REMARKS	DEPTH (FEET)

BORING TERMINATED: _____
BORING REFUSAL: _____
WATER TOB DEPTH _____
WATER 24 HR.: DEPTH _____
WATER LOSSES _____
CASING: SIZE _____ LENGTH _____

METHOD OF ADVANCING BORING	DEPTH
POWER AUGER	TO
HAND CHOP: W/MUD: W/WATER	TO
ROTARY DRILL: W/MUD: W/WATER	TO
DIAMOND CORE	TO

QA / QC INSTALLED BY: _____ CHECKED BY: _____ DISCREPANCIES: _____

HF

143123

TYPE II MONITORING WELL INSTALLATION DIAGRAM

JOB NAME _____

WELL NO. _____ JOB NO. _____

DATE _____ TIME _____

WELL LOCATION _____

GROUND SURFACE ELEVATION _____

TOP OF SCREEN ELEVATION _____

REFERENCE POINT ELEVATION _____

TYPE SAND PACK _____ GRADATION _____

SAND PACK MANUFACTURER _____

SCREEN MATERIAL _____

MANUFACTURER _____

RISER MATERIAL _____

MANUFACTURER _____

RISER DIAMETER _____

DRILLING TECHNIQUE _____

AUGER SIZE AND TYPE _____

BENTONITE TYPE _____

MANUFACTURER _____

CEMENT TYPE _____

MANUFACTURER _____

BOREHOLE DIAMETER _____

SCREEN DIAMETER _____ SLOT SIZE _____

LAW ENVIRONMENTAL, INC.

