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DRAFT GROUNDWATER SAMPLING AND ANALYSIS PLAN NAS FORT WORTH TX
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CH2M HILL

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NAVAL AIR STATION
FORT WORTH JRB
CARSWELL FIELD
TEXAS

ADMINISTRATIVE RECORD
COVER SHEET

AR File Number 304

HQ Air Force Center for Environmental Excellence

DRAFT

GROUNDWATER SAMPLING AND ANALYSIS PLAN

Contract No.: F41624-94-D-8053-0039
Project No.: W/O 72435

Prepared for:
HQ AFCEE / ERD
NAS Fort Worth JRB
Carswell Field, Texas

Submitted by:
CH2M HILL
5339 N. Alpha Road, Suite 300
Dallas, Texas 75240-7352

August 1996

Notice

The enclosed Draft *Groundwater Sampling and Analysis Plan* (August 1996) was prepared to define the objectives, approach, and procedures to be utilized for the basewide groundwater sampling and analysis program at Naval Air Station Fort Worth Joint Reserve Base (NAS Fort Worth JRB). It was prepared as a draft document dated August 23, 1996, and utilized by AFCEE as such for the implementation of groundwater sampling events under the basewide groundwater sampling and analysis program during January 1997, April 1997, July 1997, and October 1997. Finalization/modification of draft sampling and analysis procedures originally described in the *Groundwater Sampling and Analysis Plan* (August 1996) for each of those sampling events are incorporated into the technical reports which detail each event.

Preface

This Groundwater Sampling and Analysis Plan was prepared for the Air Force Center for Environmental Excellence (AFCEE) for the purpose of conducting base-wide groundwater monitoring at Naval Air Station (NAS) Fort Worth Joint Reserve Base (JRB), Carswell Field, Texas. This plan was prepared under Contract Number F41624-94-D-8053, Delivery Order 39, issued to CH2M HILL. Activities to be included in this contract were set forth in the Statement of Work dated April 12, 1996. The AFCEE Contracting Officer's Representative (COR) is Joseph Dunkle. CH2M HILL's Program Manager is William Boettner, and the Project Manager is Margaret O'Hare.

The GSAP incorporates by reference the Base-Wide Quality Assurance Project Plan (QAPP) dated August 1996 (and approved modifications).

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13. ABSTRACT (Maximum 200 words)

This document presents the Field Sampling Plan and Work Plan combined into the Groundwater Sampling and Analysis Plan (GSAP) for NAS Fort Worth JRB, Carswell Field.
The GSAP details sample collection procedures for the proposed investigation including field QC, record keeping requirements, decontamination requirements, and management of investigation derived waste. Also included is the purpose and objectives of the Air Force IRP and the proposed Groundwater Sampling and Analysis Program.
This GSAP was written for use by contractors and laboratories who perform environmental services at NAS Fort Worth JRB in support of AFCEE contracts to ensure scientifically valid and defensible data.

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Executive Summary

The Groundwater Sampling and Analysis Plan (GSAP) describes the objectives and components of the groundwater sampling and analysis program being implemented at NAS Fort Worth JRB. This program has been structured to incorporate a short- and long-term risk-based strategy for addressing groundwater contamination associated with Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) identified at the base. The data collected during this program will be used to evaluate the potential for off-site migration of contamination and provide a basis for evaluating remediation strategies at each unit, as necessary, and with time can be modified into a long-term monitoring program for the base.

To meet these objectives, the GSAP outlines procedures for the following activities:

- Water level measurements
- Groundwater quality sampling
- Removal of light non-aqueous phase liquids from selected locations
- Water quality analyses
- Well-maintenance reviews
- Data management and transfer
- Reporting

Data generated during these activities will be used to evaluate off-site migration potential, changes in the nature and extent of contamination, and changes in base-wide groundwater flow patterns. These evaluations will be used to support the following long-term activities in light of the long-term objective:

- Long-term monitoring - collect data for regulatory compliance issues associated with closure of SWMUs/AOCs;

- Additional source and plume delineation - define horizontal or vertical migration of contamination associated with miscellaneous hot spots and potential source areas where data are not currently available;

- Non-aqueous phase liquid delineation - determine the presence and thickness of light non-aqueous phase liquids (LNAPLs) and dense non-aqueous phase liquids (DNAPLs). LNAPL removal will also occur in selected areas.

- Off-site monitoring program - monitor off-base or potential off-base contamination (surface water and/or groundwater);

- Paluxy aquifer investigation - monitor/identify bedrock contamination potential; review boring logs to identify locations for additional bedrock wells;

- Natural attenuation modeling - collect data to demonstrate that natural attenuation of contaminants is occurring and the extent of attenuation expected at the perimeter of the facility;

- Alternative concentration limits (ACLs) monitoring - monitor contaminant levels (at a minimum, monitor for trichloroethylene (TCE)) for comparison to ACLs; ACLs are levels that may be applied to on-site locations for closure; modeling can be used to demonstrate that if ACLs are met on-site, off-site receptors are protected; and
- Well closure plan - develop a process for identifying wells to be closed because they are no longer needed for source identification or long-term monitoring.

The components of the groundwater monitoring program that were designed to support the long-term objective are based on a review of existing data from previous investigations and a current understanding of the remediation plans for the SWMUs and AOCs. These components will require modification to accommodate new data resulting from ongoing and future investigations/remedial actions at NAS Fort Worth JRB.

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1.0 Introduction

The groundwater sampling and analysis program described by this Groundwater Sampling and Analysis Plan (GSAP) for Naval Air Station Fort Worth Joint Reserve Base (NAS Fort Worth JRB), Carswell Field, incorporates the philosophy of the Air Force Installation Restoration Program (IRP) and information currently available to describe the base and historical operations associated with waste handling. This section provides an overview of the IRP program, a description of NAS Fort Worth JRB, and a summary of the wastes handled at the base. Also included is an introduction to the solid waste management units (SWMU) and areas of concern (AOC) which have been identified on the base, and whether or not they require remediation.

1.1 The U.S. Air Force Installation Restoration Program

The objective of the U.S. Air Force IRP is to assess past hazardous waste disposal and spill sites at U.S. Air Force installations and to develop remedial actions consistent with the National Contingency Plan (NCP) for sites that pose a threat to human health and welfare or the environment. This section presents information on the program origins, objectives, and organization.

1.1.1 Program Origins

The 1976 Resource Conservation and Recovery Act (RCRA) is one of the primary federal laws governing the disposal of hazardous wastes. Sections 6001 and 6003 of RCRA require federal agencies to comply with local and state environmental regulations and provide information to the U.S. Environmental Protection Agency (EPA) concerning past disposal practices at federal sites. RCRA Section 3012 requires state agencies to inventory past hazardous waste disposal sites and provide information to the EPA concerning those sites.

In 1980, Congress enacted the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund). CERCLA outlines the responsibility for identifying and remediating contaminated sites in the United States and its possessions. The CERCLA legislation identifies the EPA as the primary policy and enforcement agency regarding contaminated sites.

The 1986 Superfund Amendments and Reauthorization Act (SARA) extends the requirements of CERCLA and modifies CERCLA with respect to goals for remediation and the steps that lead to the selection of a remedial process. Under SARA, technologies that provide permanent removal or destruction of a contaminant are preferable to action that only contains or isolates the contaminant. SARA also provides for greater interaction with public and state agencies and extends the EPA's role in evaluating health risks associated with contamination. Under SARA, early determination of Applicable or Relevant and

Appropriate Requirements (ARARs) is required, and the consideration of potential remediation alternatives is recommended at the initiation of a Remedial Investigation/Feasibility Study (RI/FS). SARA is the primary legislation governing remedial action at past hazardous waste disposal sites.

Executive Order 12580, which was adopted in 1987, gave various federal agencies, including the Department of Defense (DoD), the responsibility to act as lead agencies to conduct investigations and implement remediation efforts when they are the sole contributor or co-contributor to contamination on or off their properties.

To ensure compliance with CERCLA, its regulations, and Executive Order 12580, the DoD developed the Installation Restoration Program (IRP), under the Defense Environmental Restoration Program (DERP), to identify potentially contaminated sites, investigate these sites, and evaluate and select remedial actions for potentially contaminated facilities. The DoD issued Defense Environmental Quality Program Policy Memorandum (DEQPPM) 80-6 regarding the IRP program in June 1980, and implemented the policies outlined in this memorandum in December 1980. The NCP was issued by EPA in 1980 to provide guidance on a process by which (1) contaminant release could be reported, (2) contamination could be identified and quantified, and (3) remedial actions could be selected. The NCP describes the responsibility of federal and state governments and those responsible for contaminant releases.

The DoD formally revised and expanded the existing IRP directives and amplified all previous directives and memoranda concerning the IRP through DEQPPM 81-5, dated December 11, 1981. The memorandum was implemented by a U.S. Air Force message dated January 21, 1982.

The IRP is the DoD's primary mechanism for response actions on U.S. Air Force installations affected by the provisions of SARA. In November 1986, in response to SARA and other EPA interim guidance, the U.S. Air Force modified the IRP to provide for a program whereby RI/FS studies could be conducted as parallel activities rather than serial activities. The program now includes ARAR determinations, identification and screening of technologies, and development of alternatives. The IRP may include multiple field activities and pilot studies prior to a detailed final analysis of alternatives. Over the years, requirements of the IRP have been developed and modified to ensure that DoD compliance with federal laws, such as RCRA, NCP, CERCLA, and SARA, can be met.

1.1.2 Program Objectives

As stated previously, the IRP is the DoD's primary mechanism for response actions on U.S. Air Force installations affected by the provisions of SARA. The objectives of the IRP include the following:

- Identification and evaluation of sites where contamination may be present on DoD property as a result of past hazardous waste disposal practices, spills, leaks, or other activities.

- Control of the migration of hazardous contaminants.
- Control of health or environment hazards that may result from past DoD disposal operations.

The alternatives that are proposed and solutions that are developed must protect public health and the environment, meet ARARs, and be technically feasible to implement at the evaluated site. To meet these objectives, the following program tasks will be completed:

- Development of a project database through literature search, field investigation, laboratory analysis, and data evaluation.
- Development and implementation of a Quality Assurance/Quality Control (QA/QC) program to ensure meaningful and defensible data.
- Development of, and adherence to, site and laboratory safety plans to protect the health and safety of personnel and to prevent the release of contaminants.
- Identification of data gaps and recommendations for additional data-gathering efforts to be performed during the IRP.
- Use of rigorous procedures to identify, evaluate, and select appropriate solutions.
- Performance of the IRP in compliance with applicable federal, state, and local regulations and guidance.

1.1.3 Program Organization

Originally, IRP studies were organized into four phases:

1. Phase I - Installation Assessment/Records Search;
2. Phase II - Confirmation/Quantification;
3. Phase III - Technology Base Development; and
4. Phase IV - Remedial Actions.

The phases of the Air Force IRP were sequential steps as compared with the steps of the Superfund remedial process, which can occur simultaneously. Although the procedures were different, the targets of the two programs were the same. In response to SARA and for the Air Force program to parallel the Superfund process, DoD directed the Air Force to implement the Superfund methodology of conducting the IRP and to abandon the phased approach.

1.2 Site Description And History

This section provides a description of NAS Fort Worth JRB, a brief history of the base and its current operations, and a summary of the wastes handled and the SWMUs and AOCs identified at the base.

1.2.1 Site Description

NAS Fort Worth JRB is located on 2,555 acres of land in Tarrant County, Texas, eight miles west of Fort Worth (Figure 1-1). It lies between the communities of White Settlement and River Oaks, within a bend of the West Fork of the Trinity River that flows along the eastern boundary of the base. The river is dammed to form Lake Worth, a drinking water supply and recreation reservoir bordering NAS Fort Worth JRB to the north. To the west, NAS Fort Worth JRB is neighbored by Air Force Plant 4 (AFP4) and by the community of White Settlement. Lockheed Martin operates AFP4 for the Air Force. It is an aircraft production plant that shares the runway and several facilities. The base is bordered on the east by the communities of River Oaks and Westworth Village, and other urban areas. Two off-site facilities, the ILS marker beacon and the Weapons Storage Area, are part of the base. Both are located west of the town of White Settlement.

1.2.2 Site History And Current Operations

Prior to 1941, the area that is now occupied by NAS Fort Worth JRB consisted of woods and pasture in an area called White Settlement. In August 1942, the base was opened as Tarrant Field Airdrome. The original mission was to train pilots to fly the new B-24 Liberator, which was being constructed across the runway by the Consolidated Aircraft Corporation.

Construction at the airfield continued into 1943, extending the runway and taxiways, and erecting hangars and additional facilities. In May 1943, the field was redesignated as Fort Worth Army Air Field. The training mission continued. In January 1945, the Fort Worth Army Air Field began to operate a transition school for the B-32 aircraft, which, like the B-24, was manufactured across the runway. The 7th Bombardment Group was assigned to the Fort Worth Army Air Field in October 1946 with B-29 aircraft.

The facility was taken under the command of the Strategic Air Command (SAC) in 1946 and renamed Carswell Air Force Base (AFB) in 1948. The SAC mission remained at Carswell AFB until 1992 when the Air Combat Command assumed control of the base. In October 1994, the U.S. Navy assumed responsibility for the facility and its name was changed from Carswell AFB to NAS Fort Worth Joint Reserve Base. The principal activities on the base have been maintaining and servicing bombers, fuel tankers, and fighter jet aircraft. Many of the activities have been in conjunction with AFP4, which has been successively operated by Consolidated Aircraft Corporation, Consolidated Vultec Corporation, General Dynamics Corporation, and most recently, Lockheed Martin.

Servicing and maintenance of the engines and equipment of the multi-engined B-52 (eight engines) and the KC-135 (four engines) aircraft generated the majority of waste liquids at Carswell AFB.

NAS Fort Worth JRB is presently a joint reserve base, composed of officers, personnel, mobile, and stationary equipment from Memphis, Tennessee; Glenview, Illinois; and Dallas, Texas Naval Air Stations; and Carswell Air Force Base. Carswell AFB was closed during the Air Force reductions of 1992. Naval Air Station Dallas and elements of Glenview and Memphis Naval Air Stations were combined into NAS Fort Worth JRB to streamline the naval budget and place key people and equipment in one central location.

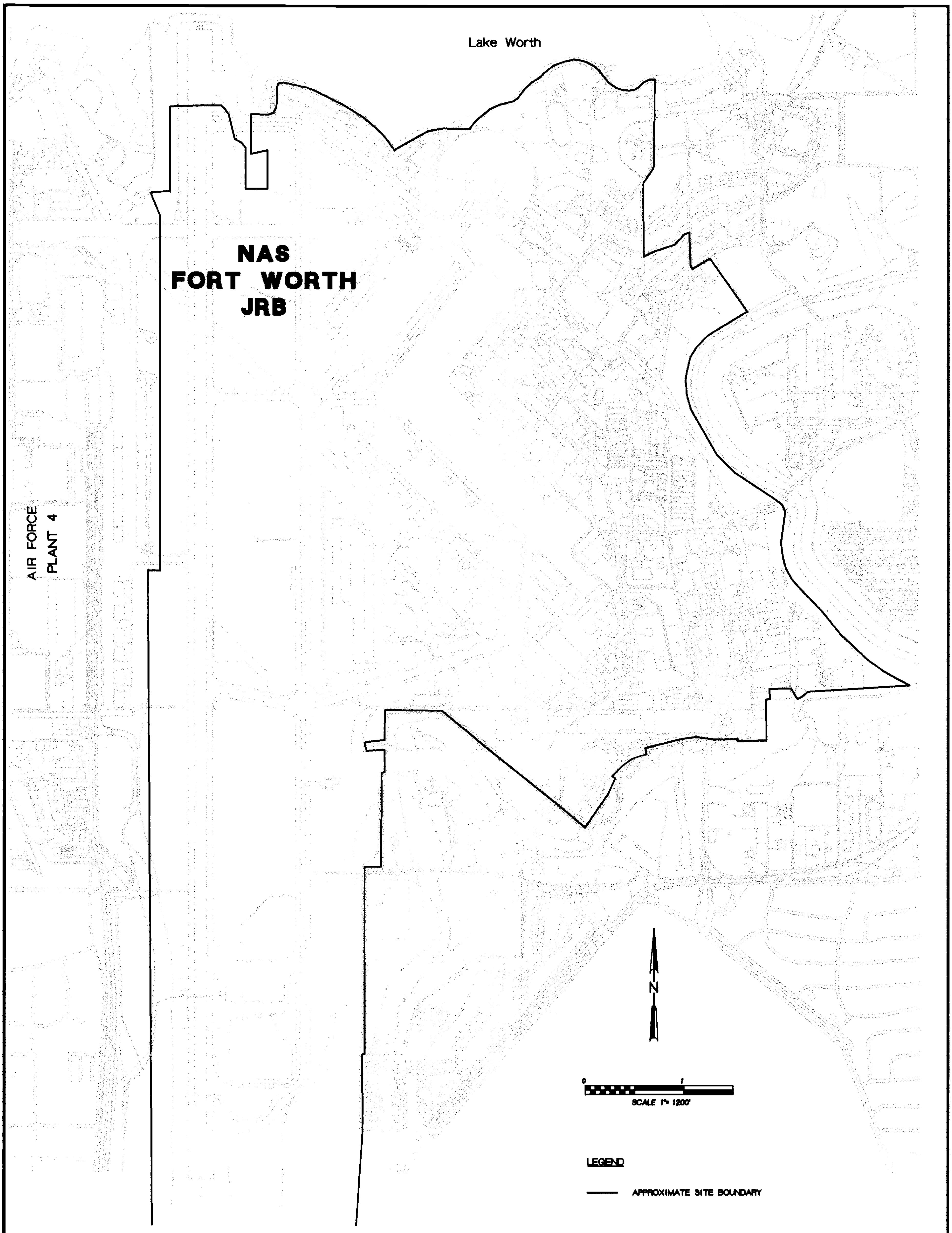
NAS Fort Worth JRB is the headquarters for 400 officers, 1400 civil employees, and 1800 active reservists, with approximately 125 assorted aircraft and over 200 separate buildings. Drilling military reservists will increase the part-time personnel number to over 6,000 military personnel. The Naval Air Station functions as a self-sustaining community, with its own fire department, police force, public works department, air terminal, medical/dental clinic, gas stations, and numerous training and service facilities

1.2.3 Summary Of Waste Handled

Most of the liquid waste generated by the industrial operations can be categorized as waste oils, recoverable fuels, and spent solvents and cleaners. Waste oils generally refers to lubricating fluids, such as crankcase oils and synthetic turbine oils. Hydraulic fluids have also been included in this category. Recoverable fuels refers to fuels drained from aircraft tanks and vehicles, such as JP-4 and MOGAS (unleaded gasoline). Spent solvents and cleaners refers to liquids used for degreasing and general cleaning of aircraft, aircraft systems, electronic components, and vehicles. This category includes PD-680 (petroleum naptha) and various chlorinated organic compounds, such as carbon tetrachloride, trichloroethylene (TCE), and 1,1,1-trichloroethane (1,1,1-TCA). Specific types of solvents in use by the Air Force have changed over the years. In the 1950s, carbon tetrachloride was in common use. Its use was replaced by TCE about 1960. Since then, TCE and 1,1,1-TCA have been commonly used; however, TCE usage has decreased in favor of 1,1,1-TCA. Today, PD-680 Type II, 1,1,1-TCA and, to a limited extent, TCE are in common use. Waste paint solvents or thinners and strippers are generated by corrosion control activities. Typical thinners include isobutyl acetate, toluene, methyl ethyl ketone (MEK), isopropanol, naphtha, and xylene. Paint strippers generally contain such compounds as methylene chloride, toluene, ammonium hydroxide, and phenolics.

1.2.4 Investigation History

The IRP was initiated in 1984 at what was then Carswell AFB with a records search, the result of which was the identification of 15 sites requiring further evaluation (CH2M Hill, 1984). A total of 68 SWMUs were identified as part of a RCRA Facility Assessment (RFA) conducted for what was then Carswell AFB (EPA, 1989), and 17 AOCs later were identified at the base in a letter from the Texas Natural Resource Conservation Commission (TNRCC) to the Air Force dated March 25, 1995 (TNRCC, 1995). These are listed on Tables 1-1 and 1-2, and their locations are shown on Figure 1-2.



NAS FORT WORTH JRB
TEXAS

SITE LOCATION MAP

GROUNDWATER SAMPLING AND ANALYSIS PROGRAM

Reviewed by: P. VAN NOORT	Figure No: FIGURE 1-1	
	Project No: 135009.01.03	
Drawn by: V. THIRUNAGARI	File Name: P:/135009/FIGURES/GSAP0001.DGN	Date: 8/17/96

Since 1942, most hazardous waste generated through operations and activities at Carswell AFB has been disposed of in landfills, reused on base, or processed through the Defense Property Disposal Office (DPDO) for off-base recycling or disposal. Since 1984, several of these sites (which include landfills, fire training areas, oil/water separators, and evidence of spills at waste accumulation areas) have been investigated. Some were determined to require no further action (NFA) and are currently considered closed by TNRCC. Portions of the facility are subject to Air Force Base Realignment and Closure (BRAC) management, while other portions are managed by AFCEE under the Defense Environmental Restoration Account (DERA). These management responsibilities are included on Tables 1-1 and 1-2.

1.3 Groundwater Sampling And Analysis Program Objectives

A base-wide groundwater sampling and analysis program was initiated for NAS Fort Worth JRB in April 1995 to address groundwater contamination associated with various SWMUs and AOCs identified on the base. Four rounds of this quarterly program have been implemented to date: April 1995, July 1995, October 1995, and January 1996 (LAW Environmental [LAW], 1995a and 1995b). The groundwater sampling and analysis program approach has been reviewed based on the results of the first four rounds of the program, and the focus of the program adjusted to incorporate a risk-based strategy. This Groundwater Sampling and Analysis Plan (GSAP) presents the current program approach. Short- and long-term objectives were established for the program so that adequate data would be collected to evaluate critical exposure pathways involving groundwater, and to support eventual closure of the SWMUs and AOCs.

The current objectives have been based on the following assumptions:

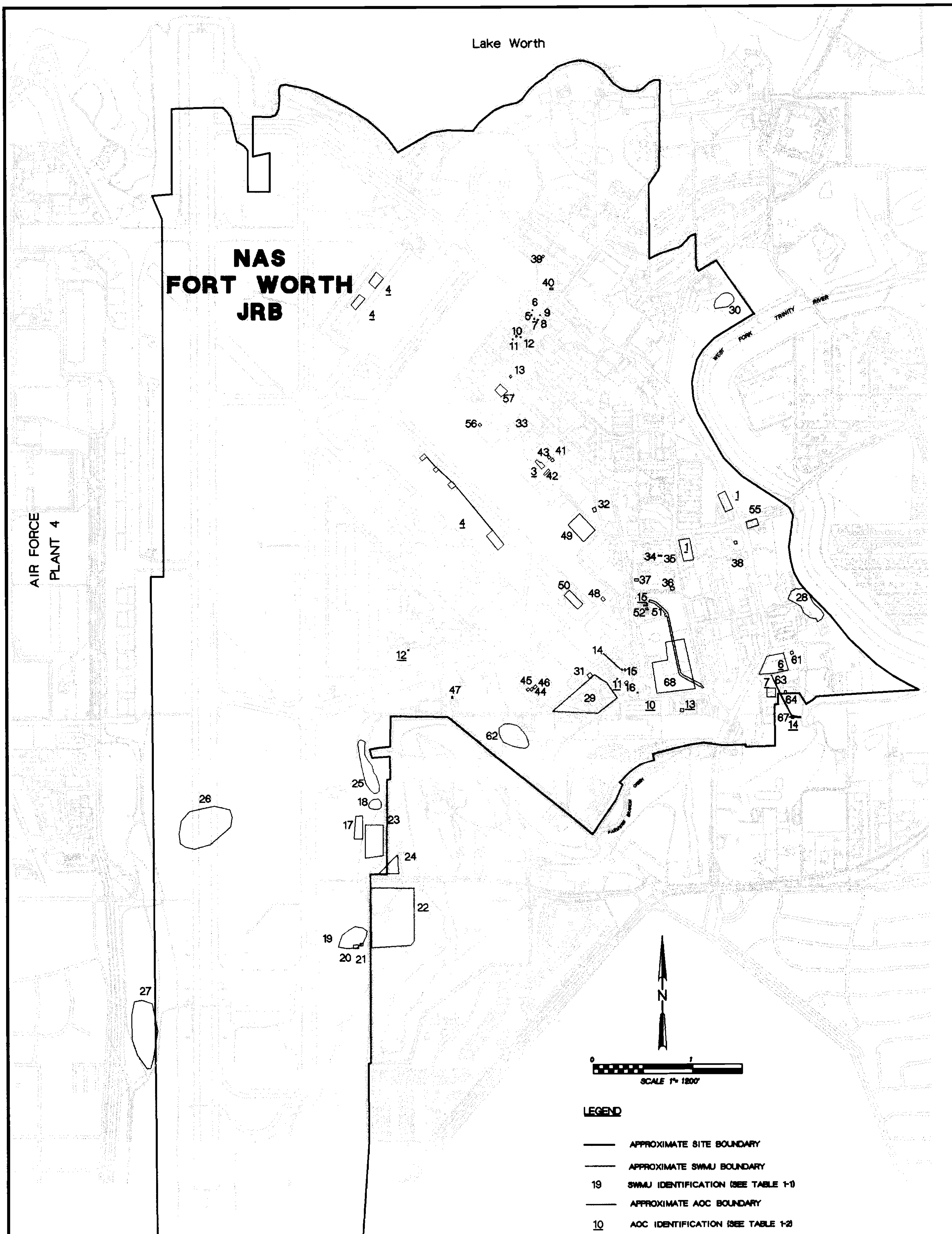
- There is potential for impacts to off-site groundwater:

    1 Off-site groundwater use (e.g., off-site residents using groundwater as drinking water source)

    2. Groundwater contamination to migrate and discharge to surface water bodies (e.g., Farmers Branch Creek and West Fork of the Trinity River);

- There is no current exposure to on-site groundwater (i.e., groundwater is not currently used for drinking water or irrigation) and future chronic exposure to on-site groundwater is unlikely, although exposure during some future activities could occur;

Natural attenuation of contaminants is occurring in soil and groundwater.



NOTE:

SWMU 53 (Storm Water System), SWMU 54 (Storm Water Interceptors), and SWMU 66 (Sanitary Sewer System) are located base-wide and are not depicted on this map.

AOC 2 (Airfield Groundwater) broadly defines groundwater contamination beneath NAS Fort Worth JRB; and therefore is not depicted on this map.

NAS FORT WORTH JRB TEXAS	
SWMU/AOC LOCATION MAP GROUNDWATER SAMPLING AND ANALYSIS PROGRAM	
Reviewed by: P. VAN NOORT	Figure No: FIGURE 1-2
	Project No: 135009.01.03
Drawn by: V. THIRUNAGARI	File Name: P:/135009/FIGURES/GSAP0003.DGN — Date: 8/17/96

These assumptions were developed from a review of the results of the first four rounds of the groundwater sampling and analysis program and from a review of other groundwater investigations conducted at the base to address specific sites. For example, the report for the East Area (Radian, 1991) discusses the potential for migration of contamination from groundwater to surface water (Farmers Branch Creek). In addition, Parsons Engineering (1995) has evaluated the natural attenuation of benzene in the area around the POL Tank Farm (SWMU 68).

The short-term objective for the groundwater sampling and analysis program is to identify potential impacts to off-site groundwater receptors. Perimeter wells include wells located near the NAS Fort Worth JRB boundaries and/or immediately upgradient of surface water bodies where groundwater may discharge to the surface water.

The long-term objective of the groundwater sampling and analysis program is to establish a process for collecting data to support closure of SWMUs and AOCs and to identify and/or confirm potential impacts to off-site receptors.

The groundwater sampling and analysis program has been structured to provide information to support the following activities in light of the long-term objective:

- Long-term monitoring - collect data for regulatory compliance issues associated with closure of SWMUs/AOCs;
- Additional source and plume delineation - define horizontal or vertical migration of contamination associated with miscellaneous hot spots and potential source areas where data are not currently available;
- Non-aqueous phase liquid delineation - determine the presence and thickness of light non-aqueous phase liquids (LNAPLs) and dense non-aqueous phase liquids (DNAPLs). LNAPL removal will also occur during the first two rounds of sampling in selected areas.
- Off-site monitoring program - monitor off-base or potential off-base contamination (surface water and/or groundwater);
- Paluxy aquifer investigation - monitor/identify bedrock contamination potential; review boring logs to identify locations for additional bedrock wells;
- Natural attenuation modeling - collect data to demonstrate that natural attenuation of contaminants is occurring and the extent of attenuation expected at the perimeter of the facility;
- Alternative Concentration Limits (ACLs) monitoring - monitor contaminant levels (at a minimum, monitor for trichloroethylene (TCE)) for comparison to ACLs; ACLs are levels that may be applied to on-site locations for closure; modeling can be used to demonstrate that if ACLs are met on-site, off-site receptors are protected; and

- Well closure plan - develop a process for identifying wells to be closed because they are no longer needed for source identification or long-term monitoring.

The components of the groundwater sampling and analysis program that were designed to support the long-term objective are based on a review of existing data from previous investigations and a current understanding of the remediation plans for the SWMUs and AOCs. These components may require modification to accommodate new data resulting from ongoing and future investigations/remedial actions at NAS Fort Worth JRB. If necessary, the GSAP will be amended to reflect modifications to the long-term objective components.

1.4 Groundwater Sampling And Analysis Plan Approach

This GSAP has been developed to provide a framework to achieve the objectives described above. This document describes in detail the approach for the current program, which has been designed to address the short-term objective and to provide preliminary data in support of the long-term objective. The current approach includes the following components:

- Water level measurements;
- Groundwater quality sampling;
- LNAPL removal from selected locations;
- Methods for water quality analyses;
- Well maintenance needs and procedures;
- Data management and transfer procedures;
- Reporting formats and objectives.