FIELD REPRESENTATIVE _____

DRILLING CONTRACTOR _____

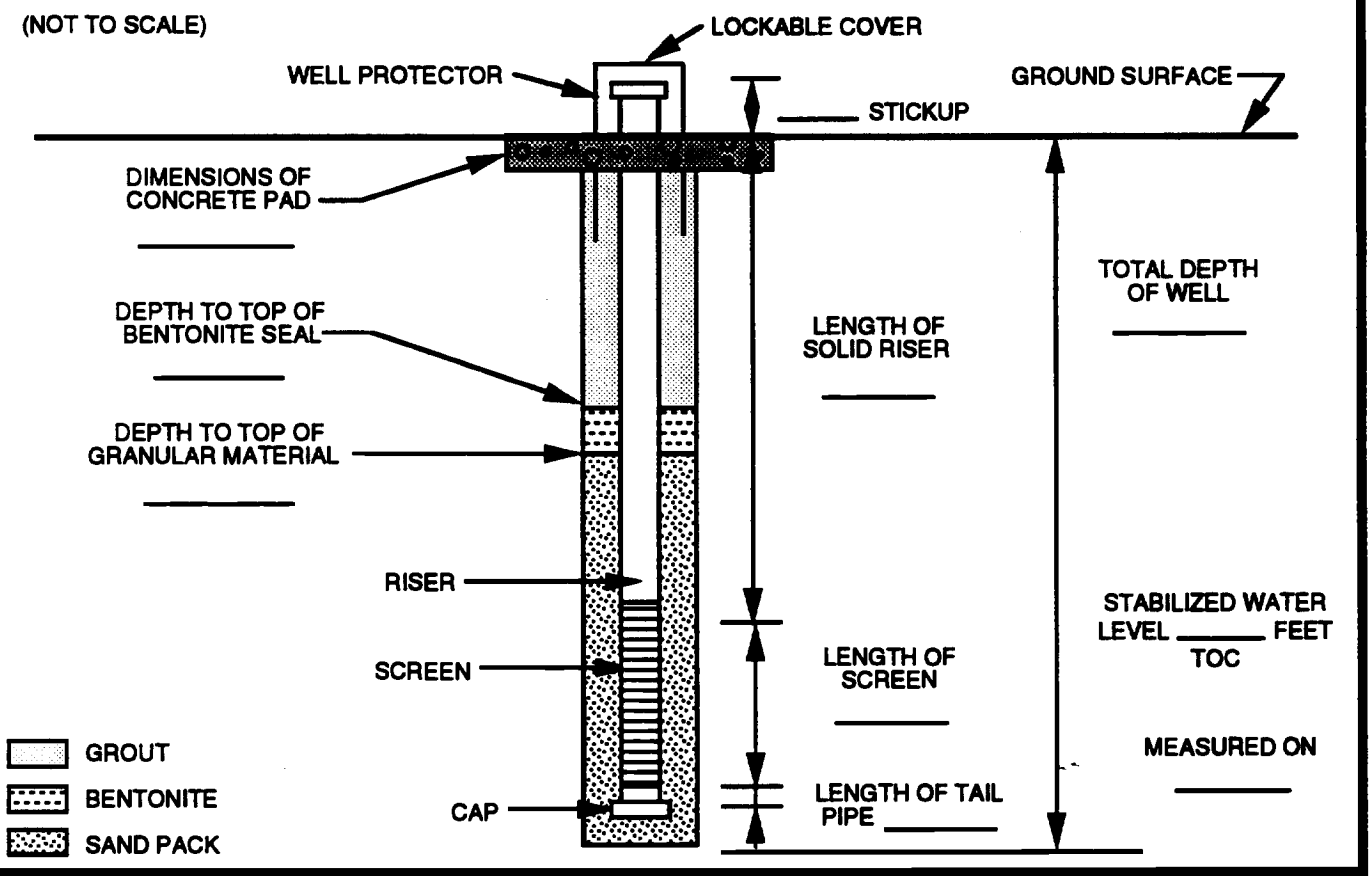
AMOUNT BENTONITE USED _____

AMOUNT CEMENT USED _____

AMOUNT SAND USED _____

STATIC WATER DEPTH (after dev.) _____

REMARKS _____



QA / QC

INSTALLED BY: _____ INSTALLATION OBSERVED BY: _____

DISCREPANCIES: _____

FIGURE 3-4

JOB NAME _____ JOB No. _____

BY _____ CHECKED_____ SHEET _____ OF _____

WELL DEVELOPMENT DATA

1. Well No. _____
2. Date of Installation : _____
3. Date of Redevelopment : _____
4. Static Water Level : Before Development _____ ft.: 24 Hours After _____ ft
5. Quantity of Water Loss During Drilling, If Used _____ Gal.
6. Quantity of Standing Water in Well and Annulus Before Development _____ Gal.

	Start	During		End
7. Physical Appearance	_____	_____	_____	_____
Specific Conductance (umhos/cm)	_____	_____	_____	_____
Temperature (c°)	_____	_____	_____	_____
pH (s.u.)	_____	_____	_____	_____

8. Depth From Top of Well Casing to Bottom of Well _____ ft.
9. Screen Length _____ ft.
10. Depth to Top of Sediment : Before Development _____ ft.; After Development _____ ft.
11. Type and Size of Well Development Equipment : _____

_____

12. Description of Surge Technique, If Used : _____

_____

13. Height of Well Casing Above Ground Surface : _____ ft.
14. Quantity of Water Removed : _____ Gal. Time for Removal : _____ Hr./Min.
15. 1-Liter Water Sample Collected : _____ (Time)
16. Turbidity in Nephelometric Units _____ NTUs

*Development Conditions : 1) Well Water If Reasonably Clear
2) Sediment Thickness 5% of Screen Length
3) Removal of 5 Well Volumes, Including Saturated Filter Annulus
4) Stabilization of Specific Conductance and Water Temperature

HF WDDR-4

FIGURE 3-5

CHAIN OF CUSTODY RECORD

4636

SAMPLING INFORMATION

NAME OF FACILITY: _____

STREET ADDRESS: _____

CITY/STATE: _____ ZIP: _____

PROJECT NAME	JOB NO.
SAMPLERS (SIGNATURE)	
SAMPLING DATE	

TIME	GRAB	COMP.	SOURCE CODE*	SAMPLE STATION DESCRIPTION	TOTAL NO. OF CONTAINERS	CONTAINER TYPE: 40 ml/G ($Na_2S_2O_3$) + 5 H_2O	1 L G, P (HNO_3)	1 L G, P (NaOH)	1 L G, P (H_2SO_4)	1 L G, P	1 L P, (NaOH + Ascorbic Acid)	1 L, Teflon	1 L G, P (Zn Acetate + NaOH)	8oz. G, P	1 L G - Amber	1 L P - Opaque	250 ml/G - Amber

RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)	RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)
RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)	RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED AT LABORATORY: (SIGNATURE)

DISTRIBUTION: ORIGINAL AND PINK COPIES ACCOMPANY SAMPLE SHIPMENT TO LABORATORY.
PINK COPY RETAINED BY LABORATORY. YELLOW COPY RETAINED BY SAMPLERS.

REMARKS: _____

* SOURCE CODES:
RECOVERY WELL - RW
RCRA MONITORING WELL - MW
SOIL/SEDIMENT - SO
SLUDGE - SL
NPDES DISCHARGE - ND
DRINKING WATER - DW

HF

3.4.2 Laboratory Record Keeping

The laboratory will maintain records sufficient to document all phases of sample control, from initial receipt of the samples through all stages of analysis and data generation. The laboratory will maintain written procedures for all analytical methods, and adhere to strict QA/QC guidelines. In-depth laboratory procedures are outlined in the Sampling and Analysis Plan.

3.5 DATA ASSESSMENT

3.5.1 Present Investigation

Quality assurance is an important factor in maintaining the integrity of a project in which data collection consumes much of the project time and effort. A structured process of quality control is needed through all stages of the project and should be designed so that the project effort can build on data confidence as the investigation data base expands. Data quality assurance commences with the Notice to Proceed. The following steps will be followed to maintain this effort.

- A complete and thorough knowledge of the Statement of Work
- Open channels of communication between Law and AFCEE and documentation of that communication
- Completeness and accuracy of the project Work Plan, Sampling and Analysis, Safety and Health Plan, and all documents submitted

- Field investigations and laboratory analysis will follow procedures outlined in the Work Plan and Sampling and Analysis Plan

- Field records will be complete and all activities will be documented (Section 3.4)

- Laboratory methods and QA/QC will be complete and all activities will be documented (Sampling and Analysis Plan)

The field and laboratory data will be reviewed for precision, accuracy, representativeness, comparability, and completeness. Discrepancies in any data set will be noted.

3.6 RISK ASSESSMENT

An evaluation of the current or potential threat to human health posed by the constituents detected at Carswell AFB in the absence of remedial action is required under the National Contingency Plan (NCP) regulations. This evaluation process is known as a baseline risk assessment.

Risk assessments for each site should consider both current use and future use scenarios. The risk assessment approach should be consistent with that prescribed by USEPA, such as found in the Risk Assessment Guidance for Superfund (RAGS), Vol. 1 (EPA, 1989). This approach consists of the following steps:

1. Identification of the Chemicals of Potential Concern
2. Exposure Assessment
3. Toxicity Assessment
4. Risk Characterization

For the risk assessment, only Law data will be evaluated. It should be noted that the number of samples collected for some media being evaluated are not ideal for quantitative risk assessment. Data sets with less than 10 samples will not have the 95% upper confidence limit calculated. Rather, the maximum concentration value will be used.

Radian performed a previous risk assessment under guidance prior to RAGS. In the event that the risk evaluation for this effort produces significantly different risk concerns than those presented by Radian, additional risk calculation efforts may be recommended.

The objective of the risk assessment is to identify media and specific constituents in the media which may present unacceptable risk. The identification of these materials then provides direction for the feasibility study to develop remedial alternatives for those materials.