It is expected that following two rounds of monitoring under the current approach, the program will be reviewed and adjusted as necessary to focus more on the long-term objectives of the program. In anticipation of these modifications, a conceptual framework for monitoring is provided that supports all components of the long-term objectives. This framework includes sampling of existing wells, recommendations for installation of additional wells, and recommendations for chemical parameters to be included in the sampling program. The framework is based on a current understanding of the remediation plans for the SWMUs and AOCs. Details for subsequent monitoring rounds will be developed based on results of the first two rounds and the overall remediation strategy for NAS Fort Worth JRB. In addition, the framework may require modification based on results of ongoing and future investigation/remedial action programs at NAS Fort Worth JRB. The GSAP will be amended as necessary to accommodate these modifications to the framework.

The GSAP incorporates by reference the analytical methods and procedures outlined in the Base-Wide Quality Assurance Project Plan (QAPP) for NAS Fort Worth JRB (CH2M HILL, 1996a). An approved Health and Safety Plan (HSP) is required to be in place prior to each sampling event. An approved HSP is currently in place to address the first two rounds of sampling under the current groundwater sampling and analysis program (CH2M HILL, 1996b). Additional HSPs will be prepared to address subsequent work.

1.5 Groundwater Sampling And Analysis Plan Organization

Section 2.0 of this GSAP includes a summary of major findings and conclusions from previous investigations. Rationale and selection of monitor wells for use in water level measurements are presented in Section 3.1. Rationale and selection of monitor wells, sampling frequency, and methods for water quality analyses are presented in Section 3.2. Inspection and maintenance procedures, as well as standards for closure of wells are in Section 3.3. Data management and data quality evaluation procedures are presented in Section 4.0. Section 5.0 outlines the procedures for updating the base-wide groundwater monitoring program GSAP, Section 6.0 provides the schedule for sampling and reporting over the next two rounds, and Section 7.0 lists references. Appendix A presents a list of monitor wells and location coordinates for NAS Fort Worth JRB. Specific sampling procedures are contained in Appendix B. Appendix C provides the appropriate AFCEE forms.

2.0 Environmental Setting

The following sections describe the environmental setting and the conceptual site model of NAS Fort Worth JRB relevant to the groundwater sampling and analysis program.

2.1 Physiography

NAS Fort Worth JRB is located in the Grand Prairie Section of the Central Lowlands Physiographic Province of Texas. The area is characterized by broad, gently rolling plains with moderately sloping terraces of sedimentary rock outcrops. These plains are covered by a variable thickness of light brown to black loamy soil upon which grasslands are developed. Isolated stands of upland timber are found where farming has not occurred or regrowth is advanced.

The topography of this area is essentially flat except where streams, such as Farmers Branch Creek, have excised the surface. Major topographic exceptions include the West Fork of the Trinity River and Lake Worth, where more relief is developed. Since the early 1940s, the area of NAS Fort Worth JRB has been subjected to extensive surface modification associated with cut and fill activities during site development. These activities have resulted in a more uniform plain than is naturally developed elsewhere in this region.

Ground surface elevations range from approximately 590 feet above mean sea level (MSL) along the shore of Lake Worth to approximately 660 feet above MSL in the southwest corner of the site.

2.2 Hydrogeologic Conceptual Model

The hydrogeologic conceptual model for NAS Fort Worth JRB is based on the geologic stratigraphy underlying the base and the characteristics of groundwater flow through that stratigraphy. In developing this conceptual model, previous and ongoing site investigations were reviewed as well as ongoing U. S. Geological Survey (USGS) investigations. This section describes the current understanding of the hydrogeologic conceptual model for NAS Fort Worth JRB, describes data gaps, and ongoing hydrogeologic investigations that may provide additional information for refinement of the model.

2.2.1 Geology

NAS Fort Worth JRB is underlain by sediments ranging in age from Cretaceous to Recent and ranging in composition from limestone to fill material. Table 2-1 lists the stratigraphic units encountered at NAS Fort Worth JRB. From oldest to youngest, the Cretaceous rocks that crop out near AFP4 and NAS Fort Worth JRB are the Paluxy Formation (water bearing), the Walnut Formation, and the Goodland Limestone. The Paluxy is an aquifer and

Table 2-1
Stratigraphic units at Air Force Plant 4 and Naval Air Station, Fort Worth, Texas
Groundwater Sampling and Analysis Plan (From Kuniaski, et. al, 1996)
August, 1996

Era	System	Series/Group	Stratigraphic Unit	Thickness (feet)[1]	Lithologic Characteristics[2]	Water-yielding Characteristics
Cenozoic	Quatemary (1.8 mya to present)	Holocene	Fill material	0-20	Construction debris	Permeability varies, gravels and sands permeable
			Recent alluvial deposits	0-50	Gravel, sand, silt, clay	
		Pleistocene	Terrace alluvial deposits	0-60	Gravel, sand, silt, clay	Permeability varies, gravels and sands permeable
	Tertiary (1.8 to 65 mya)	Eocene/Wilcox		--	--	--
		Paleocene/Midway		--	--	--
Mesozoic	Cretaceous (65 to 140 mya)	Gulfian		--	--	--
		Comanchean/ Washita		--	--	--
		Comanchean/ Fredericksburg		--	--	--
			Goodland Limestone	0-40	White fossilferous limestone, coarsely nodular, resistant, and dense—contains some marl	Impermeable where not weathered—considered confining unit
			Walnut Formation	0.5-30	Medium to dark grey clay and limestone with shell conglomerates, fossilferous, Gryphaea beds	Very low permeability—considered confining unit
		Comanchean/ Trinity	Paluxy Formation	130-175	Light grey to greenish-grey sandstone and mudstone; fine-grained to coarse-grained sandstone	Considered aquifer, yields small to moderate quantities of water
			Glen Rose Formation	150, range unknown at AFP4	Brownish-yellow and gray alternating limestone, marl, shale, and sand	Low permeability—considered confining unit in area of AFP4
			Twin Mountains Formation3	200, range unknown at AFP4	Fine-to coarse-grained sandstone, shale and claystone, basal gravel conglomerate	Coarse sandstones and parts of formation considered aquifer, yields moderate to large quantities of water

[1]Thickness determined from site logs, except for Glen Rose Limestone and Twin Mountains Formation (Baker and others, 1990, figure 4)
[2]Lithologic characteristics determined from field observations and from Winton and Adkins, 1919; University of Texas, Bureau of Economic Geology, 1972; U.S. Army Corps of Engineers, 1986; Baker and others, 1990; Environmental Science and Engineering, Inc., 1994.
[3]This stratigraphic name does not conform to the usage of the U.S. Geological Survey.

is confined by the overlying Walnut Formation and the Goodland Limestone. These bedrock units are overlain by unconsolidated materials consisting of alluvium and fill. Figure 2-1 shows the generalized geologic section at NAS Fort Worth JRB.

2.2.1.1 Paluxy Formation

The Paluxy Formation, commonly called the Paluxy Sand, is the upper member of the Lower Cretaceous Trinity Group. The Paluxy Formation underlies all of NAS Fort Worth JRB and AFP4 and outcrops along the shore of Lake Worth.

The formation consists of several thick sandstone layers separated by thin, discontinuous shale and claystone layers.

Beneath NAS Fort Worth JRB, the Paluxy ranges in thickness from about 133 feet to about 175 feet (Hargis + Associates, 1989b). The formation is composed of light gray to greenish-gray coarse to fine grained sandstone and dense mudstone, which may occur as weathered reddish orange outcrops (Kuniansky, et. al., 1996). The lower section of the Paluxy is generally coarser grained than the upper section. The sandstone is poorly cemented to slightly indurated with sparry calcite cement (Caughey, 1977). Traces of iron pyrite, iron oxide, and glauconite (an iron rich rock) occur in the sandstone and may be locally abundant. Thinner beds occur which may contain pyrite nodules, traces of lignite, silicified wood, and carbonized plant fragments. Low-angle cross bedding has been detected in core samples and in outcrops along the shoreline of Lake Worth northwest of AFP4 and NAS Fort Worth JRB.

Bedding in the Paluxy Formation may be horizontally laminated, massive, or burrowed. The thickness of the formation may be variable across the site and individual units within the Paluxy may be thin or missing locally.

2.2.1.2 Walnut Formation

Above the Paluxy Formation, the Walnut Formation consists of medium to dark gray clay and limestone and contains shell conglomerates, clay, and shale. Black fissile shale, rich in naturally occurring hydrocarbons, has been found in several boreholes from the upper part of the formation The unit ranges in thickness from 0.5 to 30+ feet at AFP4 (Kuniansky, et. al., 1996). A disconformity separates the top of the Paluxy from the Walnut.

2.2.1.3 Goodland Limestone

The Goodland Limestone is present above the Walnut Formation in the subsurface beneath AFP4 and NAS Fort Worth JRB except where removed by erosion. The unit consists of a white, fossiliferous, very massive limestone that contains some thin beds of clay and marl. The top surface of the Goodland Limestone is highly eroded by meander bends and stream channels beneath the site. The surface of the Goodland Limestone appears to have been exposed in the geologic past and has a well-developed paleotopography representative of stream down-cutting and weathering.

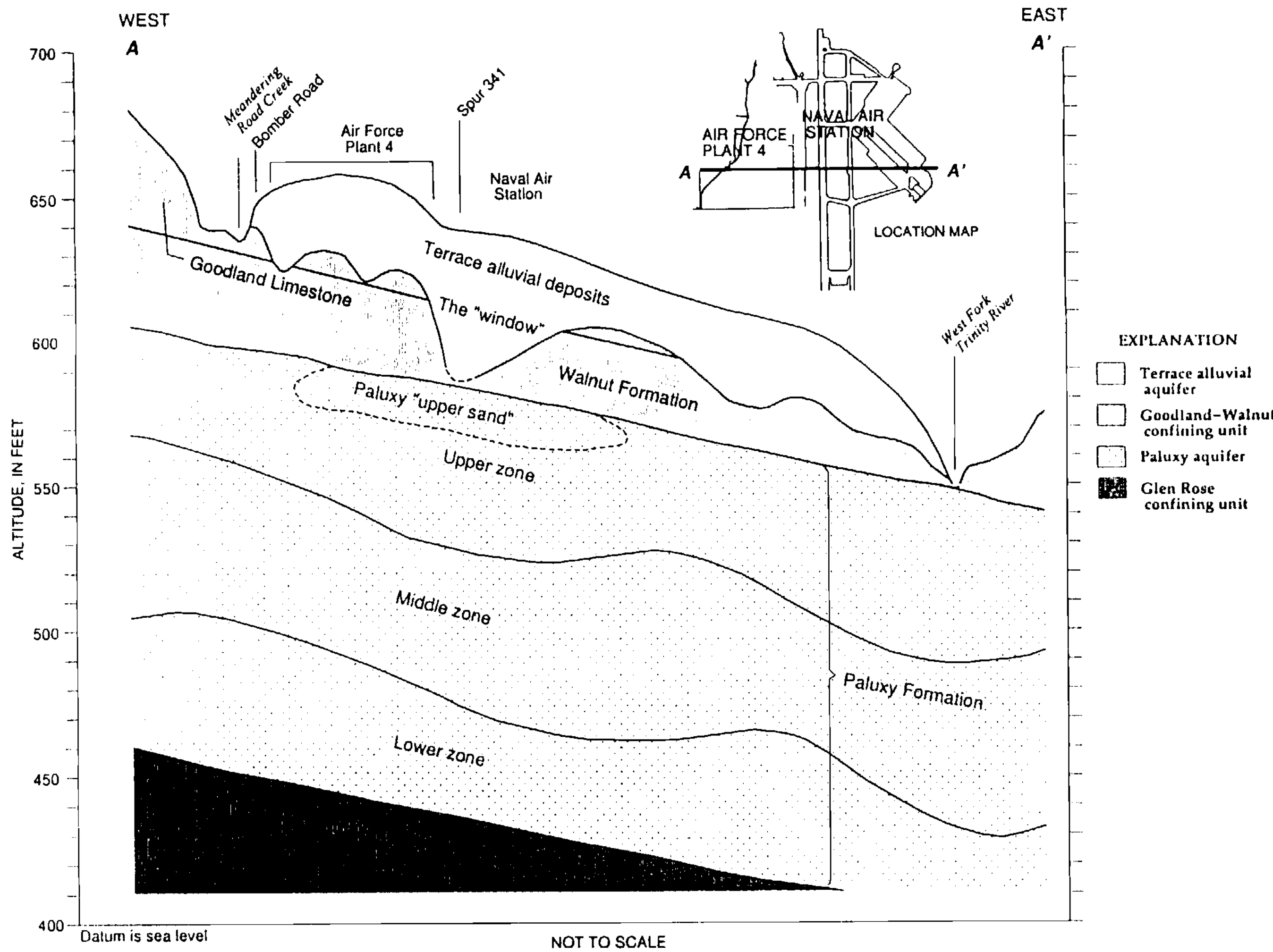


Figure 2-1 Generalized Hydrogeologic Section at AFP4 and NAS, Fort Worth, Texas (*Hydrogeology at Air Force Plant 4 and Vicinity and Water Quality of the Paluxy Aquifer, Fort Worth, Texas.* U.S. Geological Survey Water-Resources Investigations Report 96—4091, 1996.

2.2.1.4 Alluvium

Overlying the Cretaceous formations are alluvial deposits laid down by the Trinity River and other streams. These stream deposits consist of heterogeneous deposits of interbedded clay, silt and poorly to moderately well sorted sand, gravel, and occasional cobbles. Individual beds are continuous only over short distances and exhibit evidence of extensive cross cutting and reworking by later stream action. The source material for these beds is the clastic detritus of limestone and shell fragments, with minor amounts of quartz sand.

Alluvial deposits are found in nearly all areas of NAS Fort Worth JRB and their thickness is locally variable. The thickest accumulations correspond to the depressions in the weathered and channelized paleotopographic surface of the underlying limestone formations. One of the thickest deposits appears to occur in the channel of a paleo stream that runs from the northwest to the southeast beneath the site. Other deposits occur where additional stream channels are interfingered beneath other areas of the site.

2.2.1.5 Fill

Since the early 1940s, significant site alteration has been completed to situate runways and buildings. These construction activities involved extensive cut and fill earthwork to level the site for operations. These cut and fill efforts have masked the original land surface and created variable deposits of fill material. This fill is characterized as mixtures of native materials including sand, silt, clay, and gravels, combined with general refuse, construction debris, and chemical wastes.

2.2.1.6 Depositional History And Structure

The bedrock limestone formations beneath NAS Fort Worth JRB were deposited in essentially a flat lying basin resulting in horizontal bedding. Later, the beds were gently uplifted resulting in a regional bedrock dip of about 20 to 30 feet per mile to the east-southeast. The Goodland Limestone shows evidence of previous extensive subaerial exposure with channelization. The alluvium deposited on the underlying bedrock surface has filled in the erosional channels and depressions, obscuring the paleo surface and creating linear zones of increased permeability.

2.2.2 Hydrogeologic Units

The hydrogeology in the vicinity of NAS Fort Worth JRB consists of three main units:

- A shallow (water table) aquifer within the fill, alluvium, and weathered Goodland Limestone;
- An aquitard or confining unit composed of unweathered Goodland Limestone and the Walnut Formation; and
- The Paluxy Aquifer, a source of municipal water supply.

2.2.2.1 Shallow Aquifer

The shallow aquifer occurs in the unconsolidated fill, alluvium, and the weathered Goodland Limestone. The majority of the aquifer is made up of the terrace alluvial deposits that form a thin, laterally extensive deposit of gravel, sand, silt, and clay, which follows the paleo surface of the underlying bedrock. The deposits generally thicken toward the east and southeast and are thickest in the axis of the paleo stream channels that run from the northwest side of the site to the southeast. The deposits are representative of old stream channels and they crosscut one another resulting in a laterally heterogeneous deposit with interconnected hydraulic conductivity.

The shallow aquifer is not currently used for water supply and behaves as an unconfined water table system. Recharge occurs locally by both precipitation and leakage from underground utilities such as sewers and water mains. Although extensive paved areas and buildings restrict natural infiltration over much of NAS Fort Worth JRB and AFP4, precipitation infiltrates through several large grassy areas.

Groundwater flows to the east and southeast with the thickening of the alluvial deposits and the regional dip of the bedrock. Discharge from the shallow aquifer occurs primarily as baseflow to Farmers Branch Creek and discharge to the West Fork of the Trinity River. In addition, groundwater leakage may occur to the underlying Paluxy Formation in those areas where the Goodland Limestone/Walnut Formation aquitard is eroded away or thinned to less than 5 feet thick.

2.2.2.2 Goodland Walnut Confining Unit

The Goodland Limestone and the Walnut Formation form an aquitard that limits the potential for vertical flow of groundwater between the shallow aquifer and the Paluxy Aquifer. The entire section of the Walnut Formation and a significant portion of the Goodland Limestone are present throughout much of the NAS Fort Worth JRB/AFP4 area, except in those areas where erosion has reduced the thickness of the confining layer. Past investigations of the NAS Fort Worth JRB /AFP4 site have suggested the presence of an area beneath which the confining layer is thin or absent because of erosion. This area is referred to as the "Window." Areas like the paleochannels and the Window have a significant potential for downward flow of groundwater.

Vertical hydraulic conductivity of the competent Walnut Formation was measured on core samples collected during the AFP4 RI, and the mean hydraulic conductivity values calculated. The logarithmic mean of the hydraulic conductivity values is 7.0×10^{-10}cm/sec. Hydrographs from paired upper zone and Paluxy Formation monitor wells indicate there is little flow from the overlying alluvial aquifer to the Paluxy Formation in those areas where the Goodland/Walnut is not deeply eroded. In those areas where erosion has cut into the Goodland/Walnut, the potential exists for downward migration of recharge to the Paluxy.

2.2.2.3 Paluxy Aquifer

The Paluxy Aquifer beneath NAS Fort Worth JRB and AFP4 is an unconfined to semi-confined sandstone aquifer that has historically been characterized as having three zones of flow. These zones are separated by essentially continuous aquitards composed of siltstone, claystone, and/or shale. These interbeds of low permeability aquitards have not been traced over great distances laterally because of variable distribution of the units and the inexactness of identifying thin zones on the basis of drill cuttings. Results of well testing and water level measurements suggest that the Paluxy is a heterogeneous, somewhat laterally discontinuous aquifer that has hydraulic conductivities controlled by the interfingering of beds during deposition. For purposes of this conceptual model, the Paluxy will be regarded as a single unconfined to semi-confined flow system consisting of a largely sandstone matrix with abundant layers of interbedded shale, siltstone, and claystone. Aquifer productivity increases with depth and most of the municipal water supply wells are completed in the lower section of the Paluxy Formation.

Recharge to the Paluxy occurs largely as infiltration or precipitation falling on the outcrop in Wise, Parker, Hood, and Tarrant counties. Recharge also occurs as infiltration from Lake Worth and Eagle Mountain Lake, both of which lie within the boundary of the outcrop. Additional minor amounts of recharge occur as infiltration from streams that cross the outcrop. There is also evidence of leakage of upper-zone groundwater through the Window area where the thickness of the Goodland/Walnut is very thin.

2.2.3 Horizontal Groundwater Flow

The following sections describe the pattern of horizontal groundwater flow through each of the identified hydrogeologic units beneath NAS Fort Worth JRB.

2.2.3.1 Shallow Aquifer

Groundwater flows to the east and southeast within the alluvial deposits toward the Farmers Branch Creek and the West Fork of the Trinity River. Groundwater flow follows the buried surface of the bedrock as it moves. Surface water measurements and observations of seeps along Farmers Branch Creek supports this flow direction (Kuniansky, et. al., 1996).

Flow rates within the shallow aquifer are variable and are dependent upon the homogeneity of the sediments. Locally, there are zones of high conductivity and zones of low to zero conductivity, depending on the geometry of the depositional system that laid down the sediments.

2.2.3.2 Goodland/Walnut Unit

Water level measurements and test wells indicate that the top of the Paluxy Formation is unsaturated wherever it is beneath a developed section of the Goodland Limestone/Walnut Formation confining layer. This indicates that the confining layer is competent, and either limits or prevents the downward migration of groundwater except for the "Window area," where it is eroded. Beneath the Window, there appears to be a mound of groundwater suggesting that a downward gradient exists between the overlying alluvial aquifer and the underlying Paluxy aquifer. The lateral and vertical extent of this Window, still unknown, plays a large role in determining the mechanism of potential contaminant transport at NAS Fort Worth JRB.

2.2.3.3 Paluxy Aquifer

The Paluxy Aquifer is characterized by the presence of both horizontal and vertical components of flow within the aquifer and its zones (Kuniansky, et. al., 1996). Recent work by the U.S. Geological Survey (Kuniansky, et. al., 1996), suggests that the groundwater flows from west to east-southeast and generally follows the regional dip direction of the formation.

2.2.4 Vertical Groundwater Flow

The USGS recently completed a project involving the installation of nested monitor wells to determine the vertical gradient within the Paluxy (Kuniansky, et. al., 1996). Based on the contrast gradients in vertical and horizontal, it appears that the potential for vertical flow is significantly less than that of the horizontal flow. This suggests that groundwater will flow horizontally much more easily than in a downward direction. This is consistent with sandstone aquifers and plays a role in contaminant transport. While the potential for vertical flow is less than the horizontal, small downward vertical flow gradients were recorded indicating that some downward flow of groundwater occurs within the aquifer.

Well data collected by the USGS indicate that in some places in the Paluxy, the upper and middle zones are well connected hydraulically and that water can move easily in a vertical direction within these areas of the aquifer.

2.2.5 Contaminant Transport

The mode and rate of contaminant transport via the subsurface will be variable depending on the character of the hydrogeologic units and groundwater flow patterns. The following sections discuss the current understanding of the contaminant transport process for each of the hydrogeologic units beneath NAS Fort Worth JRB.

2.2.5.1 Shallow Aquifer

The shallow aquifer contains contaminants that resulted from past waste handling practices and leakage from industrial operations. These contaminants are migrating to the east and southeast consistent with the groundwater flow direction within the shallow aquifer deposits. There are two mechanisms of transport operating within the shallow aquifer. Dissolved contaminants are traveling within the water column in the dissolved phase. They generally travel at the same rate as the groundwater and their distribution is reflected in the distribution of the saturated zones within the aquifer. Other industrial contaminants include chlorinated hydrocarbons that are both less soluble in water and are denser than water. These contaminants tend to sink through the alluvial sediments until they reach a low permeability layer that restricts their further downward migration. They then tend to flow along the surface of this low permeability layer independent of the rate or direction of groundwater movement. They also become dispersed through the sediments as residuals within the pores of the permeable sediments comprising the alluvium.

2.2.5.2 Goodland Limestone and Walnut Formation

Except where these formations are thin or absent, groundwater does not travel through these units. In areas where they are thin or missing, groundwater with dissolved contaminant constituents will pass downward into the Paluxy Aquifer. The dense gradient-driven contaminants will also pass through these zones into the Paluxy Aquifer. The direction of flow for dense contaminants will be in the direction of the dip of the beds, east to southeast. As they move through the leaking confining layer, they will develop components of flow that will take them along bedding planes and through horizontally developed zones of increased permeability. Because of the regional east-southeast dip, the major direction of transport will be in that direction.

2.2.5.3 Paluxy Aquifer

Contaminants entering the Paluxy will move as dissolved phase with the dominant flow direction for groundwater, generally to the east. Dense contaminants will move east-southeast with the regional dip of the formation but will develop vectors of flow that are dependent on the distribution of lower permeability zones within the larger formation, such as claystone layers.

2.2.6 Data Gaps In The Hydrogeologic Conceptual Model

In evaluating the fate and transport of contaminants within the groundwater system beneath NAS Fort Worth JRB, a number of significant data gaps have been identified. Among them are the existence and area of Windows within the Goodland Limestone and the Walnut Formation that may allow both groundwater and contaminants to move from the shallow aquifer downward into the Paluxy Aquifer. The localized flow direction(s) within the Paluxy and their relationship to the regional flow system needs to be developed to increase knowledge of the potential for contaminant transport. The lithologic controls on groundwater flow and potential contaminant transport are still unclear and will need to be determined.

2.2.7 Ongoing Hydrogeologic Investigations

Based on available information, there is only one known hydrogeologic investigation occurring at AFP4 and NAS Fort Worth JRB, other than site-specific subsurface characterization studies discussed in Section 2.4. The USGS is currently modeling groundwater flow in the Terrace Alluvium and Paluxy Formation (Personal communication (2), 1996). The USGS is using MODFLOW to simulate pre-pumping groundwater conditions, with particular emphasis on the east area parking lot on AFP4. Model results are anticipated within the next several months. The results of this investigation may impact the current understanding of the hydrogeologic conceptual model.

In addition, Parsons Engineering Science is currently compiling hydrogeologic data, including boring logs, for inclusion in the Installation Restoration Program Information Management System (IRPIMS) database.

2.3 Nature and Extent of Groundwater Contamination

During the development of this GSAP, the most recent previous investigation data were reviewed to evaluate the nature and extent of groundwater contamination. Contaminants of concern (COCs) were identified during this evaluation. COCs are identified as compounds occurring routinely at concentrations above media-specific concentration limits (MSCs) and those expected to be detected above background concentrations (inorganic constituents only). (A base-wide background study is currently underway.) COCs are utilized to focus site characterization and risk assessment activities on contaminants that drive efforts to comply with risk reduction standards and site closure standards. Identification of COCs can often lead to utilization of less costly analytical methods.

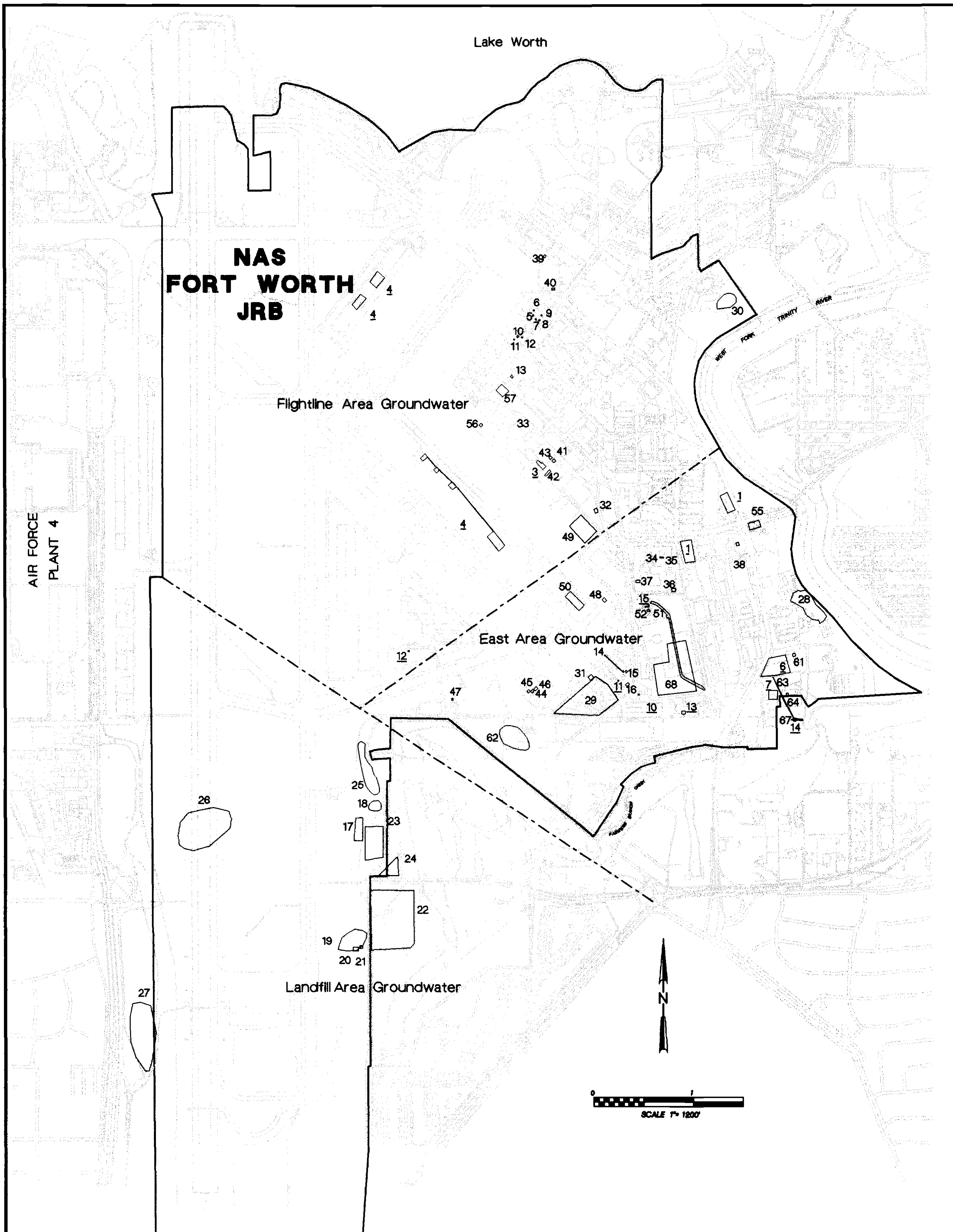
Between April 1995 and January 1996, LAW performed four rounds of quarterly groundwater monitoring. Seventy monitor wells were included in each round of sampling. The objective of the sampling program was to determine the configuration of the groundwater potentiometric surface, and to assess variations of groundwater flow direction and the extent of previously identified COCs in the groundwater on a base-wide scale. Results of the sampling program have been incorporated into the following discussion of nature and extent of groundwater contamination.

LAW grouped their discussion of groundwater results into three separate geographic areas: Zone 1, Zone 2, and Zone 3. For the purposes of this GSAP and subsequent GSAP reports, these geographic areas are identified as follows:

- Landfill Area Groundwater
- East Area Groundwater
- Flightline Area Groundwater

The nomenclature used here has no regulatory significance and is only used to facilitate discussion of SWMUs and AOCs located in areas having geographic, hydrogeologic, or contaminant characteristics. Table 2-2 correlates the groundwater management areas with known SWMUs and AOCs. The location of the areas is shown on Figure 2-2.