3.7 BENCH SCALE/TREATABILITY STUDIES

Currently, there is a pilot test being conducted on-site at the POL Tank Farm site to test the effectiveness of bioventing on the petroleum-impacted soil (ES, 1993). The test is being conducted by Engineering Science and is expected to last one year in duration. If selected for implementation at the Unnamed Stream site, this technology should be tested there as well.

Additional potential treatability studies that may be necessary include pilot tests for in-situ bioremediation of ground water (if considered for remediation purposes), pilot testing for soil vapor extraction, bench- and pilot-scale studies for ex-situ bioremediation (landfarming, soil heaping, etc), and various pilot-scale systems for ground-water extraction and treatment (i.e., air stripping efficiency, etc.) systems.

It is not anticipated that treatability studies (at the bench-or pilot-scale) will be performed on hazardous waste. In the event that hazardous waste is to be treated/tested at the bench-scale, a treatment permit will not be required, provided all the criteria for the RCRA treatability study exemption [40 CFR 261.4 (e-f)] are satisfied. If on-site, ex-situ pilot tests are to be performed on hazardous wastes, a treatment permit may be required, however.

3.8 ANALYSIS OF ALTERNATIVES

The detailed analysis of alternatives follows the development and screening of alternatives and precedes the actual selection of a remedy. Each alternative is then assessed against evaluation criteria that address the CERCLA requirements and associated statutory requirements and considerations. The analysis of individual alternatives with respect to the specified criteria should be presented in the feasibility study.

Once the individual assessments are made, a comparative analysis of alternatives is conducted, thereby identifying the advantages and disadvantages of each alternative relative to one another. Also, comparisons should provide strengths and weaknesses of the alternatives and how reasonable variations of key uncertainties could change the expectations of their relative performance. This enables the decision maker to determine which alternative is the most cost effective as well as technically feasible. The result of the detailed analysis, when combined with the risk management judgements made by the decision maker, become the rationale for selecting a preferred alternative and preparing the proposed plan.

4.0 REPORTING REQUIREMENTS

4.1 DELIVERABLES

Draft and final documents outlining the project requirements and procedures, and the results of the procedures will be prepared and submitted for review. Other documents, such as interim reports of information or progress will also be submitted.

4.1.1 R&D Status Reports

Monthly reports will be prepared at the end of each billing period to describe the progress of the project. These reports will discuss the following items:

- Identification of installation and activity in progress
- Status of work at each site and progress to date
- Percentage completion of each task, sections of reports, and schedule status
- Difficulties encountered during the reporting period
- Actions being taken to rectify problems
- Activities planned for the next month
- Changes in personnel

The monthly progress report will list target and actual completion dates for each element of activity, including project completion, and will provide an explanation for any deviation from the milestones in the Work Plan. The report will support the hours claimed for the same time period. The report will identify activities such as well installation and sampling, analysis of data, report writing and other items requiring major manpower commitments. Analytical results generated during the reporting period will be submitted with the next R&D Status Report. Chapters

or sections of the technical report may be submitted with the R&D Status Report as they are drafted.

4.1.2 RI/FS Work Plan

The RI/FS Work Plan will be prepared pursuant to the project activities outlined in the Statement of Work. The work plan will present evaluations and decisions made during the scoping process, and will present a detailed plan for conducting tasks associated with RI/FS work at Carswell AFB.

4.1.3 RI/FS Sampling and Analysis Plan

The RI/FS Sampling and Analysis Plan (SAP) will consist of two parts: the Field Sampling Plan (FSP) and the Quality Assurance Project Plan (QAPP). The FSP will present detailed data collection methods to be followed during the RI/FS and the QAPP will outline policy, organization, functional activities, and detailed laboratory and quality control procedures necessary to achieve stated data quality objectives (DQOs).

4.1.4 RI/FS Health and Safety Plan

The RI/FS Health and Safety Plan will describe safety requirements and procedures to be implemented while conducting field activities. The Health and Safety Plan will be tailored to fit the needs of this specific site investigation.