Specific COCs were identified during evaluation of previous data. These include selected volatile organic compounds (VOCs) and lead. Table 2-3 summarizes the COCs and their occurrence in each groundwater management area. While semivolatile organics (SVOCs) were encountered, the reported concentrations were generally below MSCs. The only SVOC detected above MSCs is thought to be the result of laboratory contamination.



LEGEND

- APPROXIMATE NAS FORT WORTH JRB SITE BOUNDARY
- APPROXIMATE GROUNDWATER MANAGEMENT AREAS
- APPROXIMATE SWMU BOUNDARY
- 19 SWMU IDENTIFICATION (SEE TABLE 1-1)
- APPROXIMATE AOC BOUNDARY
- 10 AOC IDENTIFICATION (SEE TABLE 1-1)

NAS FORT WORTH JRB
TEXAS

SWMU/AOC LOCATION MAP
GROUNDWATER SAMPLING AND ANALYSIS PROGRAM

Reviewed by: P. VAN NOORT	Figure No: FIGURE 2-2
	Project No: 135009.01.03
Drawn by: V. THIRUNAGARI	File Name: p:/135009/figures/gsap0004.dgn — Date: 8/8/96

Table 2-2
Correlation of Groundwater Management Areas and SWMUs and AOCs
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

Landfill Area Groundwater		East Area Groundwater			Flightline Area Groundwater		
SWMU	AOC	SWMU		AOC	SWMU		AOC
19	None	47	63	10	49	10	4
20		62		11	32		3
21		44	15	12	42	8	
22		45	16	13	43	5	
23		46	68	7	41	40	
24		29	50	6	33	9	
17		31	48	1	56	39	
18		14	37	15	57	6	
25		36	62		11	30	
26		38	51		12		
27		61	34		13		
		63	35				
		67	28				
		15	64				

Notes:

SWMU - Solid Waste Management Area
AOC - Area of Concern

Table 2-3
Summary of Contaminants of Concern
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

Contaminants of Concern	Landfill Area Groundwater	East Area Groundwater	Flightline Area Groundwater
Tetrachloroethylene (PCE)	x	x	x
Trichloroethylene (TCE)	x	x	x
Cis/Trans-1,2-dichloroethene (1,2-DCE)	x	x	x
Vinyl Chloride	x	x	x
BTEX[1]	x	x	x
Lead		x	x

Notes:
[1] BTEX: Benzene, Toluene, Ethylbenzene, Xylene

2.3.1 Landfill Area Groundwater

This area encompasses DERA sites Landfill 7 (SWMU 7) and Fire Training Area 2 (SWMU 19), in addition to several BRAC sites (Landfills 4, 5, and 8, Fire Training Area 1, Waste Burial Area). The COCs detected in groundwater in this area include several VOCs consisting of chlorinated hydrocarbons and BTEX constituents. Benzene is the only BTEX compound detected above MSCs.

In the last quarter of sampling by LAW, the most commonly detected VOC was TCE. Seventeen monitor wells exceeded the MSC value of 5 micrograms per liter (µg/L) for TCE during this event. The concentration of TCE ranged from 2550 µg/L in the center of the plume to below detection in wells located downgradient of the NAS Fort Worth JRB property boundary. While TCE is encountered beyond the NAS Fort Worth JRB property boundary, the property is under the ownership of the Air Force and the control of the Air Force Base Conversion Agency.

The VOCs are believed to have originated from previous waste activities associated with one or more of these sites, and from AFP4, located hydraulically upgradient of the site. However, specific correlation of COCs with these areas has not been made at this time. As a result of the proximity of sources, co-mingling of on-site contaminant plumes with the AFP4 TCE plume is suspected.

Beryllium is the only metal detected above MSCs and its source is unknown. It is assumed the presence of beryllium is attributed to background conditions and this will be confirmed when the results of the base-wide background study become available; beryllium is not retained as a COC for further monitoring in this area.

2.3.2 East Area Groundwater

This geographic area is comprised of numerous sites including the POL Tank Farm (SWMU 68), French Underdrain System (SWMU 64) , the former Base Refueling Area (AOC 7), Unnamed Stream (AOC 14), the Base Service Station/Base Gas Station (AOC 1), and Landfill 1 (SWMU 28). Two distinct plumes occur in this area. The first plume is associated with the POL Tank Farm, French Underdrain System, former Base Refueling Area, and the Unnamed Stream. A second plume is associated with the former Base Service Station. No significant groundwater contamination is encountered near Landfill 1.

BTEX contamination in the area of the SWMU 64 is believed to be the result of eastward migration of product from either SWMU 68 or former underground storage tanks at AOC 7 (these tanks were removed in the 1970s). At present, BTEX contamination has been detected in wells at SWMU 64. Low levels of other constituents (including chlorinated hydrocarbons) have been detected in samples from a few wells near SWMUs 64 and 68.

In the area of AOC 1, a BTEX plume exists and is believed to be the result of leaking underground gasoline storage tanks formerly located at the service station. The plume appears to be confined to the immediate vicinity of the facility. The three tanks and a waste oil tank were removed in May 1993. The source of low levels of TCE in two monitor wells in this area may be attributed to a leak in the waste oil tank.

2.3.3 Flightline Area Groundwater

This area includes several SWMUs, Airfield Groundwater (AOC 2) and the Fuel Hydrant System (AOC 4). Groundwater contamination has not been associated with any SWMUs or AOCs in this area other than AOC 2 and AOC 4. A summary of the nature and extent of groundwater contamination in these areas is summarized below.

2.3.3.1 Airfield Groundwater

The term Airfield Groundwater was originally conceived to address the groundwater plume associated with Spot 35 within the Fuel Hydrant System (AOC 4). For the purposes of this GSAP, Spot 35 is discussed as part of the Fuel Hydrant System. In general, Airfield Groundwater includes all areas of TCE contamination within the Flightline Groundwater Area including Bldg. 1628. The TCE encountered upgradient of Building 1628 may represent the leading edge of TCE contamination originating from AFP4. This includes areas not yet investigated that are adjacent to the east side of the runway, including the flightline. The primary COCs associated with AOC 2 are chlorinated hydrocarbons.

LAW reported TCE in several wells for each round of sampling. The concentration of TCE in this area ranged from 30 µg/L to 463 µg/L. The highest concentrations of TCE occur in a small area located south of Bldg. 1628.

TCE was also encountered in two separate GMI investigations conducted on NAS Fort Worth JRB (GMI, 1993; GMI, 1995). These investigations utilized direct-push technology to obtain groundwater samples. GMI indicated that the TCE encountered could not be correlated with the largest TCE plume originating from AFP4, particularly in the area encompassing AOC 4 and Bldg. 1628. Information reported by GMI suggests that other sources of TCE may be responsible for the plume distribution in this area.

2.3.3.2 Fuel Hydrant System

AOC 4 refers to the Fuel Hydrant System and Spot 35. The most recent groundwater monitoring that has occurred in this area was between in 1990 and 1992 (US Army Corps of Engineers, 1992). In general, relatively low concentrations of BTEX constituents were encountered. However, during the last sample round in 1992, benzene was detected in four monitor wells at concentrations between 51 µg/L and 767 µg/L. Groundwater contamination in this area is believed to be the result of JP-4 jet fuel releases from the fuel hydrant system that, prior to its removal in the early 1990s, had been in operation since the 1940s. BTEX and TPH "hot spots" discovered during GMI's 1994 direct-push investigation are believed to be associated with these releases (GMI, 1995). The source of TCE "hot spots" is believed to be the groundwater plume originating at AFP4. None of the wells associated with AOC 4 were sampled previously by LAW in their quarterly program.

2.3.4 Other Areas

LAW encountered LNAPL in well LSA1628-1 and benzene in LSA1628-2. Both wells were installed as part of a groundwater monitoring program associated with the removal of three underground storage tanks located near Building 1628 in 1992. The contamination is highly localized and appears to be the result of product releases from one or more of the tanks.

2.4 Ongoing Investigations

Three distinct investigations are currently in progress on NAS Fort Worth JRB, other than the groundwater sampling discussed herein. A summary of these investigations is described below.

2.4.1 Jacobs Engineering

As part of a quarterly groundwater monitoring program conducted since 1992 for AFP4, Jacobs Engineering (Jacobs) samples groundwater from wells located at AFP4 and selected wells on NAS Fort Worth JRB. The program's purpose in sampling NAS Fort Worth JRB wells is to monitor COCs that may have originated at AFP4.

Jacobs will also be conducting a Base-Wide Background Study in Fall 1996 to provide data for allowing decisions of further action to be reached at several of the sites at NAS Fort Worth JRB. The objectives of the Base-Wide Background Study are as follows (Jacobs, 1996):

- Obtain samples that are representative, to the degree possible, of background concentrations.
- Establish background levels of constituents in groundwater, surface water, sediment, and soil.
- Determine if, and to what degree, base contamination can be attributed to off-base sources.

As part of the study, Jacobs will sample eight existing monitor wells at NAS Fort Worth JRB. Since Jacobs plans to sample several wells on NAS Fort Worth JRB for both initiatives, it is necessary to coordinate with Jacobs prior to sampling to avoid redundant sampling. Coordination following sampling will be necessary to incorporate Jacob's NAS Fort Worth JRB data into quarterly and annual reports discussed under Section 5.0.

2.4.2 IT Corporation

IT Corporation (IT) has just completed the work planning documents for an investigation to assess the extent of soil and groundwater contamination in the vicinity of AOC 1 and, if possible, determine the source of BTEX constituents detected in the Trinity River. According to IT staff (Personal communication [3], 1996), seven new groundwater monitor wells will be installed in August 1996. These wells will be sampled in August and November 1996; sample analyses include BTEX, TPH, and lead. IT will not sample the existing wells near the Base Service Station. IT is also in the process of performing a base-wide investigation of the sanitary sewer system.

2.4.3 Parsons Engineering Science

On-going field activities conducted at NAS Fort Worth JRB by Parsons Engineering Science (Parsons) include:

- Investigative excavation and partial removal of the French Underdrain System (SWMU64), and grouting, backfilling, and compaction of the excavated trench (recently completed)
- Removal of the Oil/Water Separator associated with the French Underdrain System (SWMU64) (completed)
- In-situ bio-venting of BTEX-contaminant soil at the bulk loading facility of the POL tank farm (SWMU68) (in progress)
- Depending on funding, Parsons may also perform a geoprobe and monitor well installation investigation to address recommendations included in the Remedial Action Plan for Site ST14 (Parsons, 1996)

2.4.4 Geo-Marine

Geo-Marine is under contract to perform a remedial action in the Unnamed Stream area to address contaminated sediments which resulted from upgradient releases.

2.5 Other Potential Groundwater Influences

While a number of SWMUs and AOCs define the primary sources of contamination in the three major groundwater plumes, other SWMUs and AOCs located within the groundwater management areas may also impact the groundwater quality. These SWMUs and AOCs may be characterized as various waste accumulation areas, oil/water separators, storm sewers, landfills, and other miscellaneous units. This section identifies those SWMUs and AOCs and describes, when possible, the nature and extent of contamination associated with them.

2.5.1 Oil/Water Separators

Table 2-4 lists oil/water separators that may act as secondary sources of groundwater contamination. The majority of oil/water separators are located in the East Area Groundwater Management Area. Table 2-4 also lists chemical concentrations detected in surface and subsurface soils that exceed TNRCC Risk Reduction Standard No. 2. Only metals detected in surface and subsurface soil exceed TNRCC Risk Reduction Standard No. 2.

2.5.2 Waste Accumulation Areas

Waste accumulation areas are evenly distributed between the Flightline and East Area Groundwater Management areas. In general, data relating to the nature and extent of contamination at waste accumulation areas in the groundwater management areas are not available. The waste accumulation areas within the groundwater management areas are characterized by SWMU, building function, waste generated, and evidence of chemical releases. This information is provided in Table 2-5.

2.5.3 Landfills

Several landfills are located within the boundaries of NAS Fort Worth JRB. Within the groundwater management areas, the nature and extent of contamination has been defined for only three landfills. These three landfills are listed in Table 2-6. The nature and extent of contamination in several other landfills within the groundwater management areas have not been adequately characterized. Table 2-7 provides a description of these landfills, the dates of operation, waste managed, and history of releases.

Table 2-4
Oil/Water Separators
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

Site/Group	[1]GMA	Building Number	Medium	Chem. Exceed. [2]RRS2	Conc.	Units	Comments
35	East Area	1194	Subsurface soil	Beryllium	0.66	mg/kg	
37	East Area	1191	Subsurface soil	Arsenic	14	mg/kg	
40	Flightline Area	1643	--	--	0		No data
41	Flightline Area	1414	Subsurface soil	Nickel	16	mg/kg	Inactive
41	Flightline Area	1414	Subsurface soil	Beryllium	0.75	mg/kg	Inactive
44	East Area	1027	Subsurface soil	Arsenic	14	mg/kg	
44	East Area	1027	Surface soil	Lead	58	mg/kg	
44	East Area	1027	Surface soil	Arsenic	10	mg/kg	
44	East Area	1027	Surface soil	Cadmium	6.1	mg/kg	
47	East Area	1015	Subsurface soil	Chromium	15	mg/kg	Inactive
47	East Area	1015	Surface soil	Nickel	13	mg/kg	Inactive
47	East Area	1015	Surface soil	Arsenic	10	mg/kg	Inactive
52	--	1190	Surface soil	Arsenic	7.6	mg/kg	
52	--	1190	Surface soil	Cadmium	5.4	mg/kg	
52	--	1190	Surface soil	Lead	88	mg/kg	
55	--		--	--	0		No data
67	East Area	1320	Surface soil	Arsenic	18	mg/kg	
67	East Area	1320	Surface soil	Lead	36	mg/kg	
AOC 10	East Area	1064	Subsurface soil	Arsenic	16	mg/kg	
AOC 11	East Area	1060	Surface soil	Arsenic	9.6	mg/kg	
AOC 11	East Area	1060	Surface soil	Chromium	15	mg/kg	
AOC 12	East Area	4208	Surface soil	Nickel	16	mg/kg	
AOC 12	East Area	4208	Surface soil	Arsenic	19	mg/kg	
AOC 12	East Area	4208	Surface soil	Chromium	14	mg/kg	
AOC 12	East Area	4208	Surface soil	Beryllium	0.53	mg/kg	
AOC 13	East Area	1145	Surface soil	Arsenic	17	mg/kg	
AOC 13	East Area	1145	Surface soil	Lead	21	mg/kg	
AOC 13	East Area	1145	Subsurface soil	Chromium	14	mg/kg	

[1]GMA = Groundwater Management Area
[2]RRS2 = Relative Risk Standard 2

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Table 2-5
Waste Accumulation Areas
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

Site/Group	GMA	Bldg. No.	Bldg. Function	Waste Generated	HW Area	Release	Comments
11	Flightline Area	1617	Production of printed circuit boards	Etchant (sodium persulfate), lacquer thinner/ink	1618	No	No longer exists; replaced with Bldg. 1618; NFA
12	Flightline Area	1619	Jet engine repair	PD-680, jet fuel, engine oil		Yes	Stained soil adjacent to unit, cracked asphalt adjacent to pad; no longer exists
13	Flightline Area	1710	Photographic film developing and developer	Spent photo fixer		No	Work station WAAs no longer exist; NFA
16	East Area	1060	Corrosion Control Shop	Paint Lacquer, MEK, paint stripper, PD-680, polyurethane paint		Yes	Stained soil, stains extend to storm water drainage ditch; replaced with Bldg. 1059 (Hazardous Waste Storage Area)
31	East Area	1050	Pneudraulics Shop (Citri-Kleen)	Spent solvent		No	Appears inactive, NFA
32	Flightline Area	1410	Repair jet engines; assembling/disassembling/ cleaning wheels and tires; service batteries	Engine oil, solvents, degreasers, PD-680, JP-4	1415	Yes	Stained concrete; Replaced with Bldg. 1415 (Hazardous Waste Area)
33	Flightline Area	1420	Maintenance and inspection of munitions trailers	PD-680, hydraulic fluid, brake fluid, MEK	1436	Yes	Base of unit heavily stained; replace with Bldg. 1436
34	East Area	1194	Maintenance of refueling and water servicing vehicles	Waste oil, antifreeze, PD-680, transmission fluid		Yes	Stained soil along runoff pathway and at edge of parking lot; not currently used
36	East Area	1191	Vehicle body work and painting; maintenance of gov't vehicles and heavy equipment	Unleaded gasoline, waste oil, MOGAS, antifreeze		Yes	Stained soil and asphalt; oil film on ponded rainwater
39	Flightline Area	1643	Aircraft maintenance operations	Waste engine oil, PD-680, hydraulic fluid, fuel, and carbon remover		No	Active, covered with shed; NFA
42	Flightline Area	1414	Maintenance and inspection of AGE equipment	Waste oil, antifreeze, JP-4, and PD-680	1415	No	Does not exist, hydraulic fluid, may replaced by Bldg. 1415; NFA

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Table 2-5
Waste Accumulation Areas Groundwater Sampling and Analysis Plan NAS Fort Worth JRB
August 1996

Site/Group	GMA	Bldg. No.	Bldg. Function	Waste Generated	HW Area	Release	Comments
5	Flightline Area	1628	AGE Maintenance Shop, corrosion control	Waste paints and thinners, MEK, antifreeze, batteries	1627	Yes	Stained concrete and soil, vegetation; replaced with Bldg. 1627
51	East Area	Central Waste Holding Area	Three waste holding areas within fenced area;	PD-680, xylene, hazardous wastes from other WAAs	1190	No	Active 90-day hazardous waste storage area
61	East Area	1320	Maintenance of portable gasoline and diesel generators	Waste antifreeze, diesel, oil, PD-680	1319	No	Replaced with Bldg. 1319
AOC 15	East Area	1190	Storage shed			No	Active
AOC 6	East Area	RV Storage Area	Area previously used for motor pool vehicles			No	Adjacent to Bldg. 1320 (former motor pool)

GMA = Groundwater Management Area

Source: Hazardous Waste Technical Assistance Survey, Carswell AFB, TX. March 1989.

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Table 2-6
Landfills
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

Site/Group	GMA	Description	Chemicals Exceeding Risk Reduction Standard 2	Concentration (µg/L)
26	Landfill Area	Landfill 3 is located under the area currently occupied by the NAS Fort Worth JRB runway, immediately south of the culvert which carries Farmers Branch. LF03 was in operation from 1950 to 1952. During this period, the runway ended north of Farmers Branch, and the wastes were placed in a ravine. The site was used as a disposal point for all types of waste, but was primarily used for construction rubble.	Beryllium Chromium Bis(2-ethylhexyl)phthalate	9 130 190
28	East Area	Landfill 6 was originally a gravel pit used for base construction activities from 1975 to 1978. Construction rubble, tree limbs, and miscellaneous trash were buried here. Several drums of hydraulic fluid were reportedly buried in a centrally located pit.	Trichloroethylene Tetrachloroethylene 1,1-Dichloroethylene c-1,2-Dichloroethylene t-1,2-Dichloropropane t-1,2-Dichloroethylene	12,000 1,900 61 1,300 170 19
62	East Area	Landfill 1 is the original base landfill; used during the 1940s; located adjacent to the Trinity River at the current location of the Defense Reutilization and Marketing Office (DRMO); no records available concerning historical disposal practices.	Lead	22

Table 2-7
Other Miscellaneous Landfills
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

Site/Group	GMA	Description	Dates of Operation	Wastes Managed	History of Releases
SWMU 17	Landfill Area	Landfill No. 7 is located approximately 1,500 feet north of the Fire Training Area No. 2 (SWMU No. 19), east of the north-south Taxiway 197, and south of Taxiway 190. The site appeared mounded at the time of the VIS, as if waste material had been covered, but waste had also been disposed of on top of the mound. Runoff from the site flows to a shallow drainage feature, east of the unit. Landfill No. 7 has been designated Installation Restoration Program (IRP) Site No. 7 by the IRP Phase I Records Search Report. (1)	Landfill No. 7 was used from 1978 to 1983. The presence of waste at the surface of the site during the VSI indicates the unit may currently be in operation.	Landfill No. 7 was reportedly filled with clean construction rubble, and fill dirt. At the time of the VSI, concrete rubble such as broken speed bumps and parking curbs were observed at the site. Other types of waste observed included steel concrete reinforcement bar and tree limbs. The unit reportedly does not manage hazardous materials, although hazardous constituents may be present.	There is no documented history of releases for this unit. During the VSI, runoff was noted flowing east toward a shallow drainage ditch.
SWMU 25	Landfill Area	Landfill No. 8 is located just east of the north-south Taxiway 197 and south of Taxiway 190. The unit was used as a fill area during the 1960s. The unit lies over the culverts carrying Farmers Branch under the runway. At the time of the VSI, the unit appeared as a mounded-grassy area. The unit has been designated IRP Site No. 8 by the IRP Phase I Records Search report. The site was not recommended for monitoring under the Phase II program.	The unit was operational during the 1960s; it has not been used since the late 1960s.	The unit reportedly managed wood, metal, construction rubble, asphalt, concrete, and trees. No hazardous materials are reported to be buried at this site, although some of the materials may contain hazardous constituents.	There is no documented history of releases for this unit.
SWMU 27	Landfill Area	Landfill No. 10 is located in the southwestern portion of the base, south of the culvert carrying Farmers Branch, between the perimeter road and the North-South Primary/Instrument Runway. At the time of the VSI, the unit consisted of one large trench approximately 20 feet wide by 80 feet long by 12 feet deep. Also at the time of the VSI, the trench was filled with several feet of water, and a bulldozer was present at the site. The unit was not designated a site number by the IRP Phase I Records Search report.	The exact date of operation startup is unknown. The unit is presently operation.	At the time of the VSI, the unit managed concrete rubble and tree limbs. No evidence of hazardous materials was noted during the VSI.	There is no documented history of releases for this unit. No evidence of release was noted during the VSI.

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Table 2-7
Other Miscellaneous Landfills
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

Site/Group	GMA	Description	Dates of Operation	Wastes Managed	History of Releases
SWMU 29	East Area	Landfill No. 2 is located near Haile Drive and Hobby Shop Road, lying at least partially under Building 1055. The site reportedly was a borrow pit for runway construction during the 1940s and then used as a landfill. Refuse was reportedly buried in shallow trenches. The site is approximately 200 feet from a tributary of Farmers Branch. It is also within 1,000 feet of an estimated population of greater than 100 people and within one mile of other residential areas. The unit has been designated as IRP Site No. 2 by the IRP Phase I Records Search Report.	The unit was operational from 1952 until 1956. The unit has been covered since 1956.	The unit reportedly managed rubble and construction materials, and is reported to manage moderate quantities of hazardous waste.	There is no documented history of releases for this unit.
SWMU 30	Flightline Area	Landfill No. 9 is located in the northeast portion of the base, and adjacent to the West Fork Trinity River. No other information about this unit is available from either the file material or facility representatives present during the VSI.	The unit was operational from 1978 to 1983.	The unit managed clean construction rubble and trees. No hazardous materials are reported to be buried at this site, although materials with hazardous constituents may have been disposed of here.	There is not documented history of releases for this unit.

GMA = Groundwater Management Area

Source: RCRA Facility Assessment PR/VSI Report. March 1989.

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2.5.4 Storm and Sanitary Sewers/Interceptors

Three SWMUs are associated with the NAS Fort Worth JRB storm and sanitary sewer/interceptor system. They are SWMU 53, Stormwater Drainage System; SWMU 54, Stormwater Interceptors; and SWMU 66, Sanitary Sewer System. Table 2-8 provides a description of the storm and sanitary/interceptor system, the dates of operation, waste managed, and history of releases.

2.5.5 Summary

Section 2.5 summarized other potential groundwater influences in addition to those sources thought to define the three major contaminated groundwater plumes. In compiling these summaries it is apparent that there are varying levels of monitoring data available to adequately characterize these other potential groundwater influences. For those sites with little or no long-term monitoring data presently available, it is anticipated that future monitoring will be needed. Section 3.2 discusses future monitoring actions for all SWMUs/AOCs.

Table 2-8
Storm and Sanitary Sewers/Interceptors
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

Site/Group	Description	Dates of Operation	Wastes Managed	History of Releases
SWMU 53	The Stormwater Drainage System comprises the facility's network of drainage ditches and subsurface man-made conduits. This includes the storm sewer system, as well as the drainage ditches in which flow follows the topography. Three of these ditches are of particular interest. These are the flightline drainage ditch, the Building 1190 drainage ditch, and the Building 1340 drainage ditch. The flightline drainage ditch catches stormwater runoff from the runway area. Water flows from west to east, first along the west side, then beneath the runways; then, it enters Farmers Branch east of the runway. Buildings 1190 and 1340 drainage ditches carry stormwater runoff as well as releases from oil/water separators in the respective buildings (SWMU Nos. 52 and 67). The storm sewer system is reportedly constructed of concrete. Most of the drainage ditches are earthen, except for a section of the Building 1190 drainage ditch.	The system is presently operational. Although the exact date of operation startup is unknown, it is believed that this system has been in use ever since maintenance operations started at the facility.	The unit receives stormwater runoff from areas throughout the facility as well as non-oily discharges (by design) from Oil/ Water Separators. Also, any spilled material could potentially be introduced into the Stormwater Drainage System. This may contain contaminants such as petroleum products, solvents, and soap, diluted in the runoff.	The drainage ditches near Buildings 1190 and 1340 are being investigated under the IRP program. Reportedly, evidence of contamination has been observed in the ditch (Site Number 13), near Building 1190. It included a white liquid (aircraft soap), as well as petroleum products at the surface of the water and along the banks. The ditch may received discharges from the Aircraft Washing Areas (SWMU Nos. 49 and 50) and the Fuel Systems Shop (Building 1048). These releases would include J-4, PD-680, and soap. Records of analyses performed on the stream show the detection of trace quantities of TCE. More recently, analytical results from the IRP Phase II Stage 7 investigation indicate levels of soil grease ranging from less than 1 to 7,100 mg/L, and high levels of aromatic compounds in the groundwater. Also, according to that report, the source of contamination is suspected of being either a former gasoline station, or the POL Tank Farm (SWMU No. 68).
SWMU 54	A total of five Stormwater Interceptors are reported to exist at the facility. They consist of below-ground concrete sumps which are used to hold wastewater from stormwater runoff, prior to separation, or to discharge to surface water. Their main purpose is to provide containment for releases to surface water from accidental spills into the stormwater sewer system. Two of these units were encountered during the CSI, the east gate interceptor, and the south gate interceptor. The east gate interceptor holds incoming wastewater to the East Gate Oil/ Water Separator (SWMU No. 55). It is approximately 6 feet by 4 feet. Its depth and capacity were not documented. It is fully enclosed and its interior can be accessed from a 1 foot by 2.5 foot covered manhole. On the other hand, the south gate interceptor holds wastewater which is ready to be released into the Farmers Branch Creek. It is 30 feet by 50 feet, and 15 feet deep. Its top is not closed. It is covered with a metal grid. The structural integrity of these units is not documented.	The exact date of operation startup is unknown. The units are presently operational.	The wastes managed in the Interceptors consist of stormwater runoff. The quality of the water to be discharged is monitored under the NPDES permit. However, Interceptors releasing wastewater to oil/water separators contain oily contaminants, primarily consisted of hydrocarbons.	There is no documented history of releases for these units. No evidence of release was noted during the VSI.

Table 2-8
Storm and Sanitary Sewers/Interceptors
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

Site/Group	Description	Dates of Operation	Wastes Managed	History of Releases
SWMU 66	The Sanitary Sewer System consists of a network of underground pipes. The Sanitary Sewer System collects sanitary wastewater as well as some industrial wastewater from the Visual Information Center Work Station Waste Accumulation Areas (SWMU No. 13). The wastewater collected by the Sanitary Sewer System at NAS Fort Worth JRB is pumped to the City of Fort Worth for treatment. This has been the operation since the base was first constructed.	The unit has been operation since 1942, when the facility began operation. The unit is currently active.	The unit manages sanitary wastewater from throughout the facility as well as industrial wastewater from various activities.	There is not known history of release from this unit.

Source: RCRA Facility Assessment PR/VSI Report. March 1989.

3.0 Work Tasks

This section describes the work to be conducted under the groundwater sampling and analysis program for NAS Fort Worth JRB based on the current objectives and project understanding. These work tasks will be reviewed after each sampling event to ensure continuing implementation of a program structured to meet short- and long-term objectives.

3.1 Water Level Measurements

The purpose of monitoring water level measurements at NAS Fort Worth JRB is to evaluate existing groundwater flow patterns. This information will be used to assess the fate and transport of contaminants within the on-site aquifers.

Based on available survey information, 178 monitor wells exist at NAS Fort Worth JRB. The majority of wells were constructed across the water table within fill and unconsolidated alluvium. Only four monitor wells were installed in bedrock and these are screened within the Paluxy Formation. Table 3-1 lists all the monitor wells by groundwater management area. Table A-1 in Appendix A of this GSAP lists all wells, survey coordinates, and top of casing elevations currently identified for NAS Fort Worth JRB.

3.1.1 Previous Investigations

Periodic water level measurements were obtained at NAS Fort Worth JRB as part of long term groundwater monitoring by LAW between April 1995 and January 1996 (LAW, 1996) As part of the well selection process prior to sampling, LAW performed a reconnaissance survey of existing wells at NAS Fort Worth JRB. In 1994, LAW located 82 monitor wells based on available plans and conducted a limited inspection of each well to assess the potential for sampling. A summary of LAW's well assessment has been tabulated and included as Table A-2 in Appendix A of this GSAP. Table A-2 includes a description of four USGS bedrock monitor wells that were not included on LAW's original well evaluation summary.

Groundwater level measurements were obtained from approximately 70 fill and alluvial monitor wells on a quarterly basis to evaluate groundwater flow patterns. No measurements were obtained from wells constructed in bedrock. A water table contour map was developed for each event. An evaluation of these maps indicates that little change occurs in base-wide groundwater flow during the year. Monitoring data that could be used for vertical gradient evaluation was not obtained during the studies.

3.1.2 Selection of Monitor Wells for Water Level Measurements

One hundred and seventy-eight monitor wells were located and plotted on the NAS Fort Worth JRB base map shown in Figure 3-1. For the purpose of evaluating groundwater flow patterns, many of these wells do not provide unique or necessary data. In order to attain the objectives of the groundwater sampling and analysis program, each monitor well was evaluated to determine its utility in assessing base-wide groundwater flow. Where available, construction details provided in Table A-2 were reviewed. Several monitor wells were eliminated from the selected list for reasons described below:

- Located within 50 feet of another well constructed in the same strata
- Recorded as dry during construction and subsequent monitoring
- Screened interval of the well was greater than 20 feet or was screened in two or more separate strata units
- Contains product (LNAPL) with a thickness greater than 0.01 feet. However, the thickness of the product will be measured as described in Appendix B (Section B.2.4.2).

Table 3-2 lists 148 monitor wells that will be included in the water level measurement survey. Water level measurements will be taken following the procedures in Appendix B (Section B2.1.4). Wells that provide data on vertical flow or critical data near base boundaries were maintained in the monitoring network.

3.1.3 Frequency of Water Level Measurements

The 148 wells listed in Table 3-2 will be monitored and water levels checked on a semi-annual basis to evaluate base-wide groundwater flow. This monitoring frequency was selected following review of the previous data collected and verification of relatively consistent groundwater conditions throughout the year. Water levels will be monitored in wells selected for sampling at the same frequency as sampling.

3.2 Groundwater Quality Sampling

The criteria for selecting wells and chemical parameters for the first two sampling rounds of the groundwater monitoring program were developed to meet the short-term objective and provide preliminary data to support two components of the long-term objective:

- Identify potential impacts to off-site groundwater receptors
- Support closure of SWMUs/AOCs
  - Evaluate the extent of natural attenuation of contaminants occurring in the Flightline and East Area Groundwater management areas
  - Perform long-term monitoring to address regulatory compliance issues associated with closure of SWMUs/AOCs

Table 3-1
Summary of Existing Monitor Wells
Groundwater Sampling & Analysis Plan
NAS Fort Worth JRB
August 1996

Groundwater Management Area	Well Identification		
Landfill Area Groundwater	15B	LF04-4F	WP07-10B
	FT08-11A	LF04-4G	WP07-10C
	FT08-11B	LF04-4H	
	FT09-12A	LF05-01	
	FT09-12B	LF05-02	
	FT09-12C	LF05-14	
	FT09-12D	LF05-18	
	FT09-12E	LF05-19	
	GMI-04-01M	LF05-5A	
	HM-111	LF05-5B	
	HM-114	LF05-5C	
	HM-122	LF05-5D	
	HM-123	LF05-5E	
	HM-126	LF05-5F	
	HM-127	LF05-5G	
	ITMW-01T	LF05-5H	
	LF04-01	MW-12A	
	LF04-02	MW-13	
	LF04-03	MW-IT-02T	
	LF04-04	OT-15C	
	LF04-10	RW-1	
	LF04-4A	TREE	
	LF04-4B	TREE	
	LF04-4C	***USGS07P***	
	LF04-4D	USGS07T	
	LF04-4E	WP07-10A	

Note:
USGSXXX Indicates Paluxy Formation Well (i.e., Bedrock Well)

Table 3-1
Summary of Existing Monitor Wells
Groundwater Sampling & Analysis Plan
NAS Fort Worth JRB
August 1996

Groundwater Management Area	Well Identification		
East Area Groundwater	17I	PI-U9	ST14-W12
	17J	SAV-1	ST14-W13
	17K	SAV-2	ST14-W15
	17L	SD13-01	ST14-W16
	17M	SD13-02	ST14-W18
	BSS-A	SD13-03	ST14-W19
	BSS-B	SD13-04	ST14-W20
		SD13-05	ST14-W21
	LF01-1B	SD13-06	ST14-W22
	LF01-1C	SD13-07	ST14-W23
	LF01-1D	ST14-01	ST14-W31
	LF01-1E	ST14-02	ST14-W32
	MW-1	ST14-03	***USGS05P***
	MW-10	ST14-04	***USGS06P***
	MW-11	ST14-14	USGS06T
	MW-2	ST14-24	
	MW-20	ST14-25	
	MW-21	ST14-26	
	MW-3	ST14-27	
	MW-36	ST14-28	
	MW-37	ST14-29	
	MW-4	ST14-30	
	MW-5	ST14-W05	
	MW-6	ST14-W06	
	MW-7	ST14-W07	
	MW-8	ST14-W08	
	MW-9	ST14-W09	
	MW1-16	ST14-W10	
	P5	ST14-W11	

Note:
USGSXXX Indicates Paluxy Formation Well (i.e., Bedrock Well)

Table 3-1
Summary of Existing Monitor Wells
Groundwater Sampling & Analysis Plan
NAS Fort Worth JRB
August 1996

Groundwater Management Area	Well Identification	
Flightline Area Groundwater	GMI-22-02M	MW-41
	GMI-22-03M	MW-42
	GMI-22-04M	MW-48
	GMI-22-05M	MW-49
	GMI-22-06M	MW-50
	GMI-22-07M	MW-51
	GMI-22-08M	MW-52
	HM-116	MW-53
	HM-117	MW-56
	HM-118	MW-57
	HM-119	MW-57B
	HM-120	MW-58
	HM-121	MW-59
	HM-124	SPOT-35-1
	HM-125	SPOT-35-2
	K910	SPOT-35-3
	LSA1628-1	SPOT-35-4
	LSA1628-2	SPOT-35-5
	LSA1628-3	SPOT-35-6
	MW-11A	SPOT-35-7
	MW-18	***USGS01P***
	MW-19	USGS01T
	MW-1A	USGS02T
	MW-38	USGS03T
	MW-39	USGS04T
	MW-40	W-153

Note:
USGSXXX Indicates Paluxy Formation Well (i.e., Bedrock Well)

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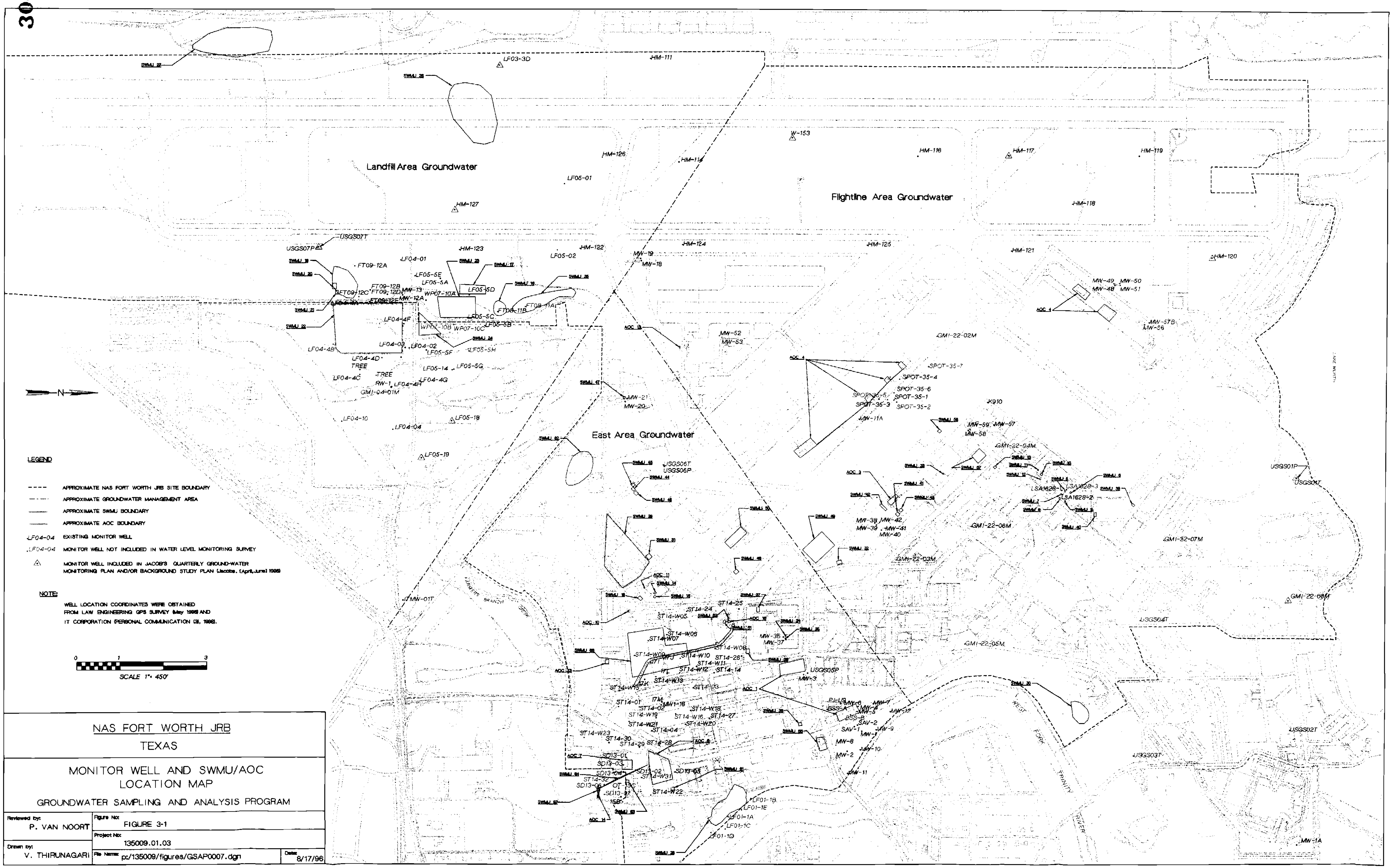

NAS FORT WORTH JRB
TEXAS

MONITOR WELL AND SWMU/AOC
LOCATION MAP
GROUNDWATER SAMPLING AND ANALYSIS PROGRAM

Reviewed by: P. VAN NOORT	Figure No: FIGURE 3-1	
	Project No: 135009.01.03	
Drawn by: V. THIRUNAGARI	File Name: p:/135009/figures/GSAP0007.dgn	Date: 8/17/96

Table 3-2
Summary of Monitor Wells Selected for Water Level Measurement
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

Groundwater Management Area	Well Identification		
Landfill Area Groundwater	FT08-11A	LF04-4G	
	FT08-11B	LF05-01	
	FT09-12A	LF05-02	
	FT09-12B	LF05-14	
	FT09-12C	LF05-18	
	FT09-12D	LF05-19	
	FT09-12E	LF05-5A	
	HM-111	LF05-5B	
	HM-114	LF05-5C	
	HM-122	LF05-5D	
	HM-123	LF05-5E	
	HM-126	LF05-5F	
	HM-127	LF05-5H	
	ITMW-01T	MW-12A	
	LF04-01	MW-IT-02T	
	LF04-02	OT-15C	
	LF04-04	TREE	
	LF04-10	***USGS07P***	
	LF04-4A	USGS07T	
	LF04-4B	WP07-10A	
	LF04-4C	WP07-10B	
	LF04-4D	WP07-10C	
	LF04-4E	RW-1	
	LF04-4F		
East Area Groundwater	15B	MW1-16	ST14-30
	17I	P5	ST14-W05
	17J	PI-U9	ST14-W06
	17K	SAV-1	ST14-W07
	17L	SD13-01	ST14-W08
	BSS-A	SD13-02	ST14-W09
	BSS-B	SD13-03	ST14-W10
		SD13-04	ST14-W11
	LF01-1B	SD13-05	ST14-W12
	LF01-1C	SD13-06	ST14-W13
	LF01-1D	SD13-07	ST14-W15
	LF01-1E	ST14-01	ST14-W16
	MW-10	ST14-02	ST14-W18
	MW-11	ST14-03	ST14-W19

East Area Groundwater (cont'd.)	MW-2 MW-20 MW-3 MW-37 MW-6 MW-7 MW-8 MW-9	ST14-04 ST14-14 ST14-24 ST14-25 ST14-26 ST14-27 ST14-28 ST14-29	ST14-W20 ST14-W21 ST14-W22 ST14-W23 ST14-W31 ST14-W32 ***USGS05P*** ***USGS06P***
Flightline Area Groundwater	GMI-22-02M GMI-22-03M GMI-22-04M GMI-22-05M GMI-22-06M GMI-22-07M GMI-22-08M HM-116 HM-117 HM-118 HM-119 HM-120 HM-121 HM-124 HM-125 K910 LSA1628-3 MW-11A MW-19 MW-1A MW-38	MW-48 MW-53 MW-56 MW-57 MW-59 SPOT-35-1 SPOT-35-5 SPOT-35-7 ***USGS01P*** USGS01T USGS02T USGS03T USGS04T W-153	USGS06T

Note: ***USGSXXX*** Indicates Deep Paluxy Formation Well

As discussed in Section 1.4, a conceptual framework was developed for subsequent sampling rounds; details such as well selection for these subsequent rounds are not, however, in this GSAP. The framework was designed to provide data to support the long-term objective of closing the SWMUs and AOCs. The framework for subsequent sampling rounds is discussed in Section 3.2.2.

It should be noted that the total number of wells sampled over the course of this sampling program is different from previous monitoring efforts. Objectives for previous monitoring programs were different (e.g., determining nature and extent of contamination or delineating specific plumes) than the long-term objective for this program of closing SWMUs and AOCs. Because sampling objectives for this program may change over time as more current results are incorporated into the overall understanding of the site, the location and number of wells to be sampled during subsequent monitoring rounds will change.

3.2.1 First and Second Sampling Rounds

Two components were considered in developing the water quality sampling approach for the first two sampling rounds: well location and chemical parameters. Criteria for each of these components were identified and used to develop a sampling matrix. Current water level contour maps and historical chemical data were reviewed to develop and support the water quality sampling approach. Table 3-3 presents the sampling matrix, including wells selected for sampling, rationale for their selection, and chemical parameters for each well. Table 3-4 summarizes the number of wells to be sampled and number of samples for each chemical parameter/analytical group. Figure 3-2 shows the wells that were selected for monitoring in the first and second rounds of the program. The criteria for well and chemical parameter selection are described in detail in the following subsections.

3.2.1.1 Well Selection

Perimeter Wells

In order to meet the short-term objective of identifying potential impacts to off-site groundwater receptors, perimeter monitor wells were selected from each groundwater management area. Perimeter wells include wells located near the NAS Fort Worth JRB boundaries and/or immediately upgradient of surface water bodies where groundwater may discharge to surface water.

Bedrock Wells

In addition to perimeter wells, the four existing bedrock wells at the site were selected to support the short-term objective. Based on review of sampling information provided by LAW and Jacobs, these wells have not been sampled previously. Data from these wells will be used to evaluate potential impacts to the Paluxy aquifer and consequently, potential impacts to off-site receptors using this aquifer as a drinking water source. Bedrock wells will only be sampled during the first round of sampling. An` evaluation of data from that round will be used to determine if additional sampling rounds are indicated.

Table 3-3
Monitoring Wells Selected for Current Sampling Program
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August, 1996

AREA	DESCRIPTION	WELL	OBJECTIVE(1)			RATIONALE	CHEMICAL PARAMETER(2)/METHOD(3)									
			1	2	3		BTEX	TCE	DO(5)	NO3/SO4	Fe(II)(5)	Alkalinity	Eh(5)	CH4	TOC	Metals
							SW8020A	SW5030A/ SW8260A	E360.1	SW9056	AFCEE	E310.1	ASTM D1498	AFCEE	9060	SW3005A/SW6020
FAGW	Airfield Groundwater (Fuel Hydrant	GMI-22-02M		X		Upgradient	X	X	X	X	X	X	X	X	X	
FAGW	System (AOC4) and AOC2	SPOT-35-4		X		Plume	X	X	X	X	X	X	X	X	X	
FAGW		SPOT-35-2		X		Plume	X	X	X	X	X	X	X	X	X	
FAGW		SPOT-35-5		X		Plume	X	X	X	X	X	X	X	X	X	
FAGW		MW-59		X		Plume	X	X	X	X	X	X	X	X	X	
FAGW		GMI-22-04M		X		Plume	X	X	X	X	X	X	X	X	X	
FAGW		LSA1628-3		X		Plume	X	X	X	X	X	X	X	X	X	
FAGW		GMI-22-07M		X		Sentry	X	X	X	X	X	X	X	X	X	
FAGW		USGS04T	X	X		Perimeter	X	X	X							X
FAGW		GMI-22-05M	X	X		Perimeter	X	X	X							X
FAGW	Bedrock	USGS01P			X	Plume	X*	X*								
[illegible]W	Former Base Service Station (AOC1)	MW-3		X		Upgradient	X		X	X	X	X	X	X	X	
[illegible]W		BSS-A		X		Upgradient	X		X	X	X	X	X	X	X	
[illegible]W		BSS-B		X		Plume	X		X	X	X	X	X	X	X	
[illegible]W		SAV-1		X		Plume	X		X	X	X	X	X	X	X	
[illegible]W		SAV-2		X		Plume	X		X	X	X	X	X	X	X	
[illegible]W		MW-1		X		Sentry	X		X	X	X	X	X	X	X	
[illegible]W		MW-9	X	X		Perimeter	X	X	X							X
[illegible]W		MW-10	X	X		Perimeter	X	X	X							X
[illegible]W		MW-11	X	X		Perimeter	X	X	X							X
[illegible]W		MW-12	X	X		Perimeter	X	X	X							X
[illegible]W	POL Tank Farm (SWMU 68),	ST14-W14		X		Upgradient	X		X	X	X	X	X	X	X	
[illegible]W	Former Base Refueling Area (AOC 7),	ST14-W24		X		Upgradient	X		X	X	X	X	X	X	X	
EAGW	French Underdrain System (SWMU 64)	ST14-W26		X		Upgradient	X		X	X	X	X	X	X	X	
EAGW		ST14-W03		X		Plume	X		X	X	X	X	X	X	X	
EAGW		ST14-W16		X		Plume	X		X	X	X	X	X	X	X	
EAGW		ST14-W18		X		Plume	X		X	X	X	X	X	X	X	
EAGW		ST14-W17M		X		Plume	X		X	X	X	X	X	X	X	
EAGW		ST14-W02		X		Plume	X		X	X	X	X	X	X	X	
EAGW		ST14-W29		X		Plume	X		X	X	X	X	X	X	X	
EAGW		ST14-W21		X		Plume	X		X	X	X	X	X	X	X	
EAGW		ST14-W04		X		Plume	X		X	X	X	X	X	X	X	
EAGW		ST14-W28		X		Plume	X		X	X	X	X	X	X	X	
EAGW		ST14-W31[4]		X		Plume	X		X	X	X	X	X	X	X	
EAGW	Unnamed Stream (AOC14)	SD13-01[4]		X		Sentry	X		X	X	X	X	X	X	X	

Table 3-3
Monitoring Wells Selected for Current Sampling Program
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August, 1996

AREA	DESCRIPTION	WELL	OBJECTIVE(1)			RATIONALE		CHEMICAL PARAMETER(2)/METHOD(3)								
			1	2	3		BTEX	TCE	DO(5)	NO3/SO4	Fe(II)(5)	Alkalinity	Eh(5)	CH4	TOC	Metals
							SW8020A	SW5030A/ SW8260A	E360.1	SW9056	AFCEE	E310.1	ASTM D1498	AFCEE	9060	SW3005A/SW6020
EAGW		SD13-02[4]		X		Sentry	X		X	X	X	X	X	X	X	
EAGW		SD13-04[4]		X		Sentry	X		X	X	X	X	X	X	X	
EAGW		SD13-06[4]	X	X		Perimeter	X	X	X							X
EAGW		SD13-07[4]	X	X		Perimeter	X	X	X							X
EAGW		OT15C[4]	X	X		Perimeter	X	X	X							X
EAGW	Landfill 1 (SWMU 28)	LF01-1B	X			Perimeter	X	X								X
EAGW		LF01-1C	X			Perimeter	X	X								X
EAGW		LF01-1D	X			Perimeter	X	X								X
EAGW		LF01-1E	X			Perimeter	X	X								X
EAGW	Bedrock	USGS05P			X	Plume	X*	X*								
EAGW	Bedrock	USGS06P			X	Plume	X*	X*								
LAGW	BRAC: Landfill 4, Landfill 5, Fire	LF05-02			X	Plume	X	X								
LAGW	Training Area 1, Landfill 8	FT09-12C			X	Plume	X	X								
LAGW	DERA: Landfill 8, Landfill 7, Fire	LF04-4F			X	Plume	X	X								
LAGW	Training Area 2, Waste Burial Area	WP07-10B			X	Plume	X	X								
LAGW		WP07-10C			X	Plume	X	X								
LAGW		LF05-5G			X	Plume	X	X								
LAGW		GM104-01M			X	Plume	X	X								
LAGW		LF04-10			X	Plume	X	X								
LAGW		LF05-18(6)	X			Perimeter	X	X								X
LAGW		LF05-19(6)	X			Perimeter	X	X								X
LAGW	Bedrock	USGS07P			X	Plume	X*	X*								

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Notes:

X*	sampled only in the first round

(1)Objectives:

1 = Identify potential impacts to offsite groundwater receptors
2 = Support closure of SWMUs/AOCs; model natural attenuation
3 = Support closure of SWMUs/AOCs; perform LTM for regulatory closure requirements

(2)Chemical Parameters:

BTEX	Benzene, Toluene, Ethylbenzene, and xylene
TCE	Trichloroethylene (includes degradation products of TCE)
DO	dissolved oxygen
NO3	nitrate
Fe(II)	ferrous iron
SO4	sulfate
TOC	Total Organic Carbon
CH4	methane (also includes ethane and ethene)
Eh	oxidation-reduction potential

(3)CH2M HILL, 1996a; AFCEE, 1995
(4) TNRCC requested wells for monitoring (TNRCC, 1996)
(5)Field parameters
(6)These wells are scheduled for sampling by Jacobs Engineering.
If Jacobs sampling plans includes parameters listed on table, data will be obtained from Jacobs and wells will not be sampled under this GSAP.

Table 3-4
Groundwater Analytical Summary Table
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB, Carswell Field Texas
August 1996

	First Round	Second Round[1]
Number of Wells	58	54
Chemical Parameter		
BTEX	57	53
TCE	35	31
DO	39	39
NO3/SO4	30	30
Fe(II)	30	30
Alkalinity	30	30
Eh	30	30
TOC	30	30
CH4	30	30
Metals	15	15
(2)QC Samples	24	23
Equipment Blanks	6	6
Ambient Blanks	6	6
Trip Blanks	6	6
Duplicates	6	5
TOTAL	382	372

Notes:

[1] Second round sampling does not include the 4 Paluxy wells

(2) QC Samples - see Appendix B, section B.1.5

BTEX	Benzene, toluene, ethylbenzene, and xylenes
TCE	Trichloroethylene (including degradation products)
DO	Dissolved oxygen (Field Parameter)
NO3/SO4	Nitrate/sulfate
Fe(II)	Ferrous iron (Field Parameter)
Eh	Oxidation-reduction potential (Field Parameter)
TOC	Total Organic Carbon
CH4	Methane

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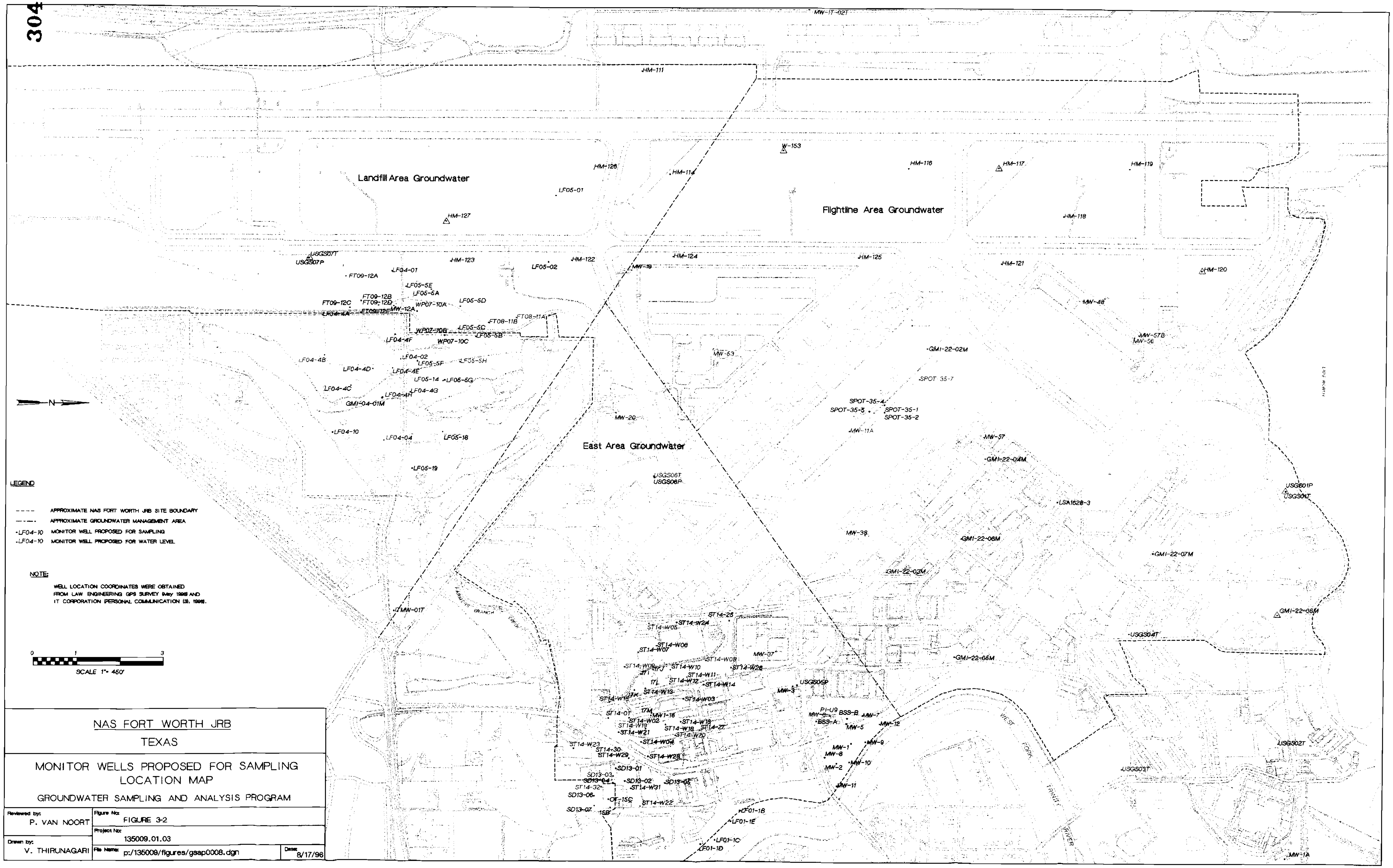

LEGEND

---- APPROXIMATE NAS FORT WORTH JRB SITE BOUNDARY
—·—· APPROXIMATE GROUNDWATER MANAGEMENT AREA
•LF04-10 MONITOR WELL PROPOSED FOR SAMPLING
•LF04-10 MONITOR WELL PROPOSED FOR WATER LEVEL

NOTE:

WELL LOCATION COORDINATES WERE OBTAINED FROM LAW ENGINEERING GPS SURVEY (May 1996) AND IT CORPORATION (PERSONAL COMMUNICATION (3), 1996).

0 1 3
SCALE 1"= 450'

NAS FORT WORTH JRB
TEXAS

MONITOR WELLS PROPOSED FOR SAMPLING LOCATION MAP

GROUNDWATER SAMPLING AND ANALYSIS PROGRAM

Reviewed by: P. VAN NOORT	Figure No: FIGURE 3-2
	Project No: 135009.01.03
Drawn by: V. THIRUNAGARI	File Name: p:/135009/figures/gsap0008.dgn — Date: 8/17/96

Natural Attenuation Wells

Four types of wells were selected for evaluating and monitoring the extent of natural chemical attenuation that may be occurring in each of the major groundwater plumes. These well types are described in the *Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater* (AFCEE, 1995) and in the *Remedial Action Plan for the Risk-Based Remediation of Site ST14, Carswell Air Force Base, Naval Air Station Fort Worth Joint Reserve Base* (Parsons, 1995). The well types are as follows:

1. Upgradient - wells located upgradient of the impacted groundwater; results will be used to evaluate background conditions;

2. Plume - wells located within or at the lateral edges of the dissolved contaminant plume; results will be used to evaluate the rate of contaminant removal by natural attenuation;

3. Sentry - wells located at the edge or downgradient of the contaminant plume; results will be used to verify natural attenuation is reducing contaminant concentrations; and

4. Perimeter - wells located at the boundaries of NAS Fort Worth JRB and/or surface water boundaries where groundwater may discharge to surface water; results will be used to monitor potential for off-site migration.

Natural attenuation wells were selected for the plume associated with the Flightline Groundwater Management Area and two plumes associated with the East Area Groundwater Management Area (i.e., Base Service Station and POL Tank Farm).

The well types for the plumes were assigned based on data from the *Second Semi-Annual Groundwater Monitoring Report* (LAW, 1996) and the following reports:

- Airfield Groundwater plume - (GMI, 1995);

- Base Service Station area - (US COE, 1993) and;

- POL Tank Farm area -(Parsons, 1995).

Wells selected for natural attenuation monitoring (including well type) are summarized on Table 3-3. (Note: Perimeter wells for natural attenuation are the same perimeter wells as those selected to meet the short-term objective.)

Long-term Monitor Wells

Wells were selected from the Landfill Groundwater Management Area to address regulatory issues associated with eventual closure of SWMUs and AOCs that are located in this geographic area. Eight wells located in areas of known contamination and two perimeter wells were identified to address long-term compliance issues.