4.1.5 Informal Technical Information Reports (ITIRs)

4.1.5.1 Analytical Data Report - This report will include the submission of analytical data, including QC results and cross

reference tables. The report will include information regarding sampling locations (wells, boreholes, surface water and sediment sampling locations, etc.) with their respective sites. Monitoring wells will be identified as being upgradient, downgradient, or side gradient of the site. Document format will follow guidelines defined in Section 3 of the Handbook to Support the Installation Restoration Program (IRP) Statements of Work for Remedial Investigation/Feasibility Studies (RI/FS).

4.1.5.2 Mylar Map - A mylar map will be constructed which shows the location of all sites and related sampling locations. The mylar map will contain the date of completion, title block, scale, and legend.

4.1.6 Technical Report

The RI/FS Technical Report will document the findings of the RI/FS. The Remedial Investigation will be conducted after submittal of the SAP and HSP in order to characterize environmental conditions and qualitatively assess the risk to human health and the environment at each site. The RI Technical Report will include documentation of geologic and hydrologic data and environmental samples, analytical methods performed on the samples, and the evaluation of the analytical results and field measurements in relation to QC data.

4.1.7 Data Management

Law will establish a data management plan to meet the data deliverable requirements of the Installation Restoration Program Information Management System (IRPIMS). Field and laboratory data will be recorded in a computerized format as required by the most current version of the IRPIMS Data Loading Handbook.

Law shall prepare the IRPIMS data files using IRP project data as instructed in the IRPIMS Data Loading Handbook. Individual IRPIMS data files (e.g., analytical results, ground-water level data, etc.) shall be delivered by Law to AFCEE/ESB in sequence according to a controlled time schedule.

Law will be responsible for the accuracy and completeness of all data submitted. Data entered into the IRPIMS data files and submitted will correspond exactly with the data contained in the original laboratory reports and other documents associated with sampling and laboratory contractual tasks. Data (as per the IRP Data Loading Handbook) generated under this effort will be submitted. Any exceptions shall be coordinated, in writing, with the TPM.

4.2 SPECIAL NOTIFICATION

The AFCEE TPM and Carswell AFB POC will be contacted immediately by telephone and receive written notification of imminent health hazards along with the supporting documentation within three days after telephone notification.

4.3 VARIATIONS

If variations in technical efforts, including field work are necessary, written concurrence from the Contracting Officer's Technical Representative will be obtained prior to proceeding with the variation. Under such circumstances, the ceiling price of the order will remain unchanged. Should an increase in the ceiling amount be necessary, contracting officer authorization will be required prior to proceeding with the variations.

5.0 PROJECT SCHEDULE

The summary schedule for the Carswell AFB Remedial Investigation/ Feasibility Study is shown in Figure 5-1. This schedule will be updated on a quarterly basis to show any changes for each of the projected tasks for the work plan, field activities and reports.

CARSWELL AIR FORCE BASE, TEXAS | PRIMAVERA PROJECT PLANNER | REMEDIAL INVEST. / FEASIBILITY STUDY

REPORT DATE 28MAY93 12:05 RUN NO. 42 | LAW ENVIRONMENTAL, INC. - GOVT SERVICES DIVISION | START DATE 12MAR93 FIN DATE 25MAR94

SCHEDULE REPORT | DATA DATE 8MAY93 PAGE NO. 1

REMEDIAL INVESTIGATION / FEASIBILITY STUDY

ACTIVITY ID	TAR DUR	CUR DUR	%	ACTIVITY DESCRIPTION	CURRENT START	EARLY FINISH	TARGET START	EARLY FINISH	VAR.
01.00	0	0	100	Notice To Proceed	12MAR93A		12MAR93		0
02.00	2	2	100	Site Visit/Presurvey	13APR93A	14APR93A	13APR93*	14APR93	0
PROJECT PLANNING									
03.01	30	25	30	Prepare Draft Work Plan	19APR93A	1JUN93	19APR93	18MAY93	-14
03.02	30	25	40	Prepare Draft H&SP	19APR93A	1JUN93	19APR93	18MAY93	-14
03.03	30	25	40	Prepare Draft SAP	19APR93A	1JUN93	19APR93	18MAY93	-14
03.04	0	0	0	Submit Draft Plans		1JUN93		18MAY93	-14
03.05	21	21	0	AFCEE Review Draft Plans	2JUN93	22JUN93	19MAY93	8JUN93	-14
03.06	21	21	0	Revise Draft Work Plan	23JUN93	13JUL93	9JUN93	29JUN93	-14
03.07	21	21	0	Revise/Finalize H&SP	23JUN93	13JUL93	9JUN93	29JUN93	-14
03.08	21	21	0	Revise Draft SAP	23JUN93	13JUL93	9JUN93	29JUN93	-14
03.09	0	0	0	Submit 2nd. Draft Plans		13JUL93		29JUN93	-14
03.10	14	14	0	AFCEE Review 2nd. Drafts	14JUL93	27JUL93	30JUN93	13JUL93	-14
03.11	21	21	0	Prepare Final Work Plan	28JUL93	17AUG93	14JUL93	3AUG93	-14
03.12	21	21	0	Prepare Final SAP	28JUL93	17AUG93	14JUL93	3AUG93	-14
03.13	0	0	0	Submit Final Plans		17AUG93		3AUG93	-14
03.14	7	7	0	AFCEE Review & Approve	18AUG93	24AUG93	4AUG93	10AUG93	-14
FIELD WORK - UNNAMED STREAM									
04.01	3	3	0	Oil/Gas Survey Well Placement	28AUG93	30AUG93	14AUG93	16AUG93	-14
04.02	7	7	0	Install/Develop 3 Wells	31AUG93	6SEP93	17AUG93	23AUG93	-14
05.00	4	4	0	1st. Round G.W. Sampling	7SEP93	10SEP93	24AUG93	27AUG93	-14
07.00	45	45	0	Sample Analysis 1st. Round	11SEP93	25OCT93	28AUG93	11OCT93	-14
06.00	2	2	0	Aquifer Slug Testing	11SEP93	12SEP93	28AUG93	29AUG93	-14
FIELD WORK - POL TANK FARM									
08.01	3	3	0	Geophysics Locate Lines	25AUG93	27AUG93	11AUG93	13AUG93	-14
08.02	5	5	0	Ground Water Field Screening	31AUG93	4SEP93	17AUG93	21AUG93	-14
08.03	3	3	0	Survey Locations	5SEP93	7SEP93	22AUG93	24AUG93	-14
FIELD ACTIVITY ITIR REPORTS									
09.02	7	7	0	ITIR Prep. Geophysics	28AUG93	3SEP93	14AUG93	20AUG93	-14
09.06	0	0	0	Submit Geophysical ITIR		3SEP93		20AUG93	-14
09.01	15	15	0	ITIR Map G.W. Screen Data	5SEP93	19SEP93	22AUG93	5SEP93	-14
09.08	30	30	0	IRPIMS Site/Sampling Locations	8SEP93	7OCT93	25AUG93	23SEP93	-14
09.03	7	7	0	ITIR Mylar Sampling Locations	8SEP93	14SEP93	25AUG93	31AUG93	-14
09.07	0	0	0	Submit Mylar Sampling ITIR		14SEP93		31AUG93	-14
09.05	0	0	0	Submit G.W. Screen ITIR		19SEP93		5SEP93	-14
09.09	0	0	0	Submit IRPIMS		7OCT93		23SEP93	-14
09.04	30	30	0	QA/QC 1st. Round G.W. Data	26OCT93	24NOV93	12OCT93	10NOV93	-14
2nd ROUND G.W. SAMPLING									
10.01	4	4	0	2nd. Round G.W. Sampling	10DEC93	13DEC93	26NOV93	29NOV93	-14
10.02	45	45	0	Sample Analysis 2nd. Round	14DEC93	27JAN94	30NOV93	13JAN94	-14
10.03	20	20	0	IRPIMS Sample Collection	14DEC93	2JAN94	30NOV93	19DEC93	-14
10.04	0	0	0	Submit IRPIMS		2JAN94		19DEC93	-14
10.05	30	30	0	ITIR Prep. & Data Validation	28JAN94	26FEB94	14JAN94	12FEB94	-14
10.06	0	0	0	Submit Data ITIR		26FEB94		12FEB94	-14
10.07	15	15	0	IRPIMS Data For All Tasks	27FEB94	13MAR94	13FEB94	27FEB94	-14
10.08	0	0	0	Submit Data IRPIMS		13MAR94		27FEB94	-14
PREPARE TECHNICAL REPORT (RI PORTION)									
11.00	81*	81*	0	Prepare Technical Report (RI Portion)	5SEP93	24NOV93	22AUG93	10NOV93	-14
PREPARE TECHNICAL REPORT (FS PORTION)									
12.01	21	21	0	ITIR Develop & Screen Alternatives	25NOV93	15DEC93	11NOV93	1DEC93	-14
12.02	0	0	0	Submit Alternatives ITIR		15DEC93		1DEC93	-14
12.07	30	30	0	Prepare RI/FS Document	16DEC93	14JAN94	2DEC93	31DEC93	-14
12.03	30	30	0	Detail Screening	16DEC93	14JAN94	2DEC93	31DEC93	-14
12.08	0	0	0	Submit Draft RI/FS		14JAN94		31DEC93	-14
12.04	0	0	0	Submit Detail Screening R & D Report		14JAN94		31DEC93	-14
12.05	22	22	0	AFCEE Review of Detail Screening	15JAN94	5FEB94	1JAN94	22JAN94	-14
12.09	22	22	0	AFCEE Review of Draft RI/FS	15JAN94	5FEB94	1JAN94	22JAN94	-14
12.10	15	15	0	Prepare Final RI/FS	27FEB94	13MAR94	13FEB94	27FEB94	-14
12.11	0	0	0	Submit Final RI/FS		13MAR94		27FEB94	-14
DECISION DOCUMENT PREP.									
13.01	31	31	0	Prepare Decision Document	15JAN94	14FEB94	1JAN94	31JAN94	-14