3.2.1.2 Chemical Parameter Selection

Chemical parameters were selected for each well based on results of previous groundwater investigations, the objectives for this sampling program, and well type.

Perimeter Wells

Perimeter wells will be sampled for BTEX, TCE (including degradation products), and metals. Since BTEX and TCE are the major constituents of concern for the facility, concentration data for these parameters will be used to evaluate the potential for off-site impacts. The metals data from the current rounds will be used to compare concentrations of metals at the facility boundaries to background levels.

Bedrock Wells

Bedrock wells will be sampled for BTEX and TCE. As with perimeter wells, concentrations of the major chemicals of concern will be used to evaluate potential impacts to off-site receptors.

Natural Attenuation Wells

Natural attenuation wells will be sampled for BTEX and dissolved oxygen (DO) in the Base Service Station and POL Tank Farm area, and BTEX, TCE (including degradation products), and dissolved oxygen in the Flightline Groundwater Management area. In addition, all upgradient, plume, and sentry wells will be monitored for parameters associated with biodegradation processes (i.e., nitrate, sulfate, ferrous iron, oxidation-reduction potential, alkalinity, and methane). These data will be used to evaluate the extent of natural attenuation that is occurring and to model future levels and extent of migration of BTEX and TCE in groundwater.

Long-term Monitor Wells

Long-term compliance wells will be sampled for BTEX and TCE. These data will be used to support the closure requirements for the SWMUs and AOCs in the Landfill Groundwater Management Area.

3.2.2 Subsequent Sampling Rounds

As part of the long-term groundwater monitoring plan for NAS Fort Worth JRB, a conceptual framework identifying future monitoring requirements, beyond those necessary to achieve the short-term monitoring objectives, was developed. The framework uses information presented that summarized the current understanding of the potential nature and extent of contamination associated with the various SWMUs and AOCs. It is also based on the information available regarding the groundwater contamination investigations conducted to date and recognizes that additional areas of groundwater contamination may exist but are not yet characterized. Table 3-5 presents the overall groundwater monitoring activity summary. This summary identifies the groundwater monitoring requirements associated with each SWMU and/or AOC. In general, the information indicates the following:

- Three groundwater management areas generally encompass the contaminant plumes associated with fuel spills or leaks in addition to contaminants migrating from AFP4. Landfills in the south portion of the facility also fall within this category. This general area may also be impacted by contamination associated with previous disposal activities. Groundwater monitoring activities associated with these plumes will provide data for evaluating the effectiveness of natural attenuation processes, in addition to providing information to use in transport models to assess the potential for further downgradient (vertical or horizontal) migration.
- A number of oil/water separators located throughout the facility that, to date, have only been partially characterized relative to historical releases. Long-term groundwater monitoring requirements assume that one monitor well is installed for each oil/water separator and that long-term groundwater monitoring is performed.
- A number of waste accumulation areas, where for the most part, no documented releases occurred. It is assumed that these areas have not contributed to groundwater contamination; consequently, long-term groundwater monitoring is not anticipated for these units.
- Other miscellaneous units, such as the sanitary sewers, stormwater interceptors, and aircraft wash areas, may have contributed to groundwater contamination; however, it is assumed that the monitoring network in place will address potential contamination resulting from releases from these units.

Based on the objectives associated with the groundwater monitoring program the proposed analytical requirements are summarized in Table 3-6. As indicated in the table, the analytical requirements are tailored to the specific objective addressed by groundwater monitoring. As additional information is obtained, for either individual SMWUs/AOCs or larger geographic areas of the facility, the analytical requirements may need to be modified to address project-specific needs. The analytical requirements focus on collecting data to characterize the COCs; the COCs are based on the results of groundwater sampling conducted to date and knowledge of historical activities at the site.

In addition, the table includes groundwater monitoring requirements associated with closure requirements for underground storage tanks (USTs). Although the USTs are not classified as SWMUs or AOCs, this information is provided because it is anticipated that some level of long-term groundwater monitoring will be necessary to provide adequate documentation to support final closure of the USTs.

Table 3-5
Long-Term Groundwater Monitoring Activity Summary
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

UNIT	DESCRIPTION	CURRENT STATUS	GROUNDWATER MONITORING ACTIVITIES
SWMU5	B1628 Waste Accum. Area	Solvents, battery storage; evidence of release. Replaced with B1627.	None specific to this unit.
SWMU6	B1628 Wash Rack & Drain	Active (part of 301st); data exists.	None specific to this unit.
SWMU7	B1628 O/W Separator	Active (part of 301st); data exists.	Groundwater data required for SWMU closure; install monitoring well following removal of separator/associated piping. Perform LTM.
SWMU8	B1628 Sludge Collection Tank	Active (part of 301st); data exists	See SMWU No. 7.
SWMU11	B1617 Waste Accum. Area	Circuit board production; no evidence of release. Inactive (part of 301st).	None specific to this unit.
SWMU12	B1619 Waste Accum. Area	Fuels, oils; evidence of possible releases. Inactive (part of 301st).	None specific to this unit.
SWMU13	B1710 Waste Accum. Area	Photo lab; no evidence of releases.	None specific to this unit.
SWMU16	B1060 Waste Accum. Area	Paints, solvents; evidence of releases. Replaced with active WAA (B1059).	None specific to this unit.
SWMU17	Landfill 7	Construction rubble; inactive; no evidence of releases.	Monitoring well installation conducted as part of a limited RFI; perform LTM.
SWMU19	Fire Training Area 2	Remedial excavation completed; closure document submitted to TNRCC.	Perform LTM.
SWMU20	Waste Fuel Oil Tank	Associated with SWMU 19.	Perform LTM.
SWMU21	Waste Oil Tank	Associated with SWMU 19.	Perform LTM.
SWMU 22	Landfill 4	Associated with parcel not in NAS boundaries; retained under BRAC.	Perform LTM.
SWMU23	Landfill 5	Associated with parcel not in NAS boundaries; retained under BRAC.	Perform LTM.
SWMU24	Waste Burial Area	Associated with parcel not in NAS boundaries; retained under	Perform LTM.

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Table 3-5
Long-Term Groundwater Monitoring Activity Summary
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

UNIT	DESCRIPTION	CURRENT STATUS	GROUNDWATER MONITORING ACTIVITIES
		BRAC.	
SWMU25	Landfill 8	Associated with parcel not in NAS boundaries; retained under BRAC.	Perform LTM following completion of a limited RFI.
SWMU26	Landfill 3	Rubble; inactive (covered by runway in 1952).	Perform LTM.
SWMU27	Landfill 10	Active for street debris disposal, but may be on *ad hoc* basis.	Monitoring well installation conducted as part of a limited RFI; perform LTM.
SWMU28	Landfill 1	Inactive (being covered by construction); data exists.	Due to perimeter location, perform LTM to assess potential for offsite releases.
SWMU29	Landfill 2	Inactive (partially covered by B1055); no evidence of releases.	Monitoring well installation conducted as part of a limited RFI; perform LTM.
SWMU30	Landfill 9	Inactive; no data found.	Monitoring well installation conducted as part of a limited RFI; perform LTM.
SWMU31	B1050 Waste Accum. Area	Oils, solvents; no evidence of releases. Inactive.	Submit NFA recommendation; no groundwater monitoring required.
SWMU32	B1410 Waste Accum. Area	Oils, fuels, solvents; evidence of releases. Replaced with active WAA (B1415).	None specific to this unit.
SWMU33	B1420 Waste Accum. Area	Solvents, oils: evidence of releases. Replaced with active WAA (B1436).	None specific to this unit.
SWMU34	B1194 Waste Accum. Area	Solvents, oils; evidence of releases. Inactive.	None specific to this unit.
SWMU35	B1194 O/W Separator	Active; data exists.	Groundwater data required for SWMU closure; install monitoring well following removal of separator/associated piping. Perform LTM.
SWMU36	B1191 Waste Accum. Area	Oils, fuels; evidence of releases. Appears to be active.	None specific to this unit.
SWMU37	B1191 O/W Separator	Active; data exists.	Groundwater data required for SWMU closure; install monitoring well following removal of separator/associated piping. Perform LTM.
SWMU39	B1643 Waste Accum. Area	Oils, fuels; no evidence of releases. Active; covered with shed.	None specific to this unit.

Table 3-5
Long-Term Groundwater Monitoring Activity Summary
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

UNIT	DESCRIPTION	CURRENT STATUS	GROUNDWATER MONITORING ACTIVITIES
SWMU40	B1643 O/W Separator	Active; no data found. Submitted as NFA; approval by TNRCC pending results of background study.	Groundwater data required for SWMU closure; install monitoring well following removal of separator/associated piping. Perform LTM.
SWMU41	B1414 O/W Separator	Inactive.	Groundwater data required for SWMU closure; install monitoring well following removal of separator/associated piping. Perform LTM.
SWMU42	B1414 Waste Accum. Area	Oils, fuels; no evidence of releases. Inactive; may have replaced by B1415.	None specific to this unit.
SWMU44	B1027 O/W Separator	Active; data exists.	Groundwater data required for SWMU closure; install monitoring well following removal of separator/associated piping. Perform LTM.
SWMU45	B1027 Waste Oil Tank	Part of B1027 O/W Separator system. Active; data exists.	See SWMU No. 44.
SWMU47	B1015 O/W Separator	Inactive	Groundwater data required for SWMU closure; install monitoring well following removal of separator/associated piping. Perform LTM.
SWMU49	Aircraft Washing Area 1	Carries runoff from runway to SWMU 53. Inactive.	None specific to this unit.
SWMU50	Aircraft Washing Area 2	Carries runoff from runway to SWMU 53. Inactive.	None specific to this unit.
SWMU51	B1190 Waste Holding Area	Solvents, misc. hazwaste. Active 90-day central holding area.	None specific to this unit.
SWMU52	B1190 O/W Separator	Discharges to SWMU 53. Active; data exists. Submitted as NFA; approval by TNRCC pending results of background study.	Groundwater data required for SWMU closure; install monitoring well following removal of separator/associated piping. Perform LTM.
SWMU53	Storm Water Drainage	Partially investigated and remediated; no data on confirmatory sampling found. Active.	None specific to this unit.
SWMU54	Storm Water Interceptors	Monitored under NPDES. Active.	None specific to this unit.
SWMU55	East Gate O/W Separator	Active; no data exists.	Groundwater data required for SWMU closure; install monitoring well following removal of separator/associated piping. Perform LTM.
SWMU 58	Pesticide Rinse Area	Inactive; pesticide rinse water	None specific to this unit.
SWMU 59	WSA Waste Accumulation Area	Inactive; NFA approved.	None specific to this unit.

Table 3-5
Long-Term Groundwater Monitoring Activity Summary
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

UNIT	DESCRIPTION	CURRENT STATUS	GROUNDWATER MONITORING ACTIVITIES
SWMU 60	Radioactive Waste Burial Site	Inactive; NFA approved.	None specific to this unit.
SWMU61	B1320 Waste Accum. Area	Oils, diesel, solvents. Replaced with B1319.	None specific to this unit.
SWMU62	Landfill 6	Construction debris, nonfriable asbestos; oils. Inactive (Navy uses for soil stockpiles).	Monitoring well installation conducted as part of a limited RFI; perform LTM.
SWMU64	French Underdrain System	Investigation by ERB/ERT in progress, including removal of O/W Separator associated with site.	Perform LTM.
SWMU 65	WSADisposal Site	Inactive; NFA approved.	None specific to this unit.
SWMU66	Sanitary Sewer System	Active; portions off NAS property under investigation by ERB.	None specific to this unit.
SWMU67	B1320 O/W Separator	Active; no data found.	Perform LTM.
SWMU68	POL Tank Farm	Active; evidence of releases. Treatability Study in progress.	Perform LTM.
AOC 1	Base Service/Gas Stations	Inactive; site characterizations in progress.	Perform LTM.
AOC 2	Airfield GW Plume	Co-mingled fuels/TCE plume from several potential sources. Plume is integrated with plume from AFP 4.	Perform LTM; additional well installations may be required.
AOC 4	Fuel Hydrant System	Inactive; all stations removed. Includes "Spot 35" in airfield parking lot.	Perform LTM; additional well installations may be required.
AOC 5	Grounds Maintenance Yard	BRAC to perform additional investigation.	Assumed LTM following site characterization.
AOC 6	RV Storage Area	Motor pool parking lot. Active. RFI planned for FY 1998.	Install monitoring wells; perform LTM.
AOC 7	Base Refueling Area	Inactive; tanks removed.	Perform LTM.
AOC 8	Aerospace Museum	BRAC to perform additional investigation.	Assumed LTM following site characterization.
AOC 9	Golf Course Maintenance Yard	BRAC to perform additional investigation.	Assumed LTM following site characterization.
AOC 10	B1064 O/W Separator	Active; data exists. Submitted as NFA; approval by TNRCC pending results of background study.	Groundwater data required for SWMU closure; install monitoring well following removal of separator/associated piping. Perform LTM.
AOC 11	B1060 O/W Separator	Active; data exists. Submitted as NFA; approval by TNRCC pending results of background study.	Groundwater data required for SWMU closure; install monitoring well following removal of separator/associated piping. Perform LTM.

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Table 3-5
Long-Term Groundwater Monitoring Activity Summary
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

UNIT	DESCRIPTION	CURRENT STATUS	GROUNDWATER MONITORING ACTIVITIES
AOC 12	B4208 O/W Separator	Active; data exists. Submitted as NFA; approval by TNRCC pending results of background study.	Groundwater data required for SWMU closure; install monitoring well following removal of separator/associated piping. Perform LTM.
AOC 13	B1145 O/W Separator	Active; data exists. Submitted as NFA; approval by TNRCC pending results of background study.	Groundwater data required for SWMU closure; install monitoring well following removal of separator/associated piping. Perform LTM.
AOC 14	Unnamed Stream	Upgradient oil/water separator and french underdrain (SWMUs 67 and 64) to be removed.	Perform LTM.
AOC 15	B1190 Storage Shed	Active.	None specific to this unit.
AOC 16	Family Camp	BRAC to perform investigation.	No groundwater monitoring activities assumed for this unit.

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Table 3-6
LTM Analytical Requirements
Groundwater Sampling and Analysis Plan
NAS Fort Worth JRB
August 1996

MONITORING OBJECTIVE	ANALYTICAL METHODS/PARAMETERS	RATIONALE
Perimeter Monitoring	SW5030A/SW8260A--Halogenated Volatile Organics SW3005A/SW6020--Trace Elements SW9056--Common Anions E310.1--Alkalinity E360.1--Dissolved Oxygen ASTM D1498--Oxidation-reduction potential	Adequate documentation required at perimeter locations to evaluate the potential for offsite releases; this requires monitoring for the full range of possible contamination, including those constituents related to background conditions and natural attenuation.
Natural Attenuation	SW5030A/SW8260A--Halogenated Volatile Organics SW9056--Common Anions E310.1--Alkalinity E360.1--Dissolved Oxygen ASTM D1498--Oxidation-reduction potential HACH Method #846--Ferrous iron (see AFCEE, 1995) Methane (see AFCEE, 1995) Total Organic Carbon (SW846, Method 9060)	Develop database for establishing the effectiveness of natural attenuation and for data comparison to ACL values.
LTM (Non-fuel related units)	Characterization: Appendix IX Constituents LTM: Site-specific. For perimeter locations, assume those listed above. For non-perimeter conditions, assume those methods under Natural Attenuation.	Assume that initial sampling activities will need to establish the baseline conditions for a site; therefore, all Appendix IX constituents are required. Following characterization, the analytical list can be reduced to include only those constituents related to the specific unit.
LTM (Fuel-related units) Assumed to include fuel storage areas and oil/water separators.	SW8020A--Volatile Organics	Long-term monitoring of contamination related to fuel storage requires only those constituents expected to be associated with fuel. For perimeter units, add additional constituents as noted above.
USTs	SW8020A--Volatile Organics SW3020A/SW7421--Lead SW8015 (Modified) DRO--TPH Diesel, Jet Fuel SW8015 (Modified) GRO--TPH Gasoline	Long-term monitoring following UST removals requires only indicator compounds associated with the fuel previously stored. Modify list according to tank history.

AFCEE, 1995. Technical Report for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater. Volume 1. November 11.
DRO--Diesel Range Organics
GRO--Gasoline Range Organics

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3.2.3 Analysis, Sampling, and Reporting Procedures

Analytical specifications for all sampling rounds will be conducted in accordance with the Base-Wide Quality Assurance Project Plan (CH2M HILL, 1996).

Standard sampling and documentation procedures have been developed for water level measurements and monitor well sampling. Use of these procedures will promote consistency in field procedures and comparability of the data over time. These standard operating procedures are included as Appendix B.

3.3 Monitor Well Inspection

The groundwater sampling and analysis program for NAS Fort Worth JRB includes an inspection and reporting component in order to ensure that representative samples are collected from the monitor wells. All wells included in either the semi-annual water level monitoring program or the current sampling program will be included in the well inspection reporting. As part of the well inspection procedure, the integrity of the surface features will be thoroughly examined and any maintenance needs recorded. Actual maintenance of wells will not be completed at the time of the inspection. Existing wells that are not currently used for water level measurements or for collecting groundwater samples will be inspected once a year.

Every monitor well scheduled for review according to the schedule described above will be inspected and any deficiencies or problems will be documented. For each well, an inspection checklist will be completed (Figure 3-3) with the following information:

- Date, inspector's initials, monitor well identification number, IRPIMS number
- Description of conditions for:
  - security posts, well pad, security casing, and dedicated sampling components, if applicable.
  - gasket, lock, and well casing.

In addition to the well inspection, each well will be checked for total depth to determine whether fine materials have accumulated inside the well casing. For wells that contain an accumulation of fine material and the thickness of the accumulation is greater than 20% of the screened interval, the well will be considered for redevelopment.

Potential recommendations for future activities will be included in groundwater monitoring reports.

FIGURE 3-3
MONITOR WELL FIELD DATA SHEET
NAS FORT WORTH JRB
GROUNDWATER SAMPLING AND ANALYSIS PROGRAM

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CH2M HILL | **Project #** ______________________

Date: ______________________

WATER LEVEL DATA		
Site/Zone:	Well No:	
	Casing Dia./Material:	
Sample Team:		
Time of measurement:	Device:	
Depth To Water (DTW):	FT below top of casing.	
Total Well Depth (TD):	FT below top of casing	
DTW by Quarter: 1st	2nd	3rd
Installed Total Depth:		
FREE PRODUCT (LNAPL/DNAPL)		
DEPTH TO FREE PRODUCT:	THICKNESS:	
SAMPLE COLLECTED: YES	NO	
PRODUCT REMOVED: YES	NO	METHOD:
HEALTH & SAFETY		
OVM (ppm): BACKGROUND:		
BREATHING ZONE:		
TOP OF CASING:		
VISUAL INSPECTION		
ID PLATE: YES NO	**DOES ID PLATE MATCH IRPIMS WELL #:** Y N	
PAD CONDITION: GOOD FAIR POOR		
PROTECTIVE CASING CONDITION: GOOD FAIR POOR		
LOCK: YES NO NEED TO REPLACE		
CAP: NONE GOOD SLIP NEED TO REPLACE		
MANHOLE GASKET: YES NO		
BOLTS: YES NO NEED TO REPLACE		
MATERIALS ADDED: BOLTS_________ CAP_________ LOCK_________		
LOGBOOK ENTRY: **YES** **NO**		

COMMENTS: ____

____

____

4.0 Data Evaluation, Data Management, And Data Transfer

Standard procedures are established here for evaluation, management, and transfer of monitor well data. Adherence to these procedures will ensure that these activities are consistent and efficient. This is especially important because multiple contractors, laboratories, and data users will be involved in producing and handling the data over time. Coordination and communication lines will be established among representatives of all involved parties to ensure that any procedural modifications and new personnel are integrated into ongoing activities.

4.1 Data Evaluation

Data evaluation will be conducted as described in the Quality Assurance Project Plan (QAPP) (CH2M HILL 1996a). All field and analytical data and supporting information will be entered into CH2M HILL's database management system within one month after collection or receipt of laboratory results. This system allows for data manipulation and evaluation, preparation of summary tables, and links to several types of graphics systems for the production of maps, all of which will be utilized in the preparation of technical reports for each of the groundwater sampling events. The database that is created will also be used in the preparation and submittal of analytical data Informal Technical Information Reports (ITIRs). Data entries will be checked for accuracy and completeness before any technical reports or IRPIMS submittals are prepared.

4.2 Data Management

Data management activities will include loading or entering, storing, transferring, and reporting field measurements and analytical results using a structured database. The database structure and software will be standardized and flexible enough to allow the data to be easily exchanged among contractors and transferred to data interpretation software such as computer-assisted drafting and design (CADD) or geographic information system (GIS). Initial system requirement specifications will be prepared and approved by involved contractors and the Air Force to ensure that the database capabilities will meet program objectives. Database documentation and a user's guide will also be prepared and maintained. Quality Assurance (QA) procedures for database security and integrity will also be established to ensure that the data collected are complete, accurate, and defensible.

Database documentation includes the system requirement specifications, programmer's manual, and user's guide. The system requirement specifications outline the requirements for the database, including data sources (field data sheets, COC forms, field computer master log, laboratory data files), data fields that will be included, general database structure, and output requirements (CADD, GIS, spreadsheets, IRPIMS files). The known or expected participants (laboratories, contractors) will also be identified. The database will be developed after agreement that the system requirements have been met. A programmer's guide will be prepared to document the specific programs and files that comprise the database. The information contained in the programmer's manual will be sufficient to ensure that modifications can be made by other programmers if necessary. A user's guide will be developed if the database will be accessed directly by data users. This will provide the information needed to navigate through the database to load the data, sort and view selected fields, prepare reports or data files, or perform approved edits (such as adding data qualifier flags).

QA documentation and procedures will also be developed to ensure that the data are properly loaded and reviewed for completeness and that a tracking system is in place for data modifications or edits performed after the data are loaded. Security and access rights will also be established to ensure that database integrity is maintained.

4.3 Data Transfer

Electronic Data File (EDF) transfer is a critical data management contractor responsibility. Data must be easily transferred to data users, among contractors, and to the IRPIMS. The system will support standard formats and have the flexibility to prepare files that can be imported into other software systems. The primary format for EDF transfer to the Air Force and other contractors will be the IRPIMS format because this format is a standard that most contractors support. IRPIMS deliverables to the Air Force will be submitted on a quarterly basis. Other formats may be needed to allow data to be imported into CADD or GIS systems for data interpretation and mapping water levels, preparing contour plots of contaminants, statistical analysis, or other interpretive tools.

5.0 Reporting Requirements

During implementation of the groundwater sampling and analysis program for NAS Fort Worth JRB, submittal of technical reports will be required for Air Force and Agency review. In addition, it is expected that the GSAP itself will require periodic modification based on evaluations and recommendations contained in the technical reports. This section provides a description of the requirements for technical reports and GSAP updates. Also addressed are notification requirements if hazards are encountered during performance of the work.

5.1 Technical Reports

Presented in the following subsections are outlines of quarterly and annual groundwater monitoring reports for the groundwater sampling and analysis program. In general, each type of report possesses certain characteristics. The quarterly report will tabulate and graphically represent the data, but will include little data interpretation. The annual report, on the other hand, will emphasize interpretation: a thorough, descriptive understanding of the findings from the previous four quarters. Both outlines are presented below, followed by examples of the types of figures and tables that would complement them. These reports will be distributed to the regulatory agencies, the Restoration Advisory Board (RAB), and the three information repositories.

5.1.1 Quarterly Monitoring Reports

Quarterly samples are taken so that the seasonally variable effects of natural features, such as precipitation and temperature, and human impact, such as base activity, can be measured. The quarterly reports emphasize factual data presented as clearly and concretely as possible using maps of well locations, numbers of wells, sampling dates, contour maps, hydrographs, and tables of water levels and results. The following is a recommended outline for the quarterly technical report:

1.0 INTRODUCTION
- 1.1 Purpose of Groundwater Monitoring at NAS Fort Worth JRB
- 1.2 Project Summary
- 1.3 Schedule for Current and Future Sampling Events

2.0 CURRENT QUARTERLY SAMPLING SUMMARY
- 2.1 Monitor Wells Used for Water Level Measurements
  - 2.1.1 Location of Wells Sampled
  - 2.1.2 Number of Wells Sampled
  - 2.1.3 Dates of Sampling
  - 2.1.4 Table of Water Levels
    - Comparison of Water Levels in Wells Screened in the Alluvium and Bedrock
- 2.2 Flow Direction
  - 2.2.1 Water Table Contour Maps

2.2.2 Table of Vertical Gradients
2.3 Changes From Prior Maps (every two quarters)

3.0 ANALYTICAL DATA
3.1 Wells Sampled for Analyses
3.1.1 Location of Wells Sampled
3.1.2 Number of Wells Sampled
3.1.3 Dates of Sampling
3.2 Analyses Performed
3.2.1 Field and Laboratory Parameters
3.2.2 Quality Assurance/Quality Control Samples
3.2.3 Description of Qualified Data
3.3 Analytical Results
3.3.1 Laboratory Data Summary (including detection limits and quantifying contaminants detected near or at reporting levels)
3.3.2 Contaminants of Concern (COC)
3.3.3 Attributes of COCs Detected
3.3.4 Distribution of COCs Detected
3.4 Changes from Prior Analytical Results

APPENDIX A: Laboratory Analytical Data
APPENDIX B: Analytical Data Quality Control/Quality Assurance
APPENDIX C: Chain-of-Custody
APPENDIX D: Maintenance Activities Performed

The information contained in Appendices A and B will include all sample data and results, as well as a detailed, comprehensive, assessment of the quality control results and data usability. These appendices may be broken down during preparation of the report to provide separate tables of analytical results.

The data presented in the Technical Report will have been validated and qualified for usability in accordance with the Base-Wide Quality Assurance Project Plan (CH2M HILL, 1996a). Section 3.2 will include a discussion of how the Data Quality Objectives, including completeness, have been met. Data gaps induced by deviations and unattained DQOs will be identified and evaluated in each report.

5.1.2. Annual Reports

The annual report allows all of the quarterly monitoring events to be viewed and understood within the context of a longer time span. The emphasis in such a report is to compile, compare, and contrast the year's data; an example would be to determine if groundwater levels or flows have varied from season to season. After interpreting the data, recommendations will be made to improve future sampling. The following is a sample outline; the actual reporting format will reflect interpretations developed from new data obtained from the quarterly program:

1.0 INTRODUCTION
- 1.1 Purpose of Groundwater Monitoring at NAS Fort Worth JRB
- 1.2 Background (including updated figure of past and present base activities)
- 1.3 Summary of Previous Four Quarters

2.0 NAS Fort Worth JRB Hydrogeology
- 2.1 Summary of Wells Sampled for Water Level Measurements
  - 2.1.1 Table of Well Construction Details
- 2.2 Quarterly Water Level Measurements
  - 2.2.1 Seasonal Changes
    - Contour Maps
    - Gradients
    - Updated Hydrographs
  - 2.2.2 Flow Directions
    - Changes and Similarities
  - 2.2.3 Horizontal and Vertical Gradients
    - Changes and Similarities
- 2.3 Hydraulic Properties
  - 2.3.1 Summary of Aquifer Test Results (results and geologic material tested)
- 2.4 Updates to the Hydrogeologic Model

3.0 ANALYTICAL DATA
- 3.1 Summary of Wells Sampled for Analyses
- 3.2 Summary of Analyses Performed
- 3.3 Analytical Results
  - 3.3.1 Laboratory Data Summary (including detection limits)
    - Time Series Plots
    - Seasonality of Data
- 3.4 Contaminants of Concern
  - 3.4.1 Changes in COC distribution
    - Comparison Over the Year, Vertically and Horizontally
  - 3.4.2 Identification of New Contaminants of Potential Concern (COPCs)

4.0 RECOMMENDATIONS
- 4.1 Recommendations for Water Level Monitoring
- 4.2 Recommendations for Analytical Monitoring
- 4.3 Recommendations for Monitor Well Maintenance/Abandonment

5.1.2.1 Tables and Figures for Annual and Quarterly Groundwater Monitoring Reports

The following are recommended tables for inclusion in quarterly and annual reports for the groundwater sampling and analysis program:

- Indicator and field parameter results, including:
  - pH
  - Temperature
  - Conductivity
  - Alkalinity
  - Dissolved oxygen
- Summary of results above the detection limit
- Comparison of two or more COPC levels

For figures, the following are recommended:

- Concentration distribution maps for COPCs (with supporting data tables)
- Comparison graphs of inorganic COPCs against background levels
- Water flow direction maps
- Water table contour maps
- Locations of monitor wells
- Hydrographs
- Selected time series plots (annual report) or if appropriate, plume progression maps

5.2 Groundwater Sampling and Analysis Plan Updates

The success of the groundwater sampling and analysis program at NAS Fort Worth JRB in terms of appropriate remediation, closure, and long-term monitoring of sites is dependent on continual improvement. The following paragraphs describes the procedures for program evaluation and updates to the GSAP.

5.2.1 Groundwater Sampling and Analysis Program Evaluations

Data will be evaluated after every quarterly sampling event for consistency, representativeness, and relevance to the short-term objective of monitoring groundwater flow and transportation of contaminants. Ongoing data evaluation will also be performed to allow determination of the appropriateness of the wells sampled and analyses performed so that adjustments can be recommended, if necessary, to minimize unnecessary sampling.

The annual data synthesis will provide a comprehensive assessment of groundwater conditions. The GSAP will be revised or updated after the annual evaluation unless special circumstances warrant more frequent corrections. Three conditions warrant revisions to the GSAP: (1) if data collected to date indicate a change in conditions that would prevent or interfere with attaining the GSAP's objectives; (2) if data gaps in groundwater flow directions, contaminant concentrations, or migration patterns have been filled; or (3) if it is necessary to meet monitoring requirements of a removal or remedial action not already covered by the existing plan. The criteria and procedures for determining data sufficiency and revising the GSAP are summarized in Section 5.2.2. When the GSAP is updated, the rationale for the revised strategy will be described and additions or modifications for water level measurements and chemical analyses will be documented to provide clear and complete guidance for those implementing the plan in the future.

5.2.2 Data Sufficiency Determination

Data will be considered sufficient to meet the GSAP objectives if they provide a representative picture of current conditions. Representativeness will be evaluated qualitatively by comparing the current data with recent (past quarter) and historical data, and by taking into consideration other ongoing activities, such as remediations or base construction, that might influence flow direction and contaminant concentrations.

The quarterly data evaluation will be directed toward identifying data gaps that limit the interpretation of groundwater flow, contaminant occurrence, or trends in concentrations at the base boundary and downgradient from known areas of contamination. This evaluation occurs after reviewing the analytical data for compliance with quality control (QC) criteria and after verifying the accuracy of the water level measurements. Quarterly evaluation of water level measurements involves preparing water table contour maps for the current quarter's measurements and comparing the current map with that from the past quarter to determine whether there are unexplained differences in levels and flow directions that could indicate data quality problems or data gaps. Chemical indicator parameters, TCE, BTEX, and lead, for the current quarter will be evaluated by comparing the results for each well with those for the most recent results collected from the well and nearby wells. If there are changes in concentrations or contaminant occurrence greater than analytical and seasonal variability might suggest, the data will be further evaluated to identify the source of the difference. If large data gaps are identified through this process, they will be reported along with recommendations for modifications during the next quarterly sampling event. Recommendations could include selecting additional or different wells for water level measurements or choosing different wells or analytical parameters for chemical measurements.

The annual data evaluation will be the primary mechanism for determining data sufficiency and the need to revise the groundwater monitoring plan. Both historical data and data collected during the past year will be used to conduct a comprehensive evaluation of the data and groundwater conditions relative to program objectives and past conditions. The water level and chemical data should be reviewed in conjunction with each other to support interpretation of both types of results. (For example, are changing flow directions causing a change in contaminant occurrence in the new downgradient direction.)

Water level data will be evaluated using some or all of the following techniques to determine whether data gaps have been filled and groundwater flow directions can be defined:

- Compare contour maps for the past four quarters with selected historical maps (from different seasons, years, etc.). Flow directions should be discernible from the maps based on knowledge of the hydrologic conditions related to both lithology and ongoing remediation or construction activities that influence flow.

- Evaluate if over-sampling has occurred by mapping subsets of wells to determine whether the water level contours change using fewer monitoring points. If the same logical contours are produced using fewer wells, then a recommendation to reduce the number of wells monitored during future quarterly sampling events may be made.
- Statistically evaluate data for seasonal trends to support interpretation of contaminant concentrations. This will only be possible after a minimum of four to six measurements are available.

If data gaps are still apparent and flow cannot be clearly defined, monitoring additional wells may be recommended. Conversely, if there are more wells than necessary to define flow in a particular area, eliminating selected wells from future sampling events will be recommended.

Contaminant concentrations will be evaluated using some or all of the following techniques to identify data gaps or changing trends in concentration, or to meet other defined data use objectives:

- Prepare contour plots of indicator contaminants (TCE, BTEX, etc.) when possible. Because areal coverage for some contaminants may be limited, contouring may not always be possible; in those cases, the concentrations will be posted on the maps and evaluated for well- or area-specific trends or without imposing contours. These maps will be the primary means to evaluate whether there are sufficient chemical measurements to assess conditions in downgradient or base boundary areas. Concurrent evaluation with water level maps is necessary to decide whether this objective has been met.
- Graph data for selected wells in time-series plots if more than four samples have been collected since the well was installed. These plots can be used to identify any obvious concentration trends. Multiple wells in an area may be plotted together to provide a more comprehensive picture.
- Perform statistical analysis for seasonal or other trends if there are enough data points (usually at least four) to satisfy the statistical procedure requirements.

Modifications in sampling frequency, analytical methods, and wells should be made based on this evaluation.

5.3 Contingency Notification

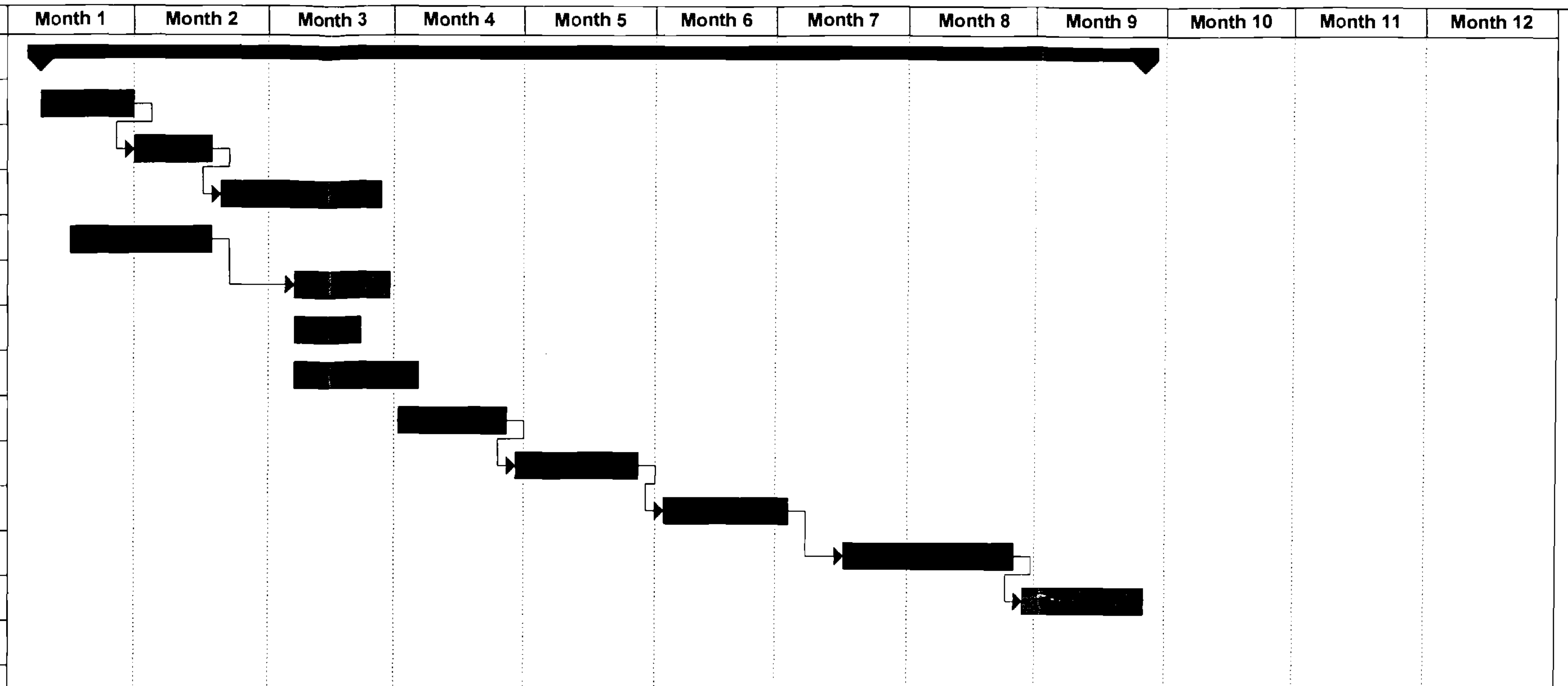
If any imminent physical or health hazards are encountered by personnel employed by the contractor or their representative during field investigation activities, the AFCEE Team Chief and NAS Fort Worth JRB Point of Contact (POC) will be contacted immediately by telephone. Follow-up written notification of the situation, including supporting documentation, will be made within three days after telephone notification.

6.0 Project Schedule

A typical schedule for completion of one sampling event under the groundwater sampling and analysis program is contained in Figure 6-1. This schedule includes mobilization, field work, database management, data validation, management of investigation-derived waste, and preparation of the event technical report. Preparation of the technical report has been set up to allow Air Force review of a preliminary draft and Agency review of the revised draft document. Responses to the review comments will be prepared along with revision of the preliminary draft and the revised draft document, resulting in a final document that incorporates Air Force and Agency input. A description of the contents of the Technical Report is provided in Section 5.0.

Not shown on the typical event schedule are submittal of the annual reports or submittal of GSAP updates. Refer to Section 5.0 for a description of these requirements.

ID	Task Name	Duration
1	SAMPLING EVENT	186d
2	MOBILIZATION	16d
3	FIELD WORK	14d
4	ANALYTICAL	28d
5	DATABASE MANAGEMENT (pre-analytical)	25d
6	DATABASE MANAGEMENT (post-analytical)	17d
7	DATA EVALUATION	12d
8	IDW MANAGEMENT	22d
9	TECHNICAL REPORT DRAFT COMPLETION [Pre-Draft to AF/Service Center at end of task]	20d
10	TECHNICAL REPORT AF/SERVICE CENTER REVIEW	21d
11	TECHNICAL REPORT DRAFT REVISION	21d
12	TECHNICAL REPORT AGENCY REVIEW	30d
13	FINAL TECHNICAL REPORT COMPLETION AND RESPONSE TO COMMENTS	21d



NAS Fort Worth JRB
Texas
Figure 6-1
Groundwater Sampling and Analysis Program
Schedule

Project: 135009
Date: 8/22/96

Task | Milestone | Rolled Up Task | Rolled Up Progress
Progress | Summary | Rolled Up Milestone

Figure 6-1

7.0 References

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Appendix A

GW Area	Well Identification	Northing	Easting	Source
EAGW	15B	6963338.735	2301032.080	LAW ENGG
EAGW	17I	6963642.662	2299626.674	LAW ENGG
EAGW	17J	6963780.053	2299584.431	LAW ENGG
EAGW	17K	6963578.343	2299799.209	LAW ENGG
EAGW	17L	6963812.735	2299741.167	LAW ENGG
EAGW	17M	6963761.950	2300037.620	ITI
EAGW	BSS-A	6965491.098	2300115.431	LAW ENGG
EAGW	BSS-B	6965811.954	2300085.914	LAW ENGG
EAGW	LF01-1A	6964466.392	2301249.837	LAW ENGG
EAGW	LF01-1B	6964700.806	2301057.006	LAW ENGG
EAGW	LF01-1C	6964438.037	2301376.050	LAW ENGG
EAGW	LF01-1D	6964288.176	2301412.716	LAW ENGG
EAGW	LF01-1E	6964606.025	2301174.300	LAW ENGG
EAGW	MW-1	6965853.592	2300345.606	LAW ENGG
EAGW	MW-10	6965836.203	2300541.575	LAW ENGG
EAGW	MW-11	6965810.342	2297057.278	LAW ENGG
EAGW	MW-12	6961041.920	2295756.200	ITI
EAGW	MW-12A	6966149.318	2300142.021	LAW ENGG
EAGW	MW-2	6965704.960	2300555.919	LAW ENGG
EAGW	MW-20	6963365.698	2296878.439	LAW ENGG
EAGW	MW-21	6963382.211	2296841.863	LAW ENGG
EAGW	MW-3	6965242.674	2299750.342	LAW ENGG
EAGW	MW-4	6965802.687	2300090.055	LAW ENGG
EAGW	MW-5	6965803.452	2300138.608	LAW ENGG
EAGW	MW-6	6965734.917	2300173.696	LAW ENGG
EAGW	MW-7	6965967.108	2300055.237	LAW ENGG
EAGW	MW-8	6965584.178	2300491.789	LAW ENGG
EAGW	MW-9	6966001.958	2300329.174	LAW ENGG
EAGW	MW1-16	6963755.160	2300066.630	ITI
EAGW	P5	6965287.560	2299737.380	ITI
EAGW	PI-U9	6965632.910	2300053.580	ITI
EAGW	SAV-1	6965776.357	2300298.887	LAW ENGG
EAGW	SAV-2	6965807.583	2300280.415	LAW ENGG
EAGW	SD13-01	6963391.743	2300621.423	LAW ENGG
EAGW	SD13-02	6963487.702	2300753.030	LAW ENGG
EAGW	SD13-03	6963362.921	2300699.630	LAW ENGG
EAGW	SD13-04	6963361.521	2300770.955	LAW ENGG
EAGW	SD13-05	6963904.275	2300775.292	LAW ENGG
EAGW	SD13-06	6963164.350	2300907.827	LAW ENGG
EAGW	SD13-07	6963167.041	2301009.342	LAW ENGG
EAGW	ST14-01	6963307.935	2300089.327	LAW ENGG
EAGW	ST14-02	6963524.076	2300089.486	LAW ENGG
EAGW	ST14-03	6964091.765	2299888.427	LAW ENGG
EAGW	ST14-04	6963656.498	2300342.951	LAW ENGG
EAGW	ST14-14	6964309.760	2299735.220	ITI
EAGW	ST14-24	6964017.889	2299084.200	LAW ENGG
EAGW	ST14-25	6964563.760	2299065.360	ITI
EAGW	ST14-26	6964593.250	2299557.040	ITI
EAGW	ST14-27	6964257.940	2300212.350	ITI

GW Area	Well Identification	Northing	Easting	Source
EAGW	ST14-28	6963728.320	2300495.990	ITI
EAGW	ST14-29	6963527.787	2300512.775	LAW ENGG
EAGW	ST14-30	6963211.534	2300466.182	LAW ENGG
EAGW	ST14-W05	6963726.062	2299093.850	LAW ENGG
EAGW	ST14-W06	6963806.563	2299330.792	LAW ENGG
EAGW	ST14-W07	6963614.609	2299393.809	LAW ENGG
EAGW	ST14-W08	6964323.981	2299479.591	LAW ENGG
EAGW	ST14-W09	6963471.685	2299550.097	LAW ENGG
EAGW	ST14-W10	6963949.340	2299730.125	LAW ENGG
EAGW	ST14-W11	6964128.603	2299657.972	LAW ENGG
EAGW	ST14-W12	6963953.266	2299581.062	LAW ENGG
EAGW	ST14-W13	6963695.163	2299776.442	LAW ENGG
EAGW	ST14-W15	6963315.787	2299923.113	LAW ENGG
EAGW	ST14-W16	6964064.608	2300128.304	LAW ENGG
EAGW	ST14-W18	6963906.725	2300162.474	LAW ENGG
EAGW	ST14-W19	6963699.799	2300203.607	LAW ENGG
EAGW	ST14-W20	6964009.080	2300275.355	LAW ENGG
EAGW	ST14-W21	6963417.822	2300242.020	LAW ENGG
EAGW	ST14-W22	6963649.635	2301016.385	LAW ENGG
EAGW	ST14-W23	6962949.056	2300410.368	LAW ENGG
EAGW	ST14-W31	6963549.672	2300830.861	LAW ENGG
EAGW	ST14-W32	6963239.017	2300815.069	ITI
EAGW	USGS05P	6965287.814	2299736.772	LAW ENGG
EAGW	USGS06P	6963772.044	2297557.582	LAW ENGG
EAGW	USGS06T	6963763.468	2297542.147	LAW ENGG
FAGW	GMI-22-02M	6966618.856	2296186.804	LAW ENGG
FAGW	GMI-22-03M	6966206.079	2298538.703	LAW ENGG
FAGW	GMI-22-04M	6967235.898	2297339.007	LAW ENGG
FAGW	GMI-22-05M	6966926.352	2299431.878	LAW ENGG
FAGW	GMI-22-06M	6966990.687	2298186.199	LAW ENGG
FAGW	GMI-22-07M	6969004.353	2298321.676	LAW ENGG
FAGW	GMI-22-08M	6970309.355	2298970.215	LAW ENGG
FAGW	HM-116	6966412.381	2294283.721	LAW ENGG
FAGW	HM-117	6967356.250	2294274.322	LAW ENGG
FAGW	HM-118	6968036.082	2294780.422	LAW ENGG
FAGW	HM-119	6968727.198	2294271.689	LAW ENGG
FAGW	HM-120	6969490.055	2295343.029	LAW ENGG
FAGW	HM-121	6967391.160	2295279.205	LAW ENGG
FAGW	HM-124	6963958.786	2295223.460	LAW ENGG
FAGW	HM-125	6965893.458	2295220.292	LAW ENGG
FAGW	K910	6967150.483	2296879.720	LAW ENGG
FAGW	LSA1628-1	6967936.218	2297802.144	LAW ENGG
FAGW	LSA1628-2	6967943.285	2297846.501	LAW ENGG
FAGW	LSA1628-3	6967993.079	2297791.257	LAW ENGG
FAGW	MW-11A	6965706.661	2300791.955	LAW ENGG
FAGW	MW-18	6963519.140	2295389.850	ITI
FAGW	MW-19	6963512.610	2295368.850	ITI
FAGW	MW-1A	6970397.320	2301542.450	ITI
FAGW	MW-36	6965034.802	2299356.658	LAW ENGG

GW Area	Well Identification	Northing	Easting	Source
FAGW	MW-37	6965061.349	2299384.988	LAW ENGG
FAGW	MW-38	6965981.092	2298153.077	LAW ENGG
FAGW	MW-39	6965999.012	2298171.115	LAW ENGG
FAGW	MW-40	6966053.097	2298224.978	LAW ENGG
FAGW	MW-41	6966088.853	2298204.568	LAW ENGG
FAGW	MW-42	6966031.035	2298144.896	LAW ENGG
FAGW	MW-48	6968478.952	2295643.543	LAW ENGG
FAGW	MW-49	6968470.498	2295623.167	LAW ENGG
FAGW	MW-50	6968528.648	2295621.700	LAW ENGG
FAGW	MW-51	6968536.471	2295639.958	LAW ENGG
FAGW	MW-52	6964355.172	2296182.561	LAW ENGG
FAGW	MW-53	6964378.184	2296200.241	LAW ENGG
FAGW	MW-56	6968789.529	2296055.932	LAW ENGG
FAGW	MW-57	6967217.160	2297112.980	LAW ENGG
FAGW	MW-57B	6968836.004	2296034.177	LAW ENGG
FAGW	MW-58	6966950.884	2297175.216	LAW ENGG
FAGW	MW-59	6966970.471	2297160.820	LAW ENGG
FAGW	SPOT-35-1	6966202.395	2296878.532	LAW ENGG
FAGW	SPOT-35-2	6966175.289	2296854.203	LAW ENGG
FAGW	SPOT-35-3	6966108.748	2296850.617	LAW ENGG
FAGW	SPOT-35-4	6966174.924	2296777.882	LAW ENGG
FAGW	SPOT-35-5	6966020.036	2296846.726	LAW ENGG
FAGW	SPOT-35-6	6966234.614	2296634.627	LAW ENGG
FAGW	SPOT-35-7	6966534.791	2296508.592	LAW ENGG
FAGW	USGS01P	6970387.260	2297664.372	LAW ENGG
FAGW	USGS01T	6970383.919	2297660.422	LAW ENGG
FAGW	USGS02T	6970326.570	2300335.041	LAW ENGG
FAGW	USGS03T	6968690.536	2300608.980	LAW ENGG
FAGW	USGS04T	6968758.861	2299177.629	LAW ENGG
FAGW	W-153	6965107.145	2294096.507	LAW ENGG
LAGW	FT08-11A	6962320.529	2295877.824	LAW ENGG
LAGW	FT08-11B	6962033.727	2295930.494	LAW ENGG
LAGW	FT09-12A	6960550.799	2295444.952	LAW ENGG
LAGW	FT09-12B	6960711.211	2295702.537	LAW ENGG
LAGW	FT09-12C	6960592.732	2295776.808	LAW ENGG
LAGW	FT09-12D	6960889.736	2295747.783	LAW ENGG
LAGW	FT09-12E	6960703.506	2295826.279	LAW ENGG
LAGW	GMI-04-01M	6960931.260	2296728.134	LAW ENGG
LAGW	HM-111	6963623.549	2293265.658	LAW ENGG
LAGW	HM-114	6963913.380	2294352.050	ITI
LAGW	HM-122	6962891.108	2295260.535	LAW ENGG
LAGW	HM-123	6961639.474	2295273.071	LAW ENGG
LAGW	HM-126	6963121.979	2294300.504	LAW ENGG
LAGW	HM-127	6961589.394	2294853.212	LAW ENGG
LAGW	ITMW-01T	6961062.050	2298967.140	ITI
LAGW	LF04-01	6961027.715	2295382.891	LAW ENGG
LAGW	LF04-02	6961116.666	2296313.704	LAW ENGG
LAGW	LF04-03	6961069.030	2296310.260	ITI
LAGW	LF04-04	6960947.279	2297169.758	LAW ENGG

GW Area	Well Identification	Northing	Easting	Source
LAGW	LF04-10	6960417.453	2297084.938	LAW ENGG
LAGW	LF04-4A	6960300.484	2295852.984	LAW ENGG
LAGW	LF04-4B	6960323.911	2296274.338	LAW ENGG
LAGW	LF04-4C	6960604.002	2296593.501	LAW ENGG
LAGW	LF04-4D	6960831.587	2296416.385	LAW ENGG
LAGW	LF04-4E	6961036.036	2296410.998	LAW ENGG
LAGW	LF04-4F	6961061.850	2296058.767	LAW ENGG
LAGW	LF04-4G	6961224.127	2296658.929	LAW ENGG
LAGW	LF04-4H	6960928.750	2296721.260	ITI
LAGW	LF05-01	6962727.628	2294577.894	LAW ENGG
LAGW	LF05-02	6962654.333	2295279.205	LAW ENGG
LAGW	LF05-14	6961562.305	2296543.610	LAW ENGG
LAGW	LF05-18	6961560.048	2297077.935	LAW ENGG
LAGW	LF05-19	6961246.474	2297465.123	LAW ENGG
LAGW	LF05-5A	6961438.557	2295580.898	LAW ENGG
LAGW	LF05-5B	6961901.555	2296078.248	LAW ENGG
LAGW	LF05-5C	6961720.051	2295993.730	LAW ENGG
LAGW	LF05-5D	6961740.466	2295757.035	LAW ENGG
LAGW	LF05-5E	6961177.867	2295550.360	LAW ENGG
LAGW	LF05-5F	6961288.640	2296336.360	ITI
LAGW	LF05-5G	6961581.317	2296536.324	LAW ENGG
LAGW	LF05-5H	6961735.963	2296343.797	LAW ENGG
LAGW	MW-13	6961035.090	2295736.390	ITI
LAGW	MW-IT-02T	6965366.410	2292616.010	ITI
LAGW	OT-15C	6963316.339	2300947.512	LAW ENGG
LAGW	RW-1	6960929.874	2296721.472	LAW ENGG
LAGW	TREE	6960772.688	2296603.000	LAW ENGG
LAGW	TREE	6960604.000	2296542.000	LAW ENGG
LAGW	USGS07P	6960150.607	2295251.112	LAW ENGG
LAGW	USGS07T	6960168.163	2295245.824	LAW ENGG
LAGW	WP07-10A	6961292.961	2295811.284	LAW ENGG
LAGW	WP07-10B	6961280.516	2296044.506	LAW ENGG
LAGW	WP07-10C	6961578.291	2296065.422	LAW ENGG

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Table A-2
Existing Monitor Well Evaluation Summary
Groundwater Sampling and Analysis Plan
August, 1996

Site Name/ SWMU #/ IRP #	Well #	Ref. Point	Stickup	Elev. (ft.MSL)	Ref. Pt. Elev. (ft.MSL)	TD (ft) when Installed (GS)	TD (ft) when Inspected (TOC)	SWL (ft) when Inspected (TOC)	Depth to Bedrock (ft.GSL)	Screened Interval (ft.bgs)	Strat. Unit	Casing Diam. (in)	Parameters when Inspcted: PVC? (Y/N)	Parameters when Inspcted: pH	Parameters when Inspcted: Bailer Down Well	HNu ppm	Product Present? (Y/N)	Well Casing Fittings	Filter Pack Interval	Seal Interval	Remarks
Landfill 01/ SWMU 28/ IRP Site 1	LF01-1A	TOC	3.77'	566.50'	570.27'	28'	33.76	15.94	7.0'	2.8'- 7.8'	AL	2"	Y	6.0	Plumb	4.0	N	T	2.6'- 9.0'	1.5'- 2.6'	Well located in close proximity to well LF01-1F
	LF01-1B	TOC	Flush	560.50'	560.25'	19.1'	19.87	14.97	NE	9.0'- 19.0'	AL	2"	Y	7.0	Plumb	4.0	N	T	8.0'- 20.0'	5.5'- 8.0'	Included in Jacobs Engineering groundwater study
	LF01-1C	TOC	Flush	560.30'	560.00'	33.1'	32.54	18.80	33.0'	22.7'- 32.7'	AL	2"	Y	7.0	Plumb	5.7	N	T	20.0'- 33.1'	17.2'- 20.0'	
	LF01-1D	TOC	3.43'	560.50'	563.93'	23.3'	28.14	20.05	23.0'	16.4'- 22.1'	AL	2"	Y	7.0	Plumb	16.1	N	T	12.0'- 23.3'	10.0'- 12.0'	Well located inside firing range
	LF01-1E	TOC	2.85'	559.40'	562.25'	29.6'	32.12	17.97	NE	19.60' 30.35'	AL	2"	Y	7.0	Plumb	73.2	N	T	12.0' 29.6'	10.0' 12.0'	
	LF01-1F	TOC	2.76'	559.90'	562.26'	30.36'				20.01'- 30.36'	AL	2"	Y				N	T	12.5'- 30.36'	10.5'- 12.5'	
Landfill 04 SWMU 22 IRP #4	LF04-4A	TOC	1.16'	624.60'	625.76'	24.0'	24.79	12.04	18.0'	14.0'- 24.0'	AL	2"	Y	7.0	Plumb	ND	N	T	10.5'- 24.0'	8.0'- 10.5'	Access to well difficult due to snakes
	LF04-4B	TOC	1.50'	618.40'	619.90'	24.0'	25.30	14.17	18.0'	13.0'- 23.0'	AL	2"	Y	7.0	Plumb	ND	N	T	12.0'- 24.0'	9.0'- 12.0'	Access to well difficult due to thick brush
	LF04-4C	TOC	2.14'	610.90'	613.04'	29.5'	28.00	19.74	28.0'	18.5'- 28.5'	AL	2"	Y	7.0	Plumb	ND	N	T	16.0'- 29.5'	14.0'- 16.0'	Included in Jacobs Engineering groundwater study
	LF04-4D	TOC	2.25'	613.10'	615.35'	30.5'	27.69	21.47	30.0'	18.0'- 28.0'	AL	2"	Y	7.0	Plumb	ND	N	T	16.5'- 30.5'	14.5'- 16.5'	
	LF04-4E	TOC	1.04'	617.50'	618.54'	35.0'	30.76	24.93	33.7'	24.3'- 35.0'	AL	2"	Y	7.0	Plumb	ND	N	T	23.9'- 35.0'	21.0'- 23.9'	
	LF04-4F	TOC	2.56'	622.80'	625.36'	35.0'	37.26	30.31	?	21.0'- 34.0'	AL	2"	Y	7.0	Plumb	ND	N	T	15.5'- 35.0'	13.5'- 15.5'	
	LF04-4G	TOC	0.92'	619.10'	620.02'	36.0'	33.20	27.22	39.5'	22.0'- 35.0'	AL	2"	Y	7.0	Plumb	ND	N	T	19.0'- 36.0'	17.0'- 19.0'	Included in Jacobs Engineering groundwater study
	LF04-4H	TOC	2.93'	610.50'	613.43'	28.0'	18.33	None	27.0'	14.0'- 27.0'	AL	2"	Y		Plumb	ND	N	T	10.0'- 28.0'	8.0'- 10.0'	Dry well
	LF04-01		2'				41.41	31.61				2"	Y	7.0	Plumb	ND	N	T			WCDNA
	LF04-02		2'				38.76	29.78				2"	Y	7.0	Plumb	ND	N	T			WCDNA
	LF04-03																Y	T			Well destroyed and replaced by recovery well; WCDNA
	LF04-04		2'				26.90	19.68				2"	Y	7.0	Plumb	36	N	T			Overgrown brush around well; WCDNA
USGS Landfill 04	P2	NA		665.8'					32'	105.6-125.4' 135.1-154.9'	P	5.5"	Y				N	T	NA	NA	2-3' clay separates two screened intervals; WCDNA

WCDNA = Well completion data not available
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P = Well completed in Paluxy Formation

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MU = Screened across multiple units
ND = Not Detected

NE = Not encountered
D = Data Gap
A = Adequate
I = Inadequate

OT = Other - See remarks

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Existing Monitor Well Evaluation Summary
Groundwater Sampling and Analysis Plan
August, 1996