CARSWELL AIR FORCE BASE, TEXAS | PRIMAVERA PROJECT PLANNER | REMEDIAL INVEST. / FEASIBILITY STUDY

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REMEDIAL INVESTIGATION / FEASIBILITY STUDY

ACTIVITY ID	TAR DUR	CUR DUR	%	ACTIVITY DESCRIPTION	CURRENT START	EARLY FINISH	TARGET START	EARLY FINISH	VAR.
DECISION DOCUMENT PREP.									
13.02	0	0	0	Submit Decision Document		14FEB94		31JAN94	-14
13.03	18	18	0	AFCEE Review of Decision Document	15FEB94	4MAR94	1FEB94	18FEB94	-14
13.04	21	21	0	Prepare Revised Decision Document	5MAR94	25MAR94	19FEB94	11MAR94	-14
13.05	0	0	0	Submit Final Decision Document		25MAR94		11MAR94	-14
PROJECT ADMINISTRATION									
14.01	327*	322*	6	Project Meetings	19APR93A	25MAR94	19APR93	11MAR94	-14
14.02	327*	322*	6	Confirmation Notices	19APR93A	25MAR94	19APR93	11MAR94	-14
14.03	327*	322*	6	Special Notifications	19APR93A	25MAR94	19APR93	11MAR94	-14
14.04	327*	322*	6	Project Management/ Monthly Reports	19APR93A	25MAR94	19APR93	11MAR94	-14

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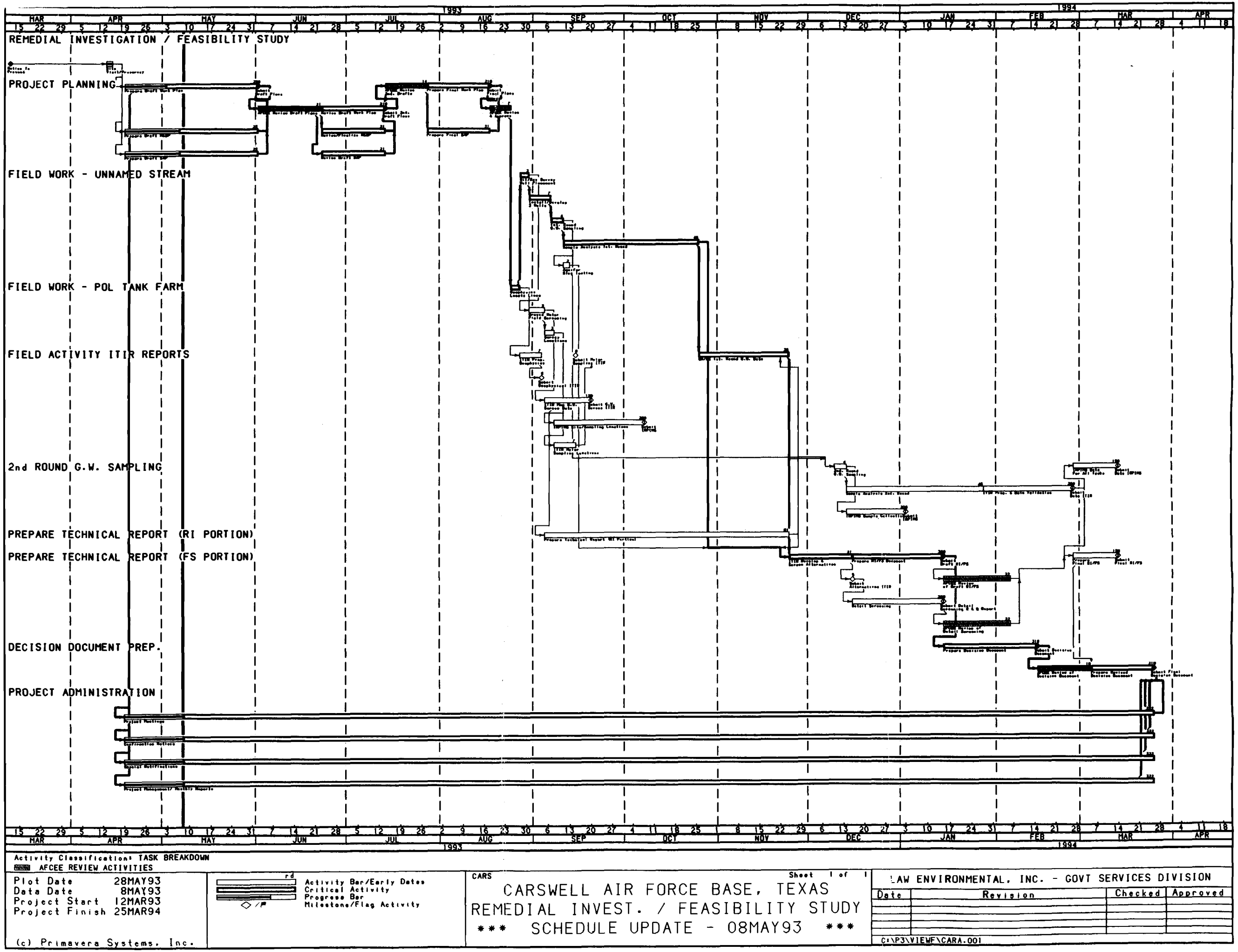
FIGURE 5-1



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FINAL PAGE