Site Name/ SWMU #/ IRP #	Well #	Ref. Point	Stickup	Elev. (ft.MSL)	Ref. Pt. Elev. (ft.MSL)	TD (ft) when Installed (GS)	TD (ft) when Inspected (TOC)	SWL (ft) when Inspected (TOC)	Depth to Bedrock (ft.GSL)	Screened Interval (ft.bgs)	Strat. Unit	Casing Diam. (in)	Parameters when Inspcted PVC? (Y/N)	pH	Bailer Down Well	HNu ppm	Product Present? (Y/N)	Well Casing Fittings	Filter Pack Interval	Seal Interval	Remarks
Landfill 05/ SWMU 23/ IRP Site 5	LF05-5A	TOC	3.78'	619.40'	623.18'	32.0'	30.38	25.05	31.0'	18.0'-28.0'	A	2"	Y	7.0	Plumb	ND	N	T	16.0'-32.0'	14.0'-16.0'	Included in Jacobs Engineering groundwater study
	LF05-5B	TOC	3.05'	597.40'	600.45'	9.0'			8.0'	4.0'-9.0'	A	2"	Y				N	T	3.5'-9.0'	2.0'-3.5'	Unable to access well
	LF05-5C	TOC	1.88'	606.80'	608.68'	22.0'	20.44	11.41	20.0'	7.0'-22.0'	A	2"	Y	7.0	Plumb	ND	N	T	6.0'-22.0'	4.0'-6.0'	
	LF05-5D	TOC	3.21'	608.50'	611.71'	20.5'	21.18	12.98	NE	10.5'-19.5'	A	2"	Y	7.0	Plumb	ND	N	T	8.0'-20.5'	6.0'-8.0'	Access to well difficult due to weeds
	LF05-5E	TOC	2.99'	623.90'	626.89'	39.1'	35.85	29.13	NE	25.1'-38.1'	A	2"	Y	7.0	Plumb	ND	N	T	21.5'-39.1'	19.5'-21.5'	Top 6" of well casing cracked
	LF05-5G	TOC	3.39'	612.00'	615.39'	27.0'	30.22	22.10	29.0'	15.25'-26.0'	A	2"	Y	7.0	Plumb	ND	N	T	11.0'-27.0'	9.0'-11.0'	
	LF05-5H	TOC	2.22'	608.40'	610.62'	25.6'	27.81	16.49	25.0'	13.85'-24.6'	A	2"	Y	7.0	Plumb	ND	N	T	8.0'-25.6'	6.0'-8.0'	Roots/other organics retrieved in bailer
	LF05-02		2'				29.98	24.34				2"	Y	7.0	Plumb	ND	N	T			WCDNA
	LF05-18		Flush				23.55	19.83				2"	Y	7.0	Plumb	11.4	N	T			WCDNA
	LF05-19		Flush				19.54	14.65				3"	Y	7.0	Plumb	1.9	N	T			WCDNA
FTA 01/ SWMU 18/ IRP Site 11	FT08-11A	TOC	3.42'	604.80'	608.22'	14.5'	17.54	11.00	13.5'	4.0'-14.0'	A	2"	Y	7.0	Plumb	ND	N	T	3.5'-14.5'	2.0'-3.5'	
	FT08-11B	TOC	4.34'	603.80'	608.14'	15.0'	17.06	8.92	14.0'	3.5'-13.5'	A	2"	Y	7.0	Plumb	ND	N	T	3.0'-15.0'	2.0'-3.0'	
FT 02/ SWMU 19/ IRP Site 12	FT09-12A	TOC	3.66'	632.00'	635.66'	25.0'	27.85	13.85	19.0'	13.0'-23.0'	A	2"	Y	7.0	Plumb	ND	N	T	10.5'-25.0'	8.0'-10.5'	
	FT09-12B	TOC	1.95'	625.60'	627.55'	40.0'	37.66	31.67	38.5'	27.5'-37.5'	A	2"	Y	7.0	Plumb	ND	N	T	26.0'-40.0'	24.0'-26.0'	
	FT09-12C	TOC	2.55'	625.50'	628.05'	38.0'	39.96	32.71	30.5'	27.5'-37.5'	A	2"	Y	7.0	Plumb	ND	N	T	25.0'-38.0'	23.0'-25.0'	
	FT09-12D	TOC	2.65'	624.80'	627.45'	35.4'	36.99	31.22	NE	21.4'-34.4'	A	2"	Y	7.0	Plumb	ND	N	T			Well located in close proximity to well FT12-12B
	FT09-12E	TOC	2.98'	624.50'	627.48'	38.5'	38.68	32.12	40.0'	24.0'-27.5'	A	2"	Y	7.0	Plumb	ND	N	T			Well located in close proximity to well FT12-12C

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Site Name/ SWMU #/ IRP #	Well #	Ref. Point	Stickup	Elev. (ft.MSL)	Ref. Pt. Elev. (ft.MSL)	TD (ft) when Installed (GS)	TD (ft) when Inspected (TOC)	SWL (ft) when Inspected (TOC)	Depth to Bedrock (ft.GSL)	Screened Interval (ft.bgs)	Strat. Unit	Casing Diam. (in)	Parameters when Inspcted PVC? (Y/N)	pH	Bailer Down Well	HNu ppm	Product Present? (Y/N)	Well Casing Fittings	Filter Pack Interval	Seal Interval	Remarks
POL Tank Farm/ SWMU 68/ IRP Site 17	17A																N	T			WCDNA
	17B																N	T			WCDNA
	17C																N	T			WCDNA
	17D																N	T			WCDNA
	17E																N	T			WCDNA
	17F																N	T			WCDNA
	17G																N	T			WCDNA
	17H																N	T			WCDNA
	17I	TOC	2.99'	575.20'	578.19'	17.5'	19.75	11.08	20.0'	4.0'- 16.5'	A	2"	Y	7.0	Plumb	9.8	N	T	6.0'- 17.5'	4.0'- 6.0'	Well located in close proximity to well ST14-W13
	17J	TOC	1.19'	577.0'	578.19'	20.2'			18.0'	8.45'- 19.20'	A	2"	Y				N	T	5.5'- 20.2'	3.5'- 5.5'	Not inspected
	17K	TOC	1.54'	573.80'	575.34'	18.7'	18.55	10.11	18.0'	7.70'- 17.70'	A	2"	Y		Plumb	2	N	T	6.0'- 18.7'	4.0'- 6.0'	well located in close proximity to well ST14-W15
	17L	TOC	2.87'	574.40'	577.27'	^20.2'			20.0'	8.45'- 19.20'	A	2"	Y				N	T	5.5'- 20.2'	3.5'- 5.5'	Unable to locate well
	17M	TOC	1.68'	572.60'	574.28'	15.9'			16.0'	4.90'- 14.90'	A	2"	Y				N	T	4.0'- 15.9'	2.0'- 4.0'	Not inspected
	ST14-01	TOC	2.69'	573.20'	575.89'	18.40'	18.55	13.86	18.2'	8.45'- 18.20'	A	2"	Y	7.0	Plumb	1.9	N	T	6.50'- 18.80'	4.50'- 6.50'	
	ST14-02	TOC	2.94'	572.70'	575.64'	17.10'	19.48	12.16	17.1'	7.05'- 16.80'	A	2"	Y		Plumb	5.65	N	T	5.00'- 17.50'	2.70'- 5.00'	
	ST14-03	TOC	1.89'	574.83'	576.72'	17.90'			18.2'	7.85'- 17.60'	A	2"	Y		Plumb		N	T	5.80'- 18.30'	3.50'- 5.80'	Unselected at AFCEE's request
	ST14-04	TOC	2.84'	572.90'	575.74'	16.50'			16.5'	6.45'- 16.20'	A	2"	Y		Plumb		N	T	4.30'- 17.00'	2.30'- 4.30'	Not inspected
	ST14-W05					16.6'			15.0'	6.59'- 15.49'	A	2"	Y				N	T	4.0'- 16.6'	2.0'- 4.0'	Not inspected
	ST14-W06					27.0'			27.0'	6.99'- 25.89'	A	2"	Y				N	T	5.0'- 27.0'	3.0'- 5.0'	Not inspected
	ST14-W07					26.0'			25.7'	5.99'- 24.89'	A	2"	Y				N	T	4.0'- 26.0'	1.8'- 4.0'	Not inspected

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POL Tank Farm/ SWMU 68/ IRP Site 17	ST14-W05					16.6'			15.0'	6.59'- 15.49'	A	2"	Y				N	T	4.0'- 16.6'	2.0'- 4.0'	Not inspected
	ST14-W06					27.0'			27.0'	6.99'- 25.89'	A	2"	Y				N	T	5.0'- 27.0'	3.0'- 5.0'	Not inspected
	ST14-W07					26.0'			25.7'	5.99'- 24.89'	A	2"	Y				N	T	4.0'- 26.0'	1.8'- 4.0'	Not inspected
	ST14-W08					26.0'			NE	8.19'- 24.89'	A	2"	Y				N	T	6.0'- 26.0'	4.0'- 6.0'	Not inspected
	ST14-W09					22.0'			NE	7.04'- 20.85'	A	2"	Y				N	T	5.0'- 22.0'	3.0'- 5.0'	Not inspected
	ST14-W10					21.0'			21.0'	6.04'- 19.89'	A	2"	Y				N	T	4.0'- 21.0'	2.0'- 4.0'	Unselected at AFCEE's request
	ST14-W11					21.0'			21.0'	6.04'- 19.89'	A	2"	Y				N	T	4.0'- 21.0'	2.0'- 4.0'	Not inspected
	ST14-W12					19.0'			19.0'	6.19'- 17.89'	A	2"	Y				N	T	4.0'- 19.0'	2.0'- 4.0'	Unselected at AFCEE's request
	ST14-W13					19.0'			NE	6.19'- 17.89'	A	2"	Y				N	T	4.0'- 19.0'	1.8'- 4.0'	Not inspected
	ST14-W14					21.66'			22.0'	6.70'- 20.55'	A	2"	Y				N	T	5.0'- 21.55'	3.0'- 5.0'	Not inspected
	ST14-W15					19.40'			19.0'	6.19'- 17.89'	A	2"	Y				N	T	4.0'- 19.4'	2.0'- 4.0'	Not inspected
	ST14-W16					20.0'			20.0'	7.19'- 18.89'	A	2"	Y				N	T	5.0'- 20.0'	3.0'- 5.0'	Not inspected
	ST14-W17												Y				N	T			WCDNA
	ST14-W18					17.0'			17.0'	4.19'- 15.89'	A	2"	Y				N	T	3.0'- 17.0'	1.0'- 3.0'	Unselected at AFCEE's request
	ST14-W19					17.0'			17.0'	6.99'- 15.89'	A	2"	Y				N	T	5.0'- 17.0'	3.0'- 5.0"	Not inspected
	ST14-W20					17.0'			17.0'	6.99'- 16.44'	A	2"	Y				N	T	4.0'- 17.0'	2.0'- 4.0"	Not inspected
	ST14-W21					18.0'			18.0'	7.99'- 16.89'	A	2"	Y				N	T	6.0'- 18.0'	4.0'- 6.0"	Not inspected
	ST14-W22					15.4'			15.0'	7.59'- 14.44'	A	2"	Y				N	T	5.0'- 15.4'	3.0'- 5.0"	Not inspected
	ST14-W23					10.5'			NE	5.54'- 9.54'	A	2"	Y				N	T	3.0'- 10.5'	1.0'- 3.0'	Not inspected
USGS Bldg. 3340	P3A	TOC	Flush	604.97'	604.77'	20.5'	19.97	11.18	20.5'	10.0'- 20.0'	A	2"	Y	7.0	Plumb	4.4	N	T	9.0'- 20.5'		No bentonite seal, but fine sand seal from 6.0' - 9.0'

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USGS Bldgs. 3109/3115	P4		Flush				30.6	19.43				2"	Y	7.0	Plumb	ND	N	T			
USGS Bldg. 3249	T3	TOC	Flush	575.23'	575.11'	8.5'	8.54	3.16	8.0'	5.5'- 8.0'	A	2"	Y	7.0	Plumb	ND	N	T	4.5'- 8.5'		No bentonite seal, but fine sand seal from 3.5' - 4.5'
USGS Bldg. 1027	T4A	TOC	Flush	606.64'	606.49'	24.5'	21.45	18.15	21.0'	12.0'- 22.0'	A	2"	Y	7.0	Plumb	4.3	N	T	11.0'- 22.5'		No bentonite seal, but fine sand seal from 8.0' - 11.0'
USGS Open Lot										15.5'- ?									13.0'-		
USGS 2nd and Boyston	T7	TOC	Flush	605.10'	604.88'	26.5'	22.85	18.62	26.5'	25.5' - 11.0'-	A	2"	Y	7.0	Plumb	15.5	N	T	26.5' - 9.5'-		No bentonite seal, but fine sand seal from 11.5' - 13.0'
N Area of Base E of Taxiway Dr.	P6A	TOC	Flush	632.52'	632.45'	16.5'	15.15	10.52	16.0'	16.0'	A	2"	Y	7.0	Plumb	8.4	N	T	16.5'		No bentonite seal, but fine sand seal from 6.5' - 9.5'
Fuel Island W of Bldg. 1430	MW-38		Flush				19.58	16.24				4"	Y	7	Plumb	ND	N	T			Pad labeled #34, but acutal well ID is #38; WCDNA
	MW-39		Flush				19.25	16.27				4"	Y	7.0	Plumb	ND	N	T			WCDNA
	MW-40		Flush				19.49	16.31				4"	Y	7.0	Plumb	ND	N	T			WCDNA
	MW-41		Flush				19.26	16.84				4"	N	7.0	No	ND	N	T			WCDNA
	MW-42		Flush				19.53	16.76				4"	Y	7.0	Plumb	140	N	T			WCDNA
	MW-43		Flush				19.43	16.43				4"	Y	7.0	Plumb	104	N	T			WCDNA
Fuel Maintenance Bldg. 1194	MW-36		Flush				19.69	4.02				4"	Y	7.0	Plumb	ND	N	T			WCDNA
	MW-37		Flush				19.73	8.57				4"	Y	7.0	Plumb	ND	N	T			WCDNA
Bldg. 1427	MW-57		Flush				14.30	12.84				4"	Y	7.0	Plumb	1	N	T			WCDNA
Bldg. 1425	MW-58		Flush				19.62	19.26				4"	Y	7.0	Plumb	ND	N	T			Pad labeled HM08, but acutal well ID is MW-58; WCDNA
Base Service Station	BSSA	TOC	Flush	566.90'	566.38'	11.0'	10.26	4.65	10.5'	5.0-10.0'	A	2"	Y	7.0	Plumb	ND	N	T	11.0'	4.0'	
	BSSB	TOC	Flush	567.10'	569.73'	9.8'	12.79	9.44	9.4'	3.80-8.80'	A	2"	Y	7.0	Plumb	ND	N	T	3.0'- 10.0'	1.0'- 3.0'	
	BSSD			561.45'					5.5'		A		Y				N	T			WCDNA
	MW-1	TOC	Flush	561.06	560.86			14.06	48.5'	8.6'- 48.6'	A(?)	4"	Y	7.0	Plumb	ND	N	T	6.0'- 48.5'	4.0'- 6.0'	Well has very long screen
	MW-2	TOC	Flush	558.30	557.81				48.0'	4.0'- 49.0'	A(?)	?	Y				N	T	6.0'- 49.0'	4.0'- 6.0'	Well has long screen; did not inspect due to fire ants in casing
	MW-3	TOC	Flush	576.96	576.76		19.82	10.75	20.0'	10.0'- 20.0'	A	4"	Y	7.0	Plumb	5.0	Y	T	7.0'- 20.5'	4.5'- 7.0'	No lock on well; sheen observed on water in casing
	MW-4	TOC	Flush	567.19	566.92		15.16	6.34		1.0'- 6.0'	A	4"	Y	7.0	Plumb	ND	N	T	1.0'- 6.0'	?	Not accepted due to data gap
	MW-5	TOC	Flush	561.36	563.90		8.08	3.35		3.5'- 11.0'	A	4"	Y	7.0	Plumb	ND	N	T	2.0'- 11.0'	1.0'- 2.0'	Installed/sampled to cover BSS data gaps per AFCEE
	MW-6	TOC	Flush	563.53	563.11		9.94	2.10			?	4"	Y	7.0	Plumb	ND	N	T	?	?	Well located on edge of road

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Base Service Station (contd.)	MW-7	TOC	Flush	567.91'	567.88'	17.0'			11.0'	6.13'- 16.13'	A	4"	Y	7.0	Plumb	ND	N	T	4.0'- 17.0'	2.0'- 4.0'	
	MW-8	TOC	Flush	556.73'	556.91'	27.0'			NE	6.0'- 26.0'	A	4"	Y	7.0	Plumb	ND	N	T	4.0'- 27.0'	2.0'- 4.0'	
	MW-9	TOC	Flush	560.44'	560.30'	29.0'	27.90	11.31	NE	8.1'- 28.1'	A	4"	Y	7.0	Plumb	ND	N	T	6.0'- 29.0'	4.0'- 6.0'	
	MW-10	TOC	Flush	559.28'	559.53'	32.0'	32.91	15.65	NE	12.0'- 32.0'	A	4"	Y	7.0	Plumb	ND	N	T	10.0'- 36.6'	8.0'- 10.0'	
	MW-11	TOC	Flush	558.88'	558.90'	38.0'	32.43	25.61	NE	12.2'- 32.2'	A	4"	Y	7.0	Plumb	ND	N	T	11.0'- 32.6'	9.0'- 11.0'	
	MW-12	TOC	Flush	560.20'	560.38'	28.0'	27.40	10.41	NE	7.7'- 27.7'	A	4"	Y	7.0	Plumb	ND	N	T	5.5'- 28.0'	3.5'- 5.5'	Installed/sampled to cover BSS data gaps per AFCEE
	SAV-1	TOC	Flush	561.62'	561.51'		18.90	14.18					Y	7.0	Plumb	ND	N	T			WCDNA
	SAV-2	TOC	Flush	561.66'	561.25'		18.80	13.68					Y	7.0	Plumb	ND	N	T			WCDNA
Various	GMI04-01M					32.0'	34.77	20.96	27.5'	16.5'- 31.5'	A	2"	Y	7.0	Plumb	ND	N	T	15.0'- 32.0'	13.0'- 15.0'	
	GMI22-01M					28.5'			28.0'	13.0'- 28.0'	A	2"	Y				N	T	11.0'- 28.5'	9.0'- 11.0'	Not Inspected
	GMI22-02M					30.5'			30.0'	15.0'- 40.0'	A	2"	Y				N	T	3.0'- 30.5'	1.0'- 3.0'	Not Inspected
	GMI22-03M					32.5'			19.0'	12.0'- 32.0'	A	2"	Y				N	T	10.5'- 32.5'	8.5'- 10.5'	Not Inspected
	GMI22-04M					23.3'			22.0'	13.0'- 23.0'	A	2"	Y				N	T	11.0'- 23.3'	9.5'- 11.0'	Not Inspected
	GMI22-05M					11.0'			11.0'	5.5'- 10.5'	A	2"	Y				N	T	3.5'- 11.0'	2.0'- 3.5'	Not Inspected
	GMI22-06M					24.0'			23.0'	13.5'- 23.5'	A	2"	Y				N	T	^11.5'- 24.0'	9.5'- 11.5'	Not Inspected
	GMI22-07M					20.5'			19.0'	10.0'- 20.5'	A	2"	Y				N	T	8.5'- 20.5'	6.5'- 8.5'	Not Inspected
	GMI22-08M					22.5'			22.5'	10.0'- 22.5'	A	2"	Y				N	T	7.0'- 22.5'	5.0'- 7.0'	Not Inspected
Bldg. 1015	MW-20		Flush				19.70	19.57				4"	Y		Plumb	3.2	N	T			Dry; WCDNA
	MW-21		Flush				19.54	19.20				4"	Y		Plumb	4.1	N	T			Dry; WCDNA
Hot Cargo Area near Bldgs. 4141/4145	MW-48																N	T			WCDNA
	MW-49																N	T			WCDNA
	MW-50																N	T			WCDNA
	MW-51																N	T			WCDNA
Hot Cargo Area near Bldgs. 4215/4216	MW-53																N	T			WCDNA

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Hot Cargo Area near	MW-56																N	T			WCDNA
Bldgs. 4170/4171	MW-57																N	T			WCDNA
Spot 35	SPOT 35-1		Flush	613.95		27.5	26.58	22.47	NE			2"	Y	7.0	Plumb	104	N	T	10.0'- 27.5'	8.0'- 10.0'	Leak detection wells
	SPOT 35-2		Flush	612.70		25.0	26.26	20.83	NE			4"	Y	7.0	Plumb	124	N	T	7.0'- 25.0'	5.0'- 7.0'-	Leak detection wells
	SPOT 35-3		Flush	612.81		25.0	23.78	19.24	NE			2"	Y	7.0	Plumb	ND	N	T	7.0'- 25.0'	5.0'- 7.0'-	Leak detection wells
	SPOT 35-4		Flush	613.70		26.3	24.41	19.82	NE	14.3'- 24.3'		4"	Y	7.0	Plumb	94	N	T	12.5'- 26.3'	8.7'- 12.5'-	Leak detection wells
	SPOT 35-5			613.94		27.2			28.3'	16.6'- 26.6'-		4"	Y				N	T	13.0'- 28.3'	10.0'- 13.0'-	Leak detection wells
	SPOT 35-6		Flush	613.53		26.4	26.64	22.66	28.5'	15.8'- 25.8'-		4"	Y	7.0	Plumb	ND	N	T	13.0'- 28.5'	10.0'- 13.0'-	Leak detection wells
Waste Burial Area/SWMU 24/ IRP Site 10	WP07-10A	TOC	0'(?)	626.70'	626.70'	39.0'			NE	27.0'- 37.0'	A	2"	Y				N	T	26.0'- 39.0'	24.0'- 26.0'	Not inspected (hornets' nest)
	WP07-10B	TOC	3.36'	621.10	624.46'	36.0'	34.50	28.78	34.5'	23.0'- 33.0'	A	2"	Y	7.0	Plumb	ND	N	T	18.0'- 36.0'	15.5'- 18.0'	
	WP07-10C	TOC	1.84'	615.40	617.24'	32.5'	28.93	21.15	30.5'	20.0'- 30.0'	A	2"	Y	7.0	Plumb	ND	N	T	17.5'- 32.5'	15.0'- 17.5'	
Entomology Dry Well/SWMU 63/ IRP #15	OT15A	TOC	-0.38	570.62'	570.24'	15.0'			14.0'	2.5'- 12.5'	A	2"	Y				N	T	3.0'- 15.0'	2.0'- 3.0'	Well installation diagram shows top of screen in grout
	OT15B												Y				N	T			Well installation diagram shows top of screen in grout
	OT15C	TOC	3.7'	564.17'	567.87'	12.0'			9.0'	5.0'- 10.0'	A	2"	Y				N	T	4.5'- 12.0'	3.0'- 4.5'	Not Inspected
Unnamed Stream SWMU #64 IRP #16	SD13-01	TOC	2.94'	570.30'	573.24'	14.50'			14.5'	7.12'- 14.32'	A	2"	Y				N	T	5.0'- 14.60'	2.9'- 5.0'	Not Inspected
	SD13-02	TOC	2.75'	570.64'	573.39'	14.20'			14.0'	9.50'- 13.50'	A	2"	Y				N	T	7.40'- 14.20'	5.10'- 7.40'	Not Inspected
	SD13-03	TOC	2.94'	568.60'	571.54'	14.10'			13.5'	7.08'- 13.85'	A	2"	Y				N	T	5.00'- 14.10'	2.70'- 5.00'	Not Inspected
	SD13-05	TOC	flush	571.59'	571.40'	^13.93'			NE	3.86'- 13.53'	A	4"	Y				N	T	1.73'- 13.93'	0.41'- 1.73'	Not Inspected
	SD13-06	TOC	2.45'	555.74'	557.66'	11.36'			6.9'	6.17'- 10.83'	AL, L	4"	Y				N	T	2.37'- 11.36'	0.15'- 2.37'	Not Inspected
	SD13-07	TOC	2.38'	554.42'	556.30'	19.13'			13.0'	18.69'	AL, L	4"	Y				N	T	19.13'	6.97'	Not Inspected

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OT = Other - See remarks

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Site Name/ SWMU #/ IRP #	Well #	Ref. Point	Stickup	Elev. (ft.MSL)	Ref. Pt. Elev. (ft.MSL)	TD (ft) when Installed (GS)	TD (ft) when Inspected (TOC)	SWL (ft) when Inspected (TOC)	Depth to Bedrock (ft.GSL)	Screened Interval (ft.bgs)	Strat. Unit	Casing Diam. (in)	Parameters when Inspcted PVC? (Y/N)	pH	Bailer Down Well	HNu ppm	Product Present? (Y/N)	Well Casing Fittings	Filter Pack Interval	Seal Interval	Remarks
Bldg. 1628	LSA1628-1	TOC	flush	602.43'	601.67'	20.0'			16.0'	8.66'-18.66'	AL, L	4"	Y				Y	T	6.66'-18.66'	4.66'-6.66'	Not included in site survey
	LSA1628-2	TOC	flush	602.26'	601.93'	20.0'			18.0'	10.0'-20.0'	AL, L	4"	Y				N	T	8.0'-20.0'	6.0'-8.0'	Not included in site survey
	LSA1628-3	TOC	flush	602.63'	601.71'	18.5'			16.5'	8.5'-18.5'	AL, L	4"	Y				N	T	6.5'-18.5'	4.5'-6.5'	Not included in site survey

WCDNA = Well completion data not available
AL = Well completed in Alluvium
L = Well completed in Goodland Limestone
P = Well completed in Paluxy Formation

T = Threaded
GJ = Glued Joints
MU = Screened across multiple units
ND = Not Detected

NE = Not encountered
D = Data Gap
A = Adequate
I = Inadequate

OT = Other - See remarks

Appendix B

Appendix B - Groundwater Sampling Field Procedures

B.1 Environmental Sampling

B.1.1 Groundwater Sampling Procedures

All purging and sampling equipment will be decontaminated according to the specifications in Section B.4.2 prior to any sampling activities and will be protected from contamination until ready for use.

Wells expected to have low levels of contamination or no contamination will be sampled prior to those wells expected to have higher levels of contamination. This practice will help reduce the potential for cross contamination between wells. All sampling activities will be recorded in the field log book. Additionally, all sampling data will be recorded on a well sampling form. Record-keeping procedures are specified in Section B.3.0.

Prior to groundwater sampling, wells will be inspected for signs of tampering or other damage. If tampering is suspected, (i.e., casing is damaged, lock or cap is missing) this will be recorded in the field log book and on the well sampling form, and reported to the Task Leader. Wells that are suspected to have been tampered with will not be sampled until the Task Leader has discussed the matter with the Project Manager.

Before the start of sampling activities, plastic sheeting shall be placed on the ground surrounding the well. The plastic sheeting will be used to provide a clean working area around the well head, and prevent any soil contaminants from contacting sampling equipment. Remove water in the protective casing or in the vaults around the well casing prior to venting and purging. Every time a casing cap is removed to measure water level or collect a sample, the air in the breathing zone will be checked with an organic vapor meter and the air in the well bore will be checked with an explosimeter. Procedures in the Health and Safety Plan (HSP) will be followed when high concentrations of organic vapors or explosive gases are detected. Air monitoring data shall be recorded on the well sampling form (Section B.3.0).

Purge pump intakes will be equipped with a positive foot check valve to prevent purged water from flowing back into the well. Purging and sampling shall be performed in a manner that minimizes aeration in the well bore and the agitation of sediments in the well and formation. Equipment will not be allowed to free-fall into a well.

In addition to the information required in Section B.3.0, the following information will be recorded each time a well is purged and sampled: (1) depth to water before and after purging, (2) well bore volume calculation, (3) sounded total depth of the monitor well, (4) the condition of each well, including visual (mirror) survey, (5) the thickness of any non-aqueous layer, (6) field parameters, such as pH, temperature, specific conductance, and turbidity. This information will be recorded in accordance with Section B.3.0 and the forms in Appendix C. This information will be encoded in IRPIMS files.

An interface probe will be used if LNAPL or a non-conductive floating product layer is suspected in the well. The interface probe will be used to determine the presence of floating product/LNAPL, if any, prior to measurement of the groundwater level. The groundwater level will then be measured to the nearest 0.01 foot using an electric water level indicator. Water levels will be measured from the notch located at the top of the well casing and recorded on the well sampling form. If well casings are not notched, measurements will be taken from the north edge of the top of the well casing, and a notch will be made using a decontaminated metal file.

Following water level measurement, the total depth of the well from the top of the casing will be determined using a weighted tape or electric sounder and recorded on the well sampling form (Appendix C). The water level depth will then be subtracted from the total depth of the well to determine the height of the water column present in the well casing. All water level and total depth measuring devices will be routinely checked with a tape measure to ensure measurements are accurate. If DNAPLs are suspected, a bailer will be lowered to the bottom of the well before purging, retrieved, and observed for the presence of DNAPL. Measurement of DNAPL will occur in accordance with procedures outline in Section B.2.4.2.

Purging of monitor wells is performed to evacuate water that has been stagnant in the well and may not be representative of the aquifer. Purging will be accomplished using a Teflon bailer or a pump.

At least three well volumes will be removed from the well before it is sampled. The well bore volume is defined as the volume of submerged casing and screen. One well volume can be calculated using the following equation (reference: Ohio EPA Technical Guidance Manual for Hydrogeologic Investigations and Groundwater Monitoring Programs, June 1993):

$$V = H \times F$$

where V = one well volume

H = the difference between the depth of well and depth to water (ft)

F = factor for volume of one-foot section of casing (gallons) from Table 1.1

F can also be calculated from the formula:

$$F = \Pi (D/2)^2 \times 7.48 \text{ gal/ft}^3$$

where D = the inside diameter of the well casing (feet).

Wells with yields too low to produce three well volumes before the well goes dry will be purged to dryness.

Table B.1
Volume Of Water In One-Foot Section Of Well Casing

Diameter of Casing (inches)	F Factor (gallons)
1.5	0.09
2	0.16
3	0.37
4	0.65
6	1.47

The temperature, pH, electrical conductivity (EC), and turbidity will be measured and recorded on the well sampling form after removing each well volume during purging. Water removed from the well during purging will be containerized. Detailed information concerning investigative-derived waste is presented in Section B.4.3.1.

Groundwater samples will be collected from wells using micropurge techniques. Previous groundwater sampling conducted at NAS Fort Worth JRB relied on traditional well purging and sampling techniques. Micropurging techniques are being instituted at this time so that data collected from this point forward will be comparable to groundwater sample data collected as part of the Base-Wide Background Study.

Micropurge is a low flowrate monitor well purging and sampling method that induces laminar (non-turbulent) flow in the immediate vicinity of the sampling pump intake, thus drawing groundwater directly from the sampled aquifer, horizontally through the well screen, and into the sampling device. Low-flow pumping rates associated with the micropurge technique are in the approximate range of 0.2 to 2.0 liter/min. These low flow rates minimize disturbance in the screened aquifer, resulting in: (1) minimal production of artificial turbidity and oxidation; (2) minimal mixing of chemically distinct zones; (3) minimal loss of volatile organic compounds; and (4) collection of representative samples while minimizing purge volume.

Except as noted below, at least three well volumes will be removed from the well before it is sampled. In consideration of the groundwater sampling and analysis program objectives, monitor wells found to contain greater than 0.01-foot of non-aqueous phase liquids (LNAPL or DNAPL) will not be sampled for water quality analyses. The thickness of LNAPL/DNAPL will be measured in accordance with the procedures described in Section B.2.4.2 and LNAPL removed in accordance with the procedures of Section B.2.4.3.

The sample may be collected after three well volumes have been removed and the temperature, pH, and EC have stabilized. Stabilization will be defined as follows: temperature +/- 1°C, pH +/- 0.1 units, EC +/- 5 percent. If these parameters do not stabilize, the sample will be collected after six well volumes have been removed, and the anomalous parameters will be brought to the Task Leader's attention. Field equipment will be calibrated in accordance with the Base-wide QAPP and Section B.2.2 of this document.

Samples will be collected after the water level has recovered to 80 percent of its static level or 16 hours after completion of purging, whichever occurs first. If a monitor well is bailed or pumped dry before three well volumes can be obtained, the sample will be collected when a sufficient volume of water has accumulated in the well.

Micropurge sampling will use small positive-displacement pumps (e.g., bladder pumps). Samples to be analyzed for volatile or gaseous constituents will not be withdrawn with pumps or at flows that degas the samples. Water-quality indicators will be monitored during micropurge (turbidity, dissolved oxygen, specific conductance, temperature).

Before collecting groundwater samples, the sampler will don clean, phthalate-free protective gloves. Samples to be analyzed for VOCs will be collected first using a bottom-filling PVC bailer. Samples to be analyzed for volatile or gaseous constituents will not be withdrawn with pumps that exert a vacuum on the sample (e.g., centrifugal). Disposable nylon rope will be used to lower and retrieve the bailers. A new length of nylon rope will be used for each well, and the rope will be disposed of following the sampling activities. Each bailer will be equipped with a dedicated stainless steel or Teflon coated leader so that the nylon rope will not contact the water in the well.

The preservative hydrochloric acid will be added to the VOC sample bottle before introducing the sample water. The sample will be collected from the bailer using a slow, controlled pour down the side of a tilted sample vial to minimize volatilization. The sample vial will be filled until a meniscus is visible and immediately sealed. When the bottle is capped, it will be inverted and gently tapped to ensure no air bubbles are present in the vial. Vials with trapped air will be refilled until no bubbles are present. After the containers are sealed, sample degassing may cause bubbles to form. These bubbles will be left in the container. These samples will never be composited, homogenized, or filtered.

Following collection of VOC samples, remaining water samples will be collected in the following order: polynuclear aromatic hydrocarbons (PAHs); metals; mercury; cyanide; total organic carbon; anions/cations; dissolved oxygen.

The pH of preserved samples will be checked in the field by pouring a small amount of the water sample onto pH paper. The paper will not touch the sample inside the container. Do not check the pH of acidified VOC samples. The preservation checks will be documented in the chain-of-custody forms. One preserved VOC sample per day per sampling crew will be checked with pH paper. The sole purpose of this sample is to check the pH of VOC samples. It will not be submitted for analysis.

Field filtering of metals will not occur.

Required sample containers, preservation methods, volumes, and holding times are given in Section B.1.2 and Table B.2. Sampling equipment will be decontaminated in accordance with Section B.4.2 upon completion of sampling activities.

B.1.2 Analytical Methods

All analytical methods specified in the GSAP can be found in the Base-Wide Quality Assurance Project Plan (CH2M Hill, 1996a), with the exception of ferrous iron and methane analyses for groundwater. These parameters are necessary as part of the data required to evaluate the effectiveness of natural chemical attenuation processes. The following summarizes the methods to be performed:

Parameter	Method	Site-Specific Water MDL	Water PQL
Ferrous Iron (FeII)	H8146	0.010 mg/l	0.024 mg/l
Methane	see AFCEE, 1995	0.004 mg/l	0.004 mg/l
Total Organic Carbon (TOC)	Method 9060	1 mg/l	1mg/l

The ferrous iron method relies on a HACH method (No. 8146) which is a calorimetric determination of ferrous iron content. Elevated ferrous iron concentrations indicate that ferric iron is being reduced as a result of COC degradation. The procedure requires collection of 100 mL of water in a glass container, filtration, and a 10 mL aliquot for analysis.

The methane analysis relies on a method developed by Kampbell et al. (1989) as cited in AFCEE (1995). The method analyzes for methane, ethane, and ethene. The presence of methane indicates BTEX degradation by methanogenesis. Ethane and ethene data are used where chlorinated solvents are suspected of undergoing biological transformation. The procedure requires water sample collection in 50 ml glass serum bottles with butyl gray/Teflon-lined caps. H2SO4 is added to reduce pH to less than 2, and the sample must be stored at 4°C.

Total organic carbon (TOC) analysis requires use of SW 846 Method 9060. This method is used to determine the concentration of organic carbon in groundwater and is applicable to measurement of organic carbon at concentrations above 1 mg/l. The TOC concentration is used as an indication of the amount of organic carbon available as a nutrient source during biodegradation. The procedure requires the sample be collected in a 4 ounce amber glass jar with teflon septum and no headspace. Sulfuric acid is added as a preservative to a pH of 2 or less. The sample has a holding time of 28 days. One blank should be provided per sample batch to determine if contamination or any memory effects are occurring. Calibration should be verified with an independently prepared check standard every 15 samples. One spike duplicate should be analyzed for every 10 samples. Refer to Table 8.2-4 of the Base-Wide QAPP for flagging conventions. Precision and accuracy data are available in Method 415.1 of Methods of Chemical Analysis of Water and Wastes.

B.1.3 Sample Handling

The purpose of this section is to identify types of sample containers, sample volumes, methods of preservation, sample identification, sample holding times, sample packaging, and shipping method.

B.1.3.1 Sample Containers

Sample containers will be provided to field personnel precleaned and treated according to EPA specifications for the methods. No sampling containers will be reused for these sampling events. Containers will be stored in clean areas to prevent exposure to fuels, solvents, and other contaminants. Amber glass bottles are used routinely where glass containers are specified in the sampling protocol.

B.1.3.2 Sample Volumes, Container Types, and Preservation Requirements

Sample volumes, container types, and preservation requirements for the analytical methods performed on the samples are listed in Table B.2.

Sample holding time tracking begins with the collection of samples and continues until the analysis is complete. Holding times for methods required routinely for AFCEE work are specified in Table B.2.

B.1.3.3 Sample Identification

Each sample collected will be assigned a unique sample identification number. The unique IRPIMS well identification shall be used for each sample. Sample containers will be labeled with the sample number and will be entered on the chain-of-custody form. To eliminate any bias by the laboratory, the relationship between the unique sample identification number and the actual field sample number will be known only to CONTRACTOR.

B.1.4 Sample Custody

Procedures to ensure the custody and integrity of the samples begin at the time of sampling and continue through transport, sample receipt, preparation, analysis and storage, data generation and reporting, and sample disposal. Records concerning the custody and condition of the samples are maintained in field and laboratory records.

The contractor will maintain chain-of-custody records for all field and field QC samples. A sample is defined as being under a person's custody if any of the following conditions exist: (1) it is in their possession, (2) it is in their view, after being in their possession, (3) it was in their possession and they locked it up or, (4) it is in a designated secure area.

All sample containers will be sealed in a manner that will prevent or detect tampering if it occurs. In no case shall tape be used to seal sample containers. Samples will not be packaged with activated carbon.

The following minimum information concerning the sample shall be documented on the AFCEE chain of custody form:

- Unique sample identification
- Date and time of sample collection
- Source of sample (including name, location, and sample type)
- Designation of **MS/MSD**
- Preservative used
- Analyses required
- Name of collector(s)
- Pertinent field data (pH, temperature)
- Serial numbers of custody seals and transportation cases (if used)
- Custody transfer signatures and dates and times of sample transfer from the field to transporters and to the laboratory or laboratories
- Bill of lading or transporter tracking number (if applicable)

Table B.2
Requirements for Containers, Preservation Techniques, Sample Volumes, and Holding Times

Name	Analytical Methods	Container[a]	Preservation[b,c]	Minimum Sample Volume or Weight	Maximum Holding Time
Mercury	SW7470 SW7471	P, G, T	HNO_3 to pH < 2, 4°C	500 mL or 8 ounces	28 days (water and soil)
Metals (except chromium (VI) and mercury)	SW6010A SW6020 and SW-846 AA methods	P, G, T	HNO_3 to pH < 2, 4°C	500 mL or 8 ounces	180 days (water and soil)
Volatile organics	SW8240B, SW8010B, SW8260A	G, Teflon-lined septum, T	4°C, 0.008% $Na_2S_2O_3$ (HCl to pH < 2 for volatile aromatics by SW8240 and SW8260)[b]	2 x 40 mL or 4 ounces	14 days (water and soil); 7 days if unpreserved by acid

a. Polyethylene (P); glass (G); brass sleeves in the sample barrel, sometimes called California brass (T).
b. No pH adjustment for soil.
c. Preservation with 0.008 percent $Na_2S_2O_3$ is only required when residual chlorine is present.

All samples will be uniquely identified, labeled, and documented in the field at the time of collection in accordance with Section B.1.2.3 of this Appendix.

Samples collected in the field will be transported to the laboratory or field testing site as expeditiously as possible. When a 4°C requirement for preserving the sample is indicated, the samples will be packed in ice or chemical refrigerant to keep them cool during collection and transportation. During transit, it is not always possible to rigorously control the temperature of the samples. As a general rule, storage at low temperature is the best way to preserve most samples. A temperature blank (a volatile organics compound sampling vial filled with water) will be included in every cooler and used to determine the internal temperature of the cooler upon receipt of the cooler at the laboratory.

B.1.5 Field Quality Control Samples

Field quality control samples to be collected include blanks and duplicates, as described in the following sections.

B.1.5.1 Ambient Blank

The ambient blank consists of ASTM Type II reagent grade water poured into a VOC sample vial at the sampling site. It is handled like an environmental sample and transported to the laboratory for analysis. Ambient blanks are prepared only when VOC samples are taken and are analyzed only for VOC analytes.

Ambient blanks are used to assess the potential introduction of contaminants from ambient sources (e.g., active runways, engine test cells, gasoline motors in operation) to the samples during sample collection. Ambient blanks will be collected downwind of possible VOC sources. One ambient blank will be taken during each sampling round.

B.1.5.2 Equipment Blank

An equipment blank is a sample of ASTM Type II reagent grade water poured into or over or pumped through the sampling device, collected in a sample container, and transported to the laboratory for analysis. Equipment blanks are used to assess the effectiveness of equipment decontamination procedures. One equipment blank will be taken by each sampling team on each day of sampling that decontamination activities occur. Equipment blanks will be collected immediately after the equipment has been decontaminated. The blank will be analyzed for all laboratory analyses requested for the environmental samples collected at the site.

B.1.5.3 Trip Blank

The trip blank consists of a VOC sample vial filled in the laboratory with ASTM Type II reagent grade water, transported to the sampling site, handled as an environmental sample and returned to the laboratory for analysis. Trip blanks are not opened in the field. Trip blanks are prepared only when VOC samples are taken and are analyzed only for VOC analytes. Trip blanks are used to assess the potential introduction of contaminants from sample containers or during the transportation and storage procedures. One trip blank will accompany each cooler samples sent to the laboratory for analysis of VOCs.

B.1.5.4 Field Duplicates

A field duplicate sample is a second sample collected at the same location as the original sample. Duplicate samples are collected simultaneously or in immediate succession, using identical recovery techniques, and treated in an identical manner during storage, transportation, and analysis. The sample containers are assigned an identification number in the field such that they cannot be identified (blind duplicate) as duplicate samples by laboratory personnel performing the analysis. Specific locations are designated for collection of field duplicate samples prior to the beginning of sample collection.

Duplicate sample results are used to assess precision of the sample collection process. Precision of soil samples to be analyzed for VOCs is assessed from collocated samples because the compositing process required to obtain uniform samples could result in loss of the compounds of interest. Ten percent of all water samples will be field duplicates.

B.2 Field Measurements

B.2.1 Parameters

The purpose of this section is to identify (1) all the parameters to be measured in the field and, (2) the equipment that will be used for the measurements.

B.2.2 Equipment Calibration And Quality Control

All equipment will be calibrated according to manufacturers' instructions procedures outlined in the Base-Wide QAPP (Table 6.2-1). Calibration of all instruments will be recorded in the field log book. Specific calibration procedures are outlined below.

- Measurement of pH will be performed in the field with a pH meter. The instrument will be field-calibrated with two buffer solutions at the beginning of each day's use. Accuracy of the measurement is maintained by selecting a standard buffer with a pH close to that of the sample (preferably within three pH units). The pH of the buffers used will be dependent upon the pH of the sample, but in each case will "bracket" the range of measurement. The stability of the calibration will be verified through the analysis of one standard periodically throughout the day as deemed necessary by the Field Investigation Task Manager, but at least once every 5 hours.

- Temperature and specific conductivity will be measured with a portable meter. Calibration of the instrument is periodically performed at the factory as part of an internal QA program. The instrument probe will be rinsed with reagent water between each use and the calibration of the specific conductivity probe will be checked at the beginning and middle of each day using a potassium chloride (KCl) solution with known conductance values.

- The hand-held portable organic vapor analyzer (OVA) with a photoionization detector (PID) is used to screen the air vapors when the well casing cap is removed. It will be calibrated daily with a 100-ppm level of isobutylene. The battery power supply will be recharged each evening prior to the next day's field activities.

- The hand-held portable atmospheric monitor used to screen the breathing zone for explosive conditions and H_2S will be calibrated daily, as described in the manufacturer's manual.

- Turbidity will be measured with a nephelometer (also known as a turbidimeter). Calibration of the instrument is periodically performed at the factory as part of routine maintenance. The stability of the calibration will be verified through the analysis of one standard periodically throughout the day as deemed necessary by the Task Leader, but at least once every 5 days.

- Dissolved Oxygen (DO) content will be measured using a portable hand held DO meter. The meter will calibrated each morning prior to use using a two-point calibration with the manufacturers recommended criteria.

B.2.3 Equipment Maintenance And Decontamination

B.2.3.1 Equipment Maintenance

Field equipment will be kept in a controlled storage room, and will be decontaminated prior to return to storage; any malfunctions will be reported to the Task Leader. The Task Leader will initiate actions necessary for the repair or replacement of defective equipment. Equipment maintenance logs are kept updated and on file. Power supplies of battery-powered instruments will be checked daily. Rechargeable instruments will be recharged daily.

B.2.3.2 Decontamination of Field Instruments

Decontamination of field instruments will be instrument-specific. The probes of the pH, temperature, DO, and specific conductivity meters will be rinsed with reagent grade water before and after each use, and at the end of each day. The measurement vial for the turbidity meter will be rinsed with deionized water before and after each use. No decontamination is required for the organic vapor analyzer.

B.2.4 Field Monitoring Measurements

Field monitoring will include groundwater level measurements, measurement of any non-aqueous phase liquids, and tracking of purge volumes. All field monitoring devices will be decontaminated in accordance with procedures in Section B.4.2.

B.2.4.1 Groundwater Level Measurements

Water-level measurements shall be taken in all wells and piezometers to determine the elevation of the water table or piezometric surface at least once within a single 24-hour period. These measurements will be taken after all wells and piezometers have been installed and developed and their water levels have recovered completely. Any conditions that may affect water levels will be recorded in the field log.

Water-level measurements will be taken with electric sounders, air lines, pressure transducers, or water-level recorders (e.g., Stevens recorder). Devices that may alter sample composition will not be used. Pressure gauges, manometers, or equivalent devices will be used for flowing wells to measure the elevation of the piezometric surface. Groundwater level shall be measured to the nearest 0.01 foot.

Static water levels will be measured each time a well is sampled, and before any equipment enters the well. If the casing cap is airtight, allow time prior to measurement for equilibration of pressures after the cap is removed. Repeat measurements until water level is stabilized.

B.2.4.2 Hydrocarbon Measurements

The thickness of hydrocarbons floating (LNAPLs) in monitor wells will be measured with an electronic interface probe. Hydrocarbon detection paste, or any other method that may affect water chemistry, will not be used. When detected, the presence of floating hydrocarbons will be confirmed by withdrawing a sample with a clear, bottom-fill Teflon bailer. If sinking hydrocarbons (DNAPLs) are suspected, a weighted cotton string will be lowered into the well to determine if such hydrocarbons are present and a measurement attempted if DNAPL is visible on the string.

B.2.4.3 LNAPL Removal Procedures

If the measured LNAPL thickness is greater than 0.05 feet, an attempt will be made to remove the product. This thickness represents a practical lower limit for potential recovery, beyond which thickness measurements are less reliable and recovery not feasible. The preliminary removal technique used will depend on the thickness of LNAPL and the relative permeability of LNAPL saturated sediments. Initial recovery attempts will use a bottom loading bailer that is slowly lowered in the well. If this method is not successful, an absorbent sock consisting of ooliphatic membrane will be tethered and lowered into the well. Any LNAPL or wastes containing LNAPL that are generated during this process will be handled and disposed in a manner consistent with the procedures described in Section B.4.3. A description of the LNAPL removal technique used will be summarized in both quarterly and annual groundwater monitoring reports and recommendations included to potentially improve LNAPL recovery efforts.

B.2.4.4 Groundwater Discharge Measurements

Groundwater discharge measurements will be obtained during monitor well purging. Groundwater discharges may be measured with orifice meters, containers of known volume, in-line meters, flumes, or weirs, following the guidelines specified in the Water Measurement Manual, Bureau of Reclamation, 1967. Measurement devices will be calibrated using containers of known volume.

B.2.5 Field Performance And System Audits

The Task Leader or a designated representative will conduct weekly informal audits of the field activities. The weekly audit for completeness will include the following items:

- Sample labels
- Chain of custody records
- Field notebooks
- Sampling operations
- Document control

The first three items above will be checked for completeness. Sampling operations will be reviewed to determine if they are performed as stated in the project-specific work plan, or as directed by the Task Leader. The informal document control audit will consist of checking each document for completeness, including items such as signatures, dates, and project numbers.

A systems audit of field operations may be required by the project-specific work plan and will be used to review the total data generation, which includes on-site review of the field operational system, physical facilities for sampling, and equipment calibrations. A performance audit may be conducted by the Project Manager (PM) and Task Leader (TL) during the first week of sampling if deemed necessary by the PM, TL, Project Chemist, or Client. The audit may focus on verifying that proper procedures are being followed so that subsequent sample data will be valid. Before the audit, a checklist will be prepared by the PM and TL that will serve as a guide for the performance audit. The audit may verify whether or not:

- Collection of samples follows the available written procedures
- Chain of custody procedures are followed for traceability of samples origin
- Appropriate QC checks are being made in the field and documented in the field logbook
- Specified equipment is available, calibrated, and working properly
- Sampling crews are adequately trained
- Record-keeping procedures are being followed and appropriate documentation is maintained
- Corrective action procedures are followed

An audit report summarizing the results and corrections will be prepared and filed in the project files.

B.3 Record Keeping

Field records sufficient to recreate all sampling and measurement activities and to meet all IRPIMS data loading requirements will be maintained. The requirements listed in this section apply to all measuring and sampling activities. Requirements specific to individual activities are listed in the section that addresses each activity. The information will be recorded with indelible ink in a permanently bound notebook with sequentially numbered pages. These records will be archived in an easily accessible form and made available to the COR or authorized representative upon request.

The following information will be recorded for all field activities: (1) location, (2) date and time, (3) identity of people performing activity, and (4) weather conditions. For field measurements: (1) the numerical value and units of each measurement, and (2) the identity of and calibration results for each field instrument, will also be recorded.

The following additional information will be recorded for all sampling activities: (1) sample type and sampling method, (2) the identity of each sample and depth(s), where applicable, from which it was collected, (3) the amount of each sample, (4) sample description (e.g., color, odor, clarity), (5) identification of sampling devices, and (6) identification of conditions that might affect the representativeness of a sample (e.g., refueling operations, damaged casing). AFCEE approved forms that will be used during field sampling are included in Appendix C.

B.4 Field Operations

The following sections describe the procedures to be used during field operations. Included are sections describing standards for site reconnaissance and restoration, equipment decontamination, and waste handling.

B.4.1 Site Reconnaissance, Preparation, And Restoration Procedures

Prior to the first groundwater sampling event, a site reconnaissance will be performed to check each well location for accessibility to finalize the sampling sequence and identify a field office and storage areas for equipment and investigative derived wastes. Vehicle access routes to well locations will be determined at this time, and maps prepared for field sampling personnel.

Liquid waste shall be accumulated in 55-gallon drums and subsequently transported to a waste storage area designated by the Air Force. Decontamination areas for personnel and portable equipment will be set up at each well location. These locations will include basins or tubs to capture decontamination fluids, which will be transferred to a large accumulation drum as necessary.

A field office site will also be designated for centralization of sample tracking, packaging, and preparation for shipping.

Each sampling location will be returned to its original condition when possible. Efforts will be made to minimize impacts to sampling locations, particularly those in or near sensitive environments, such as wetlands. Following the completion of work at a site, all drums, trash, and other waste will be removed. Decontamination and/or purge water will be transported to the designated locations.

B.4.2 Equipment Decontamination

All equipment that may directly or indirectly contact samples will be decontaminated in the designated decontamination area. This includes sampling devices and instruments, such as slugs and sounders. In addition, the sample will be prevented from coming into contact with potentially contaminating substances such as tape, oil, engine exhaust, corroded surfaces, and dirt.

The following procedure will be used to decontaminate sampling devices, such as bailers, that can be hand-manipulated. The equipment will be scrubbed with a solution of potable water and Alconox, or equivalent laboratory-grade detergent. The equipment will then be rinsed with copious quantities of potable water followed by a ASTM Type II Reagent Water. High pressure liquid chromatograph-grade water and distilled water purchased in stores are not acceptable substitutes for ASTM Type II Reagent-Grade Water. Then the equipment will be rinsed with pesticide-grade methanol followed by with pesticide-grade hexane. The equipment will be air-dried on a clean surface or rack, such as Teflon, stainless steel, or oil-free aluminum elevated at least two feet above ground. If the sampling device will not be used immediately after being decontaminated, it will be wrapped in oil-free aluminum foil, or placed in a closed stainless steel, glass, or Teflon container.

Type II Reagent-Grade Water, methanol, and hexane will be purchased, stored, and dispensed only in glass, stainless steel, or Teflon containers. These containers will have Teflon caps or cap liners. It is the contractor's responsibility to assure these materials remain free of contaminants. If any question of purity exists, new materials will be used.

B.4.3 Waste Handling

All purge water from on-site monitor wells will be containerized for disposition either on- or off-site, as appropriate. Final plans for purge water disposition based on the availability of the AFP4/IT Corporation treatment system. If this option is not available, other treatment and disposal options will be identified. The following sections describe procedures for handling investigative and noninvestigative wastes.

Waste handling will be dealt with on a site-by-site basis. Waste may be classified as noninvestigative waste or investigative waste.

Noninvestigative waste, such as litter and household garbage, will be collected on an as-needed basis to maintain each site in a clean and orderly manner. This waste will be containerized and transported to the designated sanitary landfill or collection bin. Acceptable containers will be sealed boxes or plastic garbage bags.

Investigation-derived waste will be properly containerized and temporarily stored at each site, prior to transportation. Depending on the constituents of concern, fencing or other special marking may be required. The number of containers will be estimated on an as-needed basis. Liquid waste will be containerized in sealed, U.S. Department of Transportation (DOT)-approved steel 55-gallon drums and solid waste, such as tape, PPE, paper, or plastic sheeting, shall be containerized in small dumping bins with lids. The containers will be transported in such a manner to prevent spillage. To facilitate handling, the containers will be no more than half full when moved.

Appendix C

Contained in this section are copies of the AFCEE-approved forms for field activities specifically associated with the current program. Additional forms may need to be added to address modifications to the groundwater sampling and analysis program.

304117

AFCEE APPROVED FORMS

304118

WELL DEVELOPMENT RECORD

WELL/PIEZOMETER ID _ ______
SHEET ______ of _______

PROJECT NAME: ________________ PROJECT NO. : __________________________ DATE: ____________________

LOCATION: ____________________ DATE INSTALLED: ____

TOTAL DEPTH (FTOC) ___________ CASING DIAMETER ____

METHODS OF DEVELOPMENT

☐ Swabbing ☐ Bailing ☐ Pumping ☐ Describe ____________________________________

Equipment decomtaminated prior to development ☐ Yes ☐ NO

Describe ____

EQUIPMENT NUMBERS:

pH Meter _____________ EC Meter ______________ Turbidity Meter ____________ Thermometer _____________

CASING VOLUME INFORMATION:

Casing ID (inch)	1.0	1.5	2.0	2.2	3.0	4.0	4.3	5.0	6.0	7.0	8.0
Unit Casing Volume (A) (gal/ft)	0.04	0.09	0.16	0.2	0.37	0.65	0.75	1.0	1.5	2.0	2.6

PURGING INFORMATION:

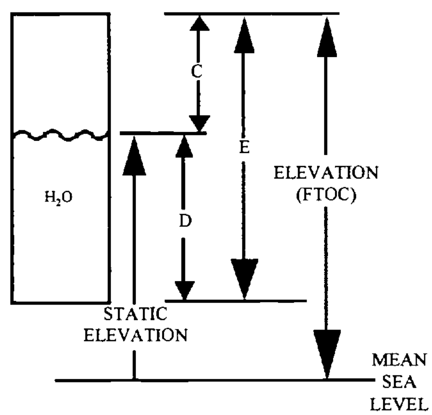
Measured Well Depth (B) _____________________ft.

Measured Water Level Depth (C) _________________ft.

Length of Static Water Colume (D) _______ - _______ = ________ ft.
(B) (C)

Casing Water Volume (E) + _______ x _______ = _________ gal
(A) (D)

Total Purge Volume = _________ (gal)



Date	Time	Water Level (FTOC)	Volume Removed (gal)	pH	EC	Temperature F or C	Turbidity/ Sand (ppm)	Comments

AFCEE FORM WD.0

304119

WASTE INVENTORY TRACKING FORM

LOCATION : ______________________________

PROJECT NAME: ______________________________

ACTIVITIES: ______________________________

Date Waste Generated	Activity Generating Waste (borehole # / well #)	Description of Waste	Field Evidence of Contamination	Estimated Volume	Type of Container (storage ID#)	Location of Container	Waste Characterization	Comments

Note: Describe whether soil or water samples have been collected for waste characterization, include date, if known.

Signature: ______________________________

MONITOR WELL STATIC WATER LEVEL FORM

PROJECT NAME: ______________________________ DATE: ____________________

WATER LEVEL INDICATOR ID # _____________ FIELD BOOK # ____________

LOCATION: __________________________________ PAGE # _________________

Monitor Well Number	Time	Depth to Static Water Level (from T.O.C.)	Total Well Depth (ft)	Explosimeter Reading (above background)	PID Reading (above background)

Note: Total well depth to be measured at time of gauging.

Comments: ____

____

____

Sampler ______________________________ Observer ______________________________

30412

FIELD SAMPLING REPORT

LOCATION: ______________________ PROJECT : ______________________

SITE: ______________________

SAMPLE INFORMATION

MATRIX ______________________ SAMPLE ID: ______________________

SAMPLING METHOD ______________ DUP./REP. OF : ______________________

BEGINNING DEPTH ______________ MATRIX SPIKE/MATRIX SPIKE DUPLICATE YES ( ) NO ( )

END DEPTH ______________________

GRAB ( ) COMPOSITE ( ) DATE: ____________ TIME: ____________

CONTAINER SIZE/TYPE	#	PRESERVATIVE/ PREPARATION	EXTRACTION METHOD	ANALYTICAL METHOD	ANALYSIS

NOTABLE OBSERVATIONS

PID READINGS	SAMPLE CHARACTERISTICS	MISCELLANEOUS
1st	COLOR:	
2nd	ODOR:	
	OTHER:	

GENERAL INFORMATION

WEATHER: SUN/CLEAR _____ OVERCAST/RAIN _____ WIND DRIECTION _______ AMBIENT TEMP ______

SHIPMENT VIA: FED-X _____ HAND DELIVER ______ COURIER _______ OTHER _______

SHIPPED TO: ____

COMMENTS: ____

SAMPLER: ______________________ OBSERVER: ______________________

MATRIX TYPE CODES

DC=DRILL CUTTINGS
WG=GROUND WATER
LH=HAZARDOUS LIQUID WASTE
SH=HAZARDOUS SOLID WASTE
SE=SEDIMENT
SL=SLUDGE
SO=SOIL
GS=SOIL GAS
WS=SURFACE WATER
SW=SWAP\WIPE

SAMPLING METHOD CODES

B=BAILER
BR=BRASS RING
CS=COMPOSITE SAMPLE
C=CONTINUOUS FLIGHT AUGER
DT=DRIVEN TUBE
W=SWAB\WIPE
G=GRAB
HA=HAND AUGER
H=HOLLOW STEM AUGER
HP=HYDRO PUNCH
SS=SPLIT SPOON
SP=SUBMERSIBLE PUMP

AFCEE FORM SR.0

MONITOR WELL PURGING FORM

304122

PROJECT : ______________________ DATE: ______________

LOCATION: ______________________ EXPLOSIMETER BOREHOLE READING ________

WELL ID: ______________________ PURGE VOLUME (3 WELLBORE VOLUMES): ______________ (gal)

WELL DEPTH: ______________________

Time	Depth to Water (ft)	Flow Meter Reading	Volume Purged (gal)	Temp. (°C)	pH	Electrical Conductivity (mmho)	Turbidity N.T.U	Comments

Note: Condition of the well: ______________________

pH - Calibrate at start and before last reading.

Sampler ______________________ Observer ______________________

AFCEE FORM WP.0

304123

FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE

304124

FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE