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SITE-SPECIFIC WORK PLAN FOR
THE PASSIVE DIFFUSION BAG SAMPLER DEMONSTRATION AT
GEORGE AFB, CALIFORNIA

August 2001

Prepared for:

Air Force Center for Environmental Excellence
Technology Transfer Division
and
Air Force Base Conversion Agency

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LIST OF ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
AFBCA	Air Force Base Conversion Agency
AFCEE	Air Force Center for Environmental Excellence
AFCEE/ERT	Air Force Center for Environmental Excellence, Technology Transfer Division
amsl	above mean sea level
ANOVA	analysis of variance
APCL	Applied Chemistry and Physics Laboratory
BGMP	Basewide Groundwater Monitoring Program
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CERLA	Comprehensive Environmental Restoration, Compensation, and Liability Act
COC	chemical of concern
DDE	4,4-dichloro-diphenol-trichloroethene
DDT	4,4-dichloro-diphenyl-trichloroethane
DoD	Department of Defense
DP	disposal pit
DSITMS	Direct Sampling Ion-Trap Mass Spectrometry
FT	fire training area
ft/ft	feet per foot
ft/day	feet per day
GIS	Geographical information system
HASP	Health and Safety Plan
IRP	Installation Restoration Program
JMM	James M. Montgomery
LF	landfill
µg/L	micrograms per liter
MTBE	Methyl tert-butyl ether
MW	monitoring well
NEDA	Northeast Disposal Area
OCCD	octachlorodibenzo-p-dioxin
OU	operable unit
OT	other type of IRP site
Parsons	Parsons Engineering Science, Inc.
PCE	Tetrachloroethane
PDBS	passive diffusion bag sampler
RI	Remedial Investigation
RPD	relative percent difference
RW	Radiological Waste
SAIC	Science Applications International Corporation
SS	spill site
STP	Sewage Treatment Plant
TCE	trichloroethene
TO	task order
TPH	total petroleum hydrocarbons

USEPA	United States Environmental Protection Agency
UST	Underground storage tank
VOC	volatile organic compound
VVWRA	Victor Valley Water Reclamation Authority
WP	waste pit

1.0 INTRODUCTION

1.1 Project Description

On 27 February 2001, Parsons Engineering Science, Inc. (Parsons) was awarded a task order (TO) under Air Force Center for Environmental Excellence (AFCEE) contract F41624-00-D-8024 (TO24) to demonstrate the use of passive diffusion bag samplers (PDBSs) in existing groundwater monitoring programs at selected Department of Defense (DoD) installations overseen by the Air Force Base Conversion Agency (AFBCA). The site of the PDBS demonstration outlined in this work plan is George Air Force Base (AFB), California. The Technology Transfer Division of AFCEE (AFCEE/ERT) has initiated the PDBS demonstration to introduce this technology to multiple DoD installations and to improve the cost effectiveness of groundwater monitoring programs for volatile organic compounds (VOCs).

Diffusion sampling is a relatively new technology designed to utilize passive sampling techniques that eliminate the need for well purging. Specifically, a diffusive-membrane capsule is filled with deionized/distilled water, sealed, suspended in a well-installation device, and lowered to a specified depth below the water level in a monitoring well. Over time (no less than 72 hours), the VOCs in the groundwater diffuse across the membrane, and the water inside the sampler reaches equilibrium with groundwater in the surrounding formation. The sampler is subsequently removed from the well, and the water in the diffusion sampler is transferred to a sample container and submitted for laboratory analysis of VOCs. Benefits of diffusion sampling include reduced sampling costs and reduced generation of investigation-derived waste.

1.2 Objective

The PDBS demonstration at George AFB has two primary objectives:

- Develop vertical profiles of VOC concentrations across the screened intervals of the sampled monitoring wells, and

- Assess the effectiveness of PDBS by statistically comparing groundwater analytical results for VOCs obtained using the current (conventional) sampling method (i.e., Micropurge sampling method). VOC results from the scheduled October 2001 Basewide Groundwater Monitoring Program (BGMP) event will be compared to the results obtained using the PDBS method.

Vertical contaminant profiles will be developed by placing PDBSs at discrete screened depths in each monitoring well included in the demonstration, and analyzing the resulting samples for VOCs. The resulting information will aid the Base in evaluating contaminant migration and fate in the saturated zone, and will allow optimization of the BGMP. The statistical comparison of the conventional and diffusion sampling results will allow assessment of the appropriateness of implementing diffusion sampling for VOCs at each sampled well.

1.3 Scope

The George AFB PDBS sampling demonstration will require two mobilizations to the site: one to place the diffusion samplers in the selected monitoring wells, and a second to retrieve the samplers from the wells. The PDBSs will be installed in late-September 2001 to provide adequate equilibration time before the current environmental contractor for George AFB, Montgomery Watson, begins the scheduled BGMP sampling event on October 15, 2001. To the extent feasible, the PDBSs will be retrieved immediately prior to the conventional BGMP sampling at the selected locations to ensure temporal comparability of the analytical results obtained using the two methods. The PDBSs will be in place for a minimum of 14 days, which fulfills the 14-day minimum equilibration time period specified in the BRAC PDBS Project Work Plan (Parsons, 2001).

1.4 Document Organization

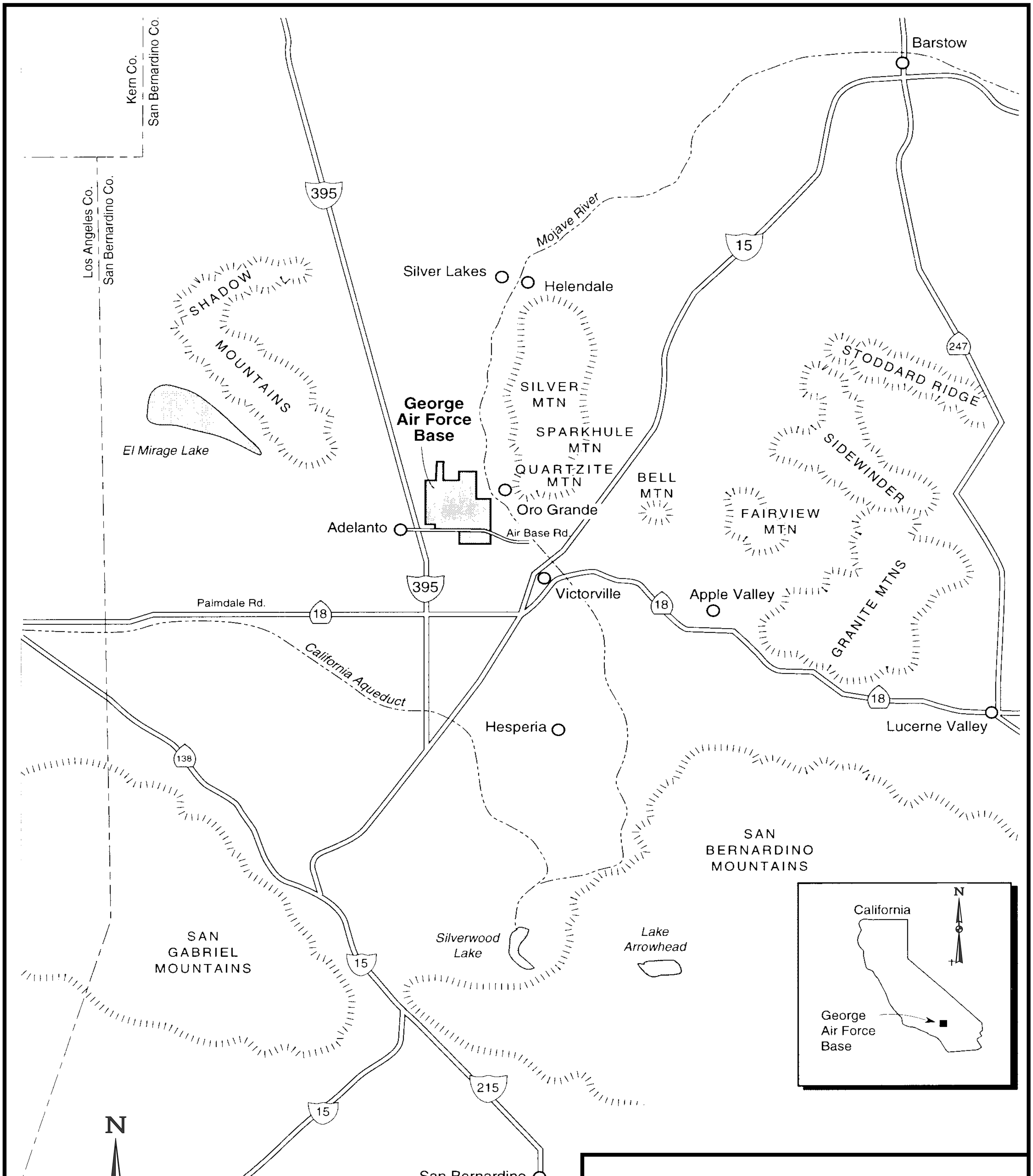
This work plan is organized into seven sections, including this introduction, and two appendices. The George AFB site description is presented in Section 2. Section 3 presents the scope of the PDBS investigation at George AFB. Project organization, schedule, and an overview of the PDBS site-specific results report are summarized in Sections 4, 5, and 6, respectively. References used in the preparation of this work plan are presented in Section 7. Appendix A provides a site-specific addendum to the Project Health and Safety Plan (HASP) (Parsons, 2001). Historic site-specific data for George AFB is provided in Appendix B.

2.0 SITE DESCRIPTION

2.1 Location and Description of George Air Force Base

George AFB is located in southern California, northwest of the city of Victorville (Figure 2.1). The Base was initially activated in 1941 as Victorville Army Airfield, and served as a training facility for pilots and bombardiers. In 1945, flying operations were discontinued, and the Base was assigned to the Air Tactical Services Command as an aircraft storage facility. In 1948, the Base was transferred to the Sacramento Air Material Command, and all stored aircraft were removed from the site. In 1950, the Base was reopened as George AFB. During the Korean War, the Base was home to the 1st Fighter Interceptor Wing and the 131st and 146th Fighter Bomber Wings. After the Korean War, George AFB remained active as a fighter training base. In 1989, the realignment and closure of George AFB was approved by the Secretary of Defense and Congress, and closure began in 1992. Currently, George AFB is not occupied by Air Force personnel, and is being converted for civilian use (airport and aircraft maintenance, and an industrial park).

Operations at George AFB required the storage, use, and disposal of hazardous materials. Active environmental cleanup has been underway at George AFB since 1981, in accordance with the Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA) guidance and regulations as part of the Air Force Installation Restoration Program (IRP). During the IRP Phase I Records Search (CH2M Hill, 1982), 54 sites that were known or suspected to have received hazardous materials were



Source: Modified from Thomas Bros. Maps, (1992).

FIGURE 2.1

VICINITY MAP

Passive Diffusion Bag Sampler Demonstration
George AFB, California

PARSONS
Denver, Colorado

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identified at George AFB. Six additional sites were identified during the IRP Phase II Confirmation/Quantification Study (Science Applications International Corporation [SAIC], 1987). Sites deemed to warrant further investigation were grouped into three operable units (OUs) (Figure 2.2).

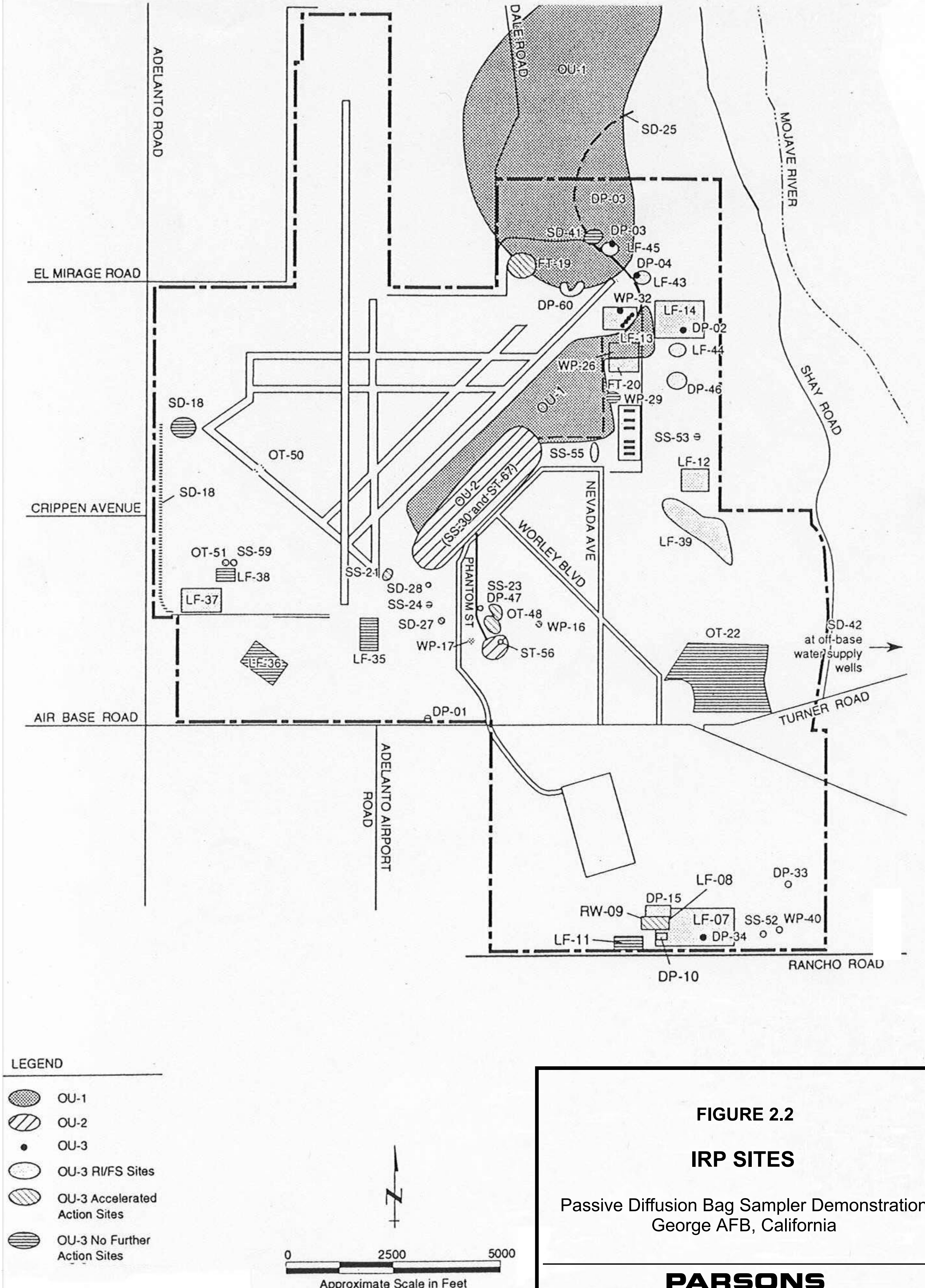
This study will focus on monitoring wells located within OU1 and OU3. OU1 includes Department of Defense (DOD) Site SD-25 (IRP Site S-20), the Industrial/Storm Drain; DOD Site WP-26 (IRP Site S-21), the Sewage Treatment Plant (STP) Percolation Ponds; and a dissolved trichloroethene (TCE) plume in groundwater beneath the Northeast Disposal Area (NEDA) in the northeastern part of the Base and adjacent, downgradient off-Base areas.

OU3 consists of 60 IRP sites located throughout George AFB. The OU3 sites consist of a variety of potential contaminant source areas including landfills, other waste storage and disposal sites, fire training areas, spill areas, and leach fields. These sites have been designated as disposal pit (DP), fire training area (FT), landfill (LF), radiological waste (RW), spill site (SS), waste pit (WP), or other (OT). The remedial investigations and site characterizations for OU3 sites are detailed in the OU3 Remedial Investigation (RI) Report (Montgomery Watson, 1996). The only IRP sites that are included in the OU3 groundwater monitoring program are rehabilitated landfill sites (Montgomery Watson, 2001a).

2.2 Geology and Hydrogeology

George AFB is located in Victor Valley, San Bernardino County, California, approximately 70 miles northeast of Los Angeles (Figure 2.1). Victor valley is within the southwestern margin of the Mojave Desert Physiographic Province, and is bounded by the Shadow Mountains on the northwest, the Mojave River on the east, and the San Gabriel Mountains on the southwest. The valley occupies the southeastern corner of a triangular-shaped crustal block bounded by the Garlock fault zone on the northwest, the Lockhart and Helendale faults on the northeast, and the San Andreas Fault on the southwest.

George AFB is situated along high bluffs overlooking the western edge of the Mojave River floodplain (Figure 2.1). Topographic relief across most of the base is low, and is flat to gently sloping. However, there is an elevation difference of about 300 feet along the escarpment between the bluffs and the Mojave River to the east and northeast, and topographic relief is pronounced. The nearly flat desert pavement west of the bluffs on which the Base is located is incised by the dry washes of a number of small, ephemeral streams ("arroyos"). These trend generally from southwest to north or northeast, and have cut steep channels in the bluffs along the Mojave River. The largest of the arroyos originates near the NEDA in the northern part of the Base, trends nearly due north for about 3,000 feet, and turns abruptly east, debouching from the escarpment along the bluffs just south of the Victor Valley Water Reclamation Authority (VVWRA) treatment plant.



Source: The Thomas Guide (1998).

FIGURE 2.2

IRP SITES

Passive Diffusion Bag Sampler Demonstration
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Victor Valley is an alluvium-filled basin containing unconsolidated deposits derived from the surrounding mountains and recent deposits of the Mojave River.

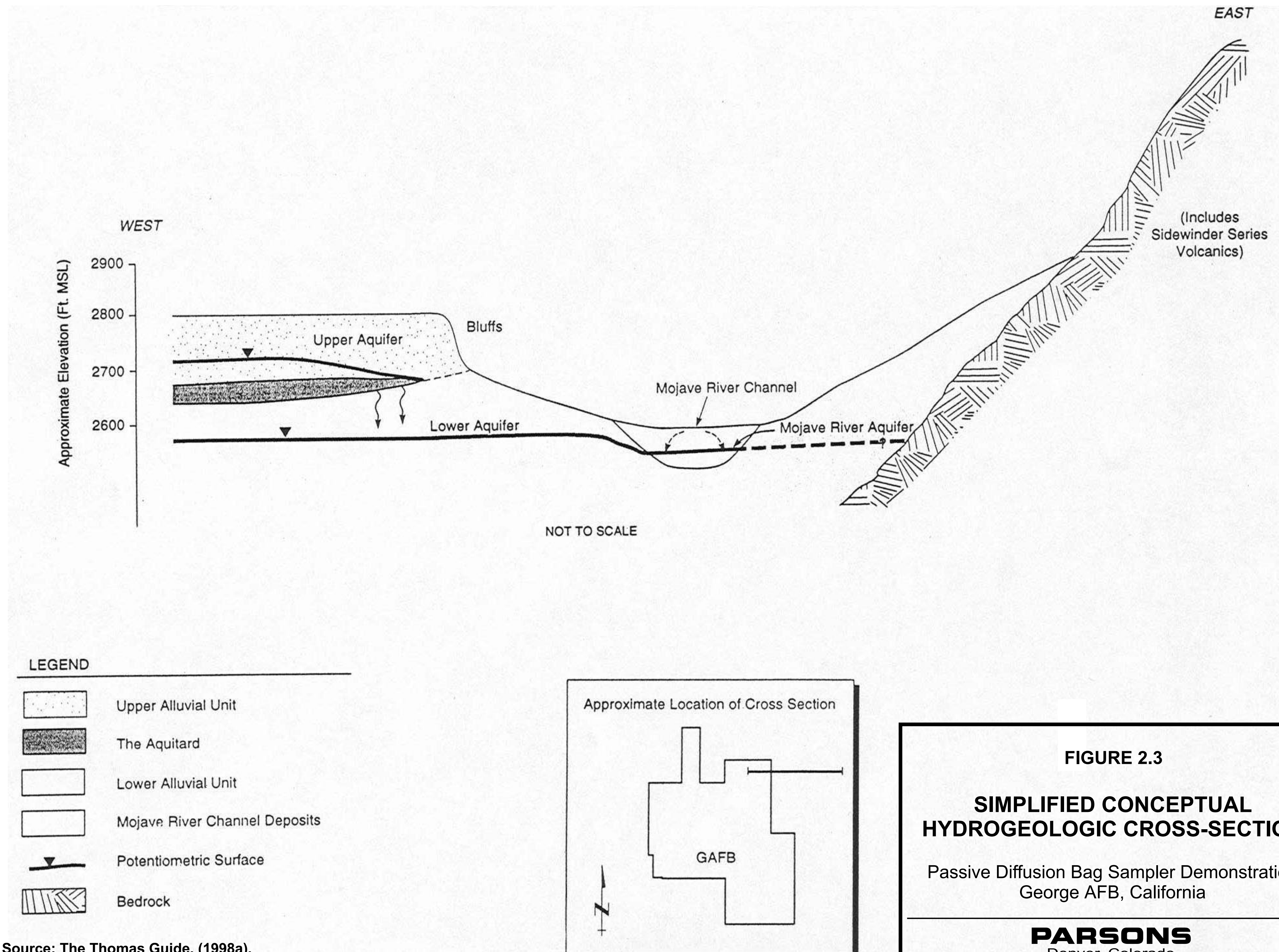
Three primary geologic units have been encountered during the subsurface investigation activities at OU1. The stratigraphically highest unit (Upper Alluvial Unit) consists of a distal alluvial fan deposit of the Victorville Fan, and is composed of sands derived from a granitic source area. Within the Upper Alluvial Unit there also are intercalated finer-grained alluvial-fan silt deposits, strata of sand and silt deposited by an antecedent Mojave River, fine-grained lacustrine deposits, and locally, gravel and caliche horizons.

The Upper Alluvial Unit overlies a silt and clay unit that may have been deposited in a lake-filled basin during Pleistocene time. The unit is thickest in the western part of the Base, where 38.5 feet of silty clay was encountered in the borehole for well RZ-03 (James M. Montgomery [JMM], 1992). The unit averages 25 feet in thickness across the Base, thinning to the east until it apparently pinches out near the bluffs that form the northeastern boundary of the Base.

The third primary unit, the Lower Alluvial Unit, consists of heterogeneous deposits of interbedded granitic sands with a minor volcanic component. The coarser sediments of the Lower Alluvial Unit appear to be associated with the distal edge of an alluvial fan, which originated in the mountains east of George AFB. The Lower Alluvial Unit may extend to a depth of at least 425 feet below ground surface (bgs) (Montgomery Watson, 1998a).

George AFB is located within the George Sub-Basin of the Upper Mojave River Groundwater Basin, which is bounded on the east and west by Mesozoic and Paleozoic bedrock. The George Sub-Basin is a structural trough filled with over 3,000 feet of Tertiary and Quaternary sediments.

Three primary hydrogeologic units, corresponding with the three primary geologic units, developed by Montgomery Watson (1998a), are present in the subsurface beneath George AFB and are depicted on Figure 2.3. The Upper Aquifer is contained within the interbedded sand and silty sand of the Upper Alluvial Unit at a depth of approximately 80 to 130 feet bgs (2,720 to 2,670 feet above mean sea level [amsl]). The Upper Aquifer is perched above the silt and clay lacustrine deposits that comprise an aquitard at approximately 130 to 170 feet bgs. The groundwater potentiometric surface within the Upper Aquifer occurs within an elevation range of approximately 2,680 to 2,760 feet amsl (Montgomery Watson, 1995). In the absence of hydraulic stresses (e.g., pumping), groundwater within the Upper Aquifer beneath George AFB flows from the south and west to the north, northeast, and northwest, with a gradient of approximately 0.003 foot per foot (ft/ft) (Figure 2.4). The gradient becomes steeper as groundwater elevations drop rapidly toward the east and northeast along the edge of the bluffs where the Upper Aquifer pinches out. The hydraulic conductivity of the unit ranges from approximately .01 feet per day (ft/day) to 48 ft/day (Montgomery Watson, 1995). Groundwater velocity within the Upper Aquifer ranges from about 0.0025 to 1.2 ft/day.



Source: The Thomas Guide, (1998a).

FIGURE 2.3

SIMPLIFIED CONCEPTUAL HYDROGEOLOGIC CROSS-SECTION

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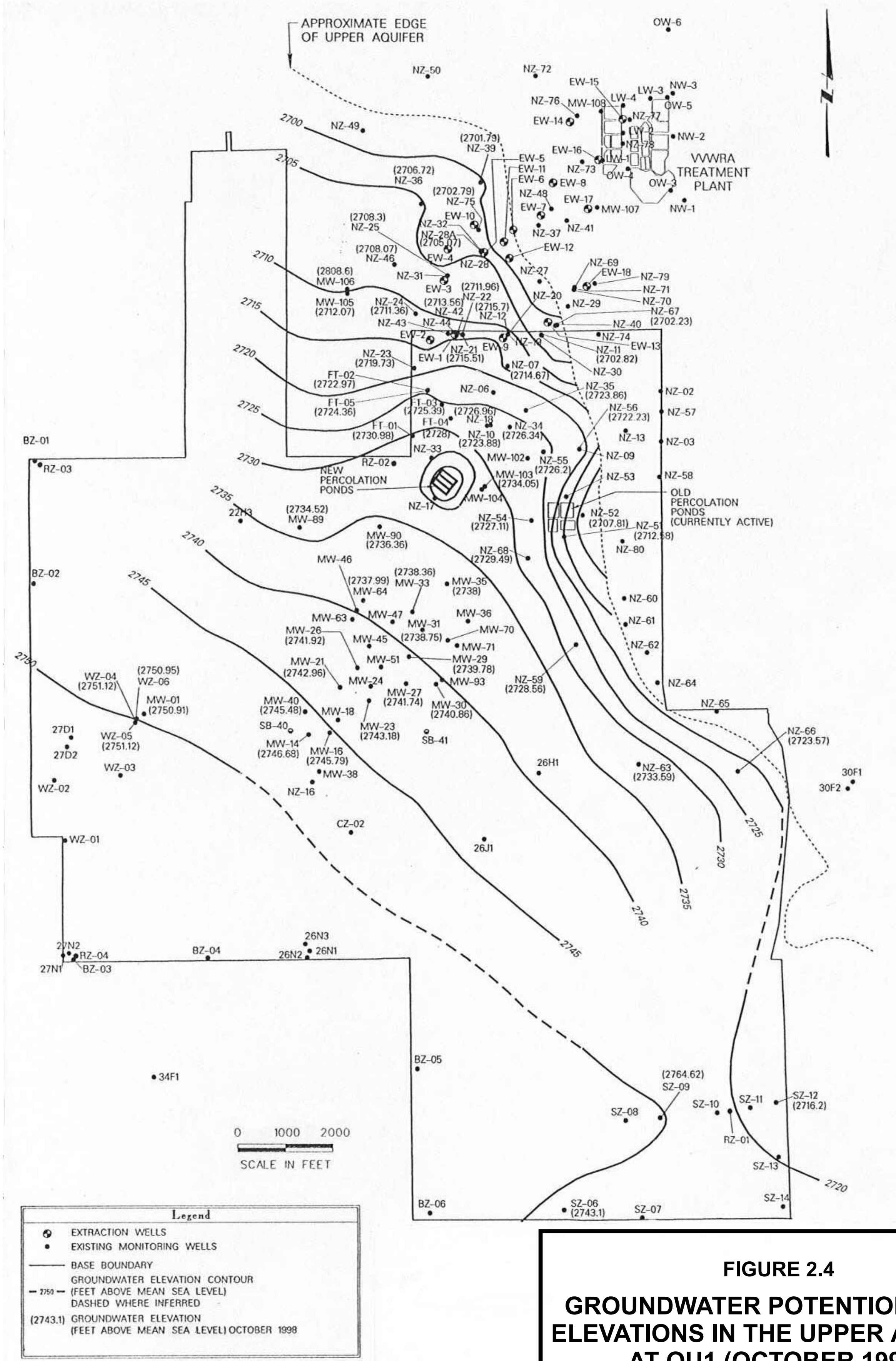

FIGURE 2.4

GROUNDWATER POTENTIOMETRIC ELEVATIONS IN THE UPPER AQUIFER AT OU1 (OCTOBER 1998)

Passive Diffusion Bag Sampler Demonstration
George AFB, California

PARSONS
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Source: Montogomery Watson, 1998a.

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The aquitard below the Upper Aquifer is composed of brown, fine-grained sandy clay to olive, plastic silty clay, which is believed to have been deposited in a playa, or lacustrine basin that once occupied the area. The aquitard occurs between elevations of 2,640 to 2,670 feet amsl (130 to 170 feet bgs), and functions as a hydrologic barrier, restricting the vertical movement of groundwater between the Upper Aquifer and the Lower (formerly called the Regional) Aquifer (Montgomery Watson, 1995). However, near the bluffs along the eastern boundary of the Base, the aquitard apparently pinches out, and the Upper Aquifer and Lower Aquifer merge, forming a single hydrostratigraphic unit (Figure 2.3).

The Lower Aquifer, the deepest hydrostratigraphic unit identified beneath George AFB, consists of interbedded sands, gravelly sands, silty sands, silts, and clays of the Lower Alluvial Unit, and is present beneath the entire Base at a depth of approximately 210 to 250 feet bgs. The groundwater potentiometric surface within the Lower Aquifer occurs within the elevation range of approximately 2,575 to 2,590 feet amsl (Montgomery Watson, 1995); therefore, a potential difference ("head") of about 100 feet exists between the Upper and Lower Aquifer systems. Groundwater within the Lower Aquifer beneath George AFB flows from southwest to northeast. The hydraulic gradient is approximately 0.0002 ft/ft in the central and western portions of the Base, and increases eastward to approximately 0.007 ft/ft as groundwater elevations drop rapidly toward the Mojave River (Montgomery Watson, 1995). The hydraulic conductivity of the Lower Aquifer ranges from about 3.8 to 88 ft/day. The rates of groundwater movement in the Lower Aquifer are estimated to range from 0.025 ft/day to 0.53 ft/day (Montgomery Watson, 1995).

Based on similarities in groundwater elevations, the Lower Aquifer appears to be in hydraulic communication with the Mojave River aquifer that occupies the river channel sediments east of the Base. Historical pump-test data (Radian, 1989) indicate a hydraulic conductivity of 573 ft/day for the Mojave River sediments. The relationship between the Lower Aquifer and regional groundwater to the north, west, and south of George AFB is not well understood. However, groundwater elevation data suggest that the Lower Aquifer may be hydraulically related to the regional groundwater system southwest of the Base.

2.3 Nature and Extent of Contamination

2.3.1 OU1

The primary chemicals of concern in groundwater at George AFB OU1 are volatile organic compounds (VOCs). The results of previous investigations indicate that tetrachloroethene (PCE), TCE, chloroform, and methylene chloride are present in groundwater within the Upper and Lower Aquifer systems at concentrations that exceed currently established regulatory levels.

TCE is the most widespread contaminant of concern. Other chemicals, some of which occur in groundwater at concentrations above regulatory levels, do not extend significant distances downgradient from possible source areas (Montgomery Watson, 1998a). TCE has been detected in groundwater in the Upper Aquifer beneath the NEDA, and in the Lower Aquifer northeast of the probable edge of the aquitard, where the two waterbearing units are thought to merge (Figure 2.3). TCE was detected in groundwater samples collected from the Upper Aquifer in October 1998 at concentrations ranging from below detection limits in wells near the new percolation ponds, to 381 micrograms per liter (µg/L) in the sample from well NZ-11, located approximately 3,500 feet northeast of the new percolation ponds and near extraction well EW-13. Northeast of the boundary of George AFB near the edge of the bluff, the aquitard is thought to thin and pinch out, and groundwater of the Upper and Lower Aquifer systems commingles (Figure 2.3). Groundwater moving northeast in the Upper Aquifer, past the edge of the aquitard, is thought to mix with water in the deeper, regional system. TCE dissolved in groundwater of the Upper Aquifer thereby migrates into the Lower Aquifer (Parsons, 1999). The highest concentration of TCE in groundwater from the Lower Aquifer (23 µg/L) was detected in samples collected in October 1998 at the northern end of the plume near monitoring well NZ-73 (Montgomery Watson, 1998b). Thus, VOCs originating at on-Base sources have migrated in groundwater past the northern Base boundary into saturated alluvial deposits that border the Mojave River northeast of George AFB (Parsons, 1999).

2.3.2 OU3

It was determined that there are a total of eight sites (DP-03, DP-04, LF-12, LF-14, FT-19a, OT-51, OT-69, and the southeast disposal area) that have impacted or have the potential to impact groundwater (Montgomery Watson, 1998c). These eight sites and associated contaminants are summarized below.

- Site DP-03 was a suspected waste acid and oil disposal site located north of the northeast end of the crosswind/secondary runway. During RI activities, lead and pyrene were detected at concentrations above established Regulatory limits (Montgomery Watson, 2001a).
- Site DP-04 was a reported pesticide and oil burial site located in close proximity to DP-03. During RI activities, lead, mercury, and zinc were detected above background concentrations and total petroleum hydrocarbons (TPH), aroclor, 4,4-dichloro-diphenol-trichloroethene (DDE), and 4,4-dichloro-diphenyl-trichloroethane (DDT) were detected above established regulatory limits (Montgomery Watson, 2001a).
- Site LF-12 is a landfill located north of base housing that reportedly received all base waste between 1953 and 1957, trash and rubble in the 1960s-1970s, and street sweeping debris in the 1980s (Montgomery Watson, 2001a). During RI activities the only contaminant detected above background concentrations was octachlorodibenzo-p-dioxin (OCCD) (Montgomery Watson, 2001).
- Site LF-14 is a base landfill that accepted municipal and industrial wastes between 1970 and 1976 (Montgomery Watson, 2001a). During RI activities, chrysene, pyrene, TPH, dieldrin, DDE, and DDT were detected above established regulatory limits (Montgomery Watson, 2001).
- Sites FT-19a, b, and c were a series of small fire training areas located north of the crosswind/secondary runway. During RI activities, TPH, TCE, benzene, ethylbenzene, toluene, and total xylenes (BTEX) were detected above established regulatory limits (Montgomery Watson, 2001a).

- Site OT-51 was an engine test cell facility which included five separate test cells located in the western portion of the base (Montgomery Watson, 2001). During RI investigations an underground storage tank (UST) was removed and TPH and BTEX constituents were detected above established regulatory limits (Montgomery Watson, 2001a).
- The Southeast Disposal Area consists of a total of nine adjacent and overlapping IRP sites. These sites were primarily used as disposal areas and occupy about 60 acres south of Air Base Road. During investigations conducted in these areas cesium (in the form of a 28-gram source), TPH, DDE, and OCDD were detected at concentrations above established regulatory limits (Montgomery Watson, 2001a).

2.4 Current Basewide Groundwater Monitoring Program

The current BGMP is being performed to meet regulatory requirements at OU1, OU2, and OU3 at George AFB. These sites are being monitored to assess potential migration of contaminant plumes. Sampling events are performed semi-annually (approximately 171 wells are included in the October 2001 event). The Base monitoring wells are sampled in accordance with the *Final Basewide Sampling and Analysis Plan* (HydroGeoLogic, 1998), and the *Sampling and Analysis Plan Addendum to the Basewide Quality Program Plan October, 2001 Event.* (Montgomery Watson, 2001b).

3.0 SCOPE OF PDBS DEMONSTRATION

An estimated total of 187 PDBSs will be installed in 34 monitoring wells located in OU1 and OU3 at George AFB as part of this project. The 34 monitoring wells have been chosen based on the presence of VOCs in groundwater during the April 2000 and April 2001 groundwater sampling events. The monitoring wells that will be sampled during this PDBS demonstration are summarized in Table 3.1, and their locations are shown on Figure 3.1.

3.1 Field Activities

Monitoring wells selected for VOC sampling using the PDBS technique (Table 3.1) were chosen from the list of monitoring wells targeted for sampling by Montgomery Watson scheduled to begin on October 15, 2001. Monitoring wells were selected based primarily on VOC concentrations detected during previous sampling events, on the presence or absence of a dedicated pump, and the hydrogeologic conditions at each site. The selected wells are those that have had detectable concentrations of VOCs at or above regulatory limits, and that do not contain dedicated pumps.

PDBSs deployed during this investigation will be installed and retrieved in general accordance with the diffusion sampler installation and recovery standard operating procedures presented in Appendix B of the AFBCA PDBS Project Work Plan (Parsons, 2001). PDBSs will be installed throughout the screened interval of each well (i.e., 1 PDBS per 3 feet of saturated screen) to obtain a vertical profile of contaminant concentrations. The PDBSs will be collected prior to the October 2001 Montgomery Watson sampling event. Analysis of the vertical profiling samples is discussed in Section 3.2.

TABLE 3.1
SAMPLING LOCATION SUMMARY
PASSIVE DIFFUSION BAG SAMPLER DEMONSTRATION
GEORGE AFB, CALIFORNIA

Well Number	Primary/ Alternate (P/A)	Total Depth (ft)[a/]	Well Diameter (in)[a/]	Screened Interval (ft Below TOC)[b/]			Approximate Water Level Range (ft below TOC)[b/]			Average Depth to Water (ft below TOC)[b/]	Dedicated Pump yes/no (Y/N)	Estimated Number of PDBSs	Primary COC - April 2001 Contaminant Concentration (ug/L)[c/]	Comments/Sampling Rationale
Upper Aquifer Wells														
OU1-MW-102	P	175.00	4	155.00	-	175.00	121.35	-	134.63	127.99	N	6	TCE (3.4)	PCE and BTEX are also present at low concentrations
FT-01	P	169.50	4	130.00	-	169.50	105.35	-	122.95	114.15	N	13	TCE (2.9)	
FT-03	P	169.00	4	134.00	-	169.00	104.92	-	119.81	112.37	N	11	TCE (6.2)	PCE and MTBE are present at low concentrations
FT-05	P	127.00	4	117.00	-	127.00	94.57	-	122.08	108.33	N	3	TCE (116.0)	Chloroform present at 6.2 ug/L
MW-01	P	191.80	4	NA	-	NA	118.71	-	140.44	129.58	N	6	Xylenes (14.6)	Toluene at 6.3 ug/L. Assume a 20 foot screen length
NZ-06	P	158.00	4	138.00	-	158.00	105.50	-	118.19	111.85	N	6	TCE (4.0)	
NZ-11	P	145.00	4	115.00	-	145.00	108.15	-	117.94	113.05	N	10	TCE (220.0)	cis-1,2-diclhoroethylene present at 6.8 ug/L
NZ-12	P	150.00	4	120.00	-	150.00	101.94	-	115.34	108.64	N	10	TCE (79.5)	
NZ-18	P	132.00	4	122.00	-	132.00	105.47	-	122.51	113.99	N	3	TCE (6.7) in April, 2000	
NZ-22	P	141.00	4	131.00	-	141.00	89.62	-	102.78	96.20	N	3	TCE (18.5)	
NZ-23	P	145.00	4	135.00	-	145.00	108.46	-	122.10	115.28	N	3	TCE (74.2) in April, 2000	
NZ-25	P	125.00	4	110	-	120.00	92.01	-	100.07	96.04	N	3	TCE (73.3)	
NZ-27	P	87.00	4	77.00	-	87.00	61.52	-	82.94	72.23	N	3	TCE (122.0) in April, 2000	
NZ-28A	P	92.20	4	NA	-	NA	59.05	-	65.30	62.18	N	3	TCE (57.9)	assume 10 foot screen length
NZ-35	P	115.00	4	105.00	-	115.00	81.80	-	97.22	89.51	N	3	TCE (12.6)	
NZ-36	P	130.00	4	120.00	-	130.00	106.96	-	109.95	108.46	N	3	TCE (22.4)	
NZ-39	P	141.00	4	116.00	-	136.00	108.00	-	112.86	110.43	N	6	TCE (46.3)	
NZ-55	P	128.40	4	108.00	-	128.00	102.45	-	116.77	109.61	N	6	TCE (395.0)	
NZ-56	P	131.50	4	111.00	-	131.00	112.40	-	120.18	116.29	N	6	TCE (87.7)	
NZ-67	P	88.30	4	65.00	-	85.00	67.10	-	74.61	70.86	N	6	TCE (337)	cis-1,2-diclhoroethylene present at 12.4 ug/L
NZ-81	P	158.00	5	143.00	-	158.00	NA	-	NA	NA	N	5	TCE (6.4)	Newly installed July, 2000
NZ-82	P	123.00	5	107.00	-	122.00	NA	-	NA	NA	N	5	TCE (231.0)	Newly installed July, 2000
NZ-83	P	124.50	5	114.00	-	124.00	NA	-	NA	NA	N	3	TCE (392.0)	Newly installed July, 2000
NZ-84	P	257.00	5	241.00	-	256.00	NA	-	NA	NA	N	5	TCE (5.7)	Newly installed July, 2000
NZ-85	P	205.50	5	190.00	-	205.00	NA	-	NA	NA	N	5	TCE (2.2)	Newly installed July, 2000
Lower Aguifer Wells														
RZ-02	P	333.20	4	310.00	-	330.00	258.72	-	260.38	259.55	N	6	None	Background location
NZ-13	P	185.00	4	155	-	185.00	162.06	-	164.65	163.36	N	10	TCE (2.3)	
NZ-29	P	187.00	4	177.00	-	187.00	167.50	-	171.43	169.47	N	3	TCE (2.1)	
NZ-37	P	142.00	4	132.00	-	142.00	125.04	-	129.99	127.52	N	3	TCE (19.2)	
NZ-41	P	125.00	4	110.00	-	125.00	85.19	-	100.03	92.61	N	5	Toluene (11.8), Xylenes (41.3)	TCE is present at 4.1 ug/L, benzene and ethylbenzene are present at low concentrations.
NZ-48	P	160.00	4	140.00	-	160.00	126.68	-	131.96	129.32	N	6	TCE (5.8)	
NZ-70	P	156.00	4	135.00	-	155.00	141.80	-	144.71	143.26	N	6	TCE (15.3)	
NZ-73	P	114.00	4	94.00	-	114.00	98.40	-	102.51	100.46	N	6	TCE (9.0)	
NZ-80	P	278.00	4	258.00	-	278.00	236.75	-	264.05	250.40	N	6	TCE (1.9)	PCE present at 1.2 ug/L

Notes:

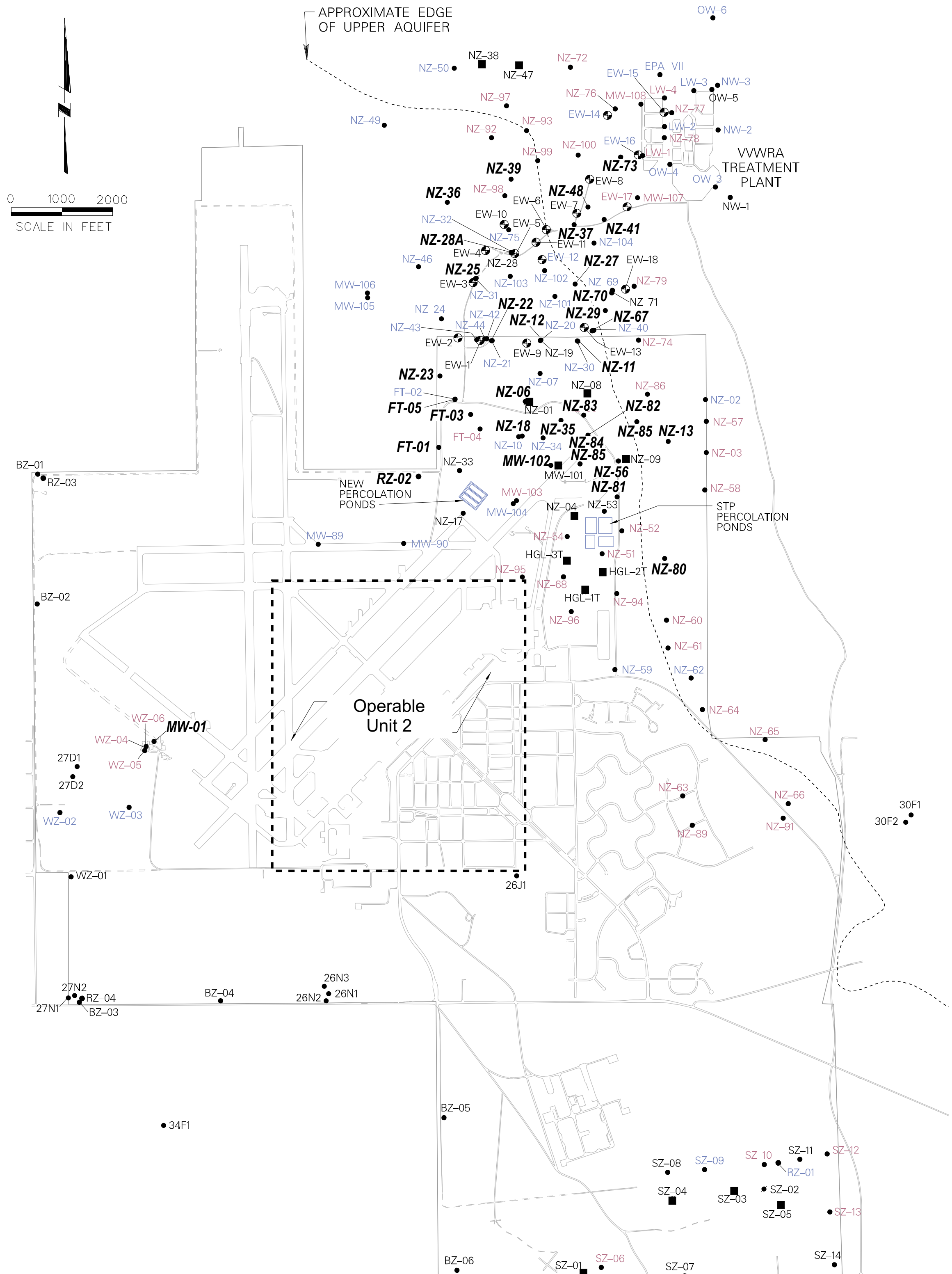
TCE = Trichloroethene; PCE = Tetrachloroethene; MTBE = Methyl tert butyl ether

[a/] ft = feet; in = inches.

[b/] TOC = top of casing.

[c/] ug/L = micrograms per liter.

[d/] NA = data is not available.



Legend

- EXTRACTION WELLS
- EXISTING MONITORING WELLS
- ABANDONED MONITORING WELLS
- BASE BOUNDARY
- ***MW-01*** PROPOSED PDBS LOCATIONS

FIGURE 3.1

PROPOSED PDBS WELL LOCATIONS

Passive Diffusion Bag Sampler Demonstration
George AFB, California

PARSONS
Denver, Colorado

Source: Montgomery Watson, 1998a.

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Sample aliquots from PDBSs installed in the 34 existing wells targeted for sampling will be shipped to Applied Physics and Chemistry Laboratory (APCL) of Chino, California for VOC analysis using US Environmental Protection Agency (USEPA) Method 8260B. This is the same laboratory that will be used by Montgomery Watson during their conventional sampling of the same wells. Field quality control samples will be collected at the following frequencies:

- 10 percent field duplicates;
- 5 percent matrix spikes and matrix spike duplicates;
- 1 pre-installation equipment rinseate;
- 1 pre-installation source water blank; and
- Approximately 4 trip blanks.

The long term monitoring program SAP for George AFB (HydroGeoLogic, 1998) and the SAP addendeum for the fall, 2001 LTM event (Montgomery Watson, 2001b) will be adopted as the site specific SAP for the PDBS demonstration where appropriate. The Methods and procedures specific to the PDBSs from the AFBCA Program SAP (Parsons, 2001) will be adhered to during all PDBS related activities at George AFB.

3.2 Contaminant Profiling

Per the project work plan (Parsons, 2001), contaminant profiling within the screened intervals of the BGMP wells is intended to be conducted using field-screening methods. The sample interval from each well that was installed closest to the conventional sampling pump depth will be submitted to APCL for VOC analysis.

Field-screening will be performed using direct sampling ion trap mass spectrometry (DSITMS) technology via USEPA SW846 Method 8265. DSITMS is an innovative technology for determining the presence or absence and measuring the concentration of VOC's and in air, water and soil. DSITMS introduces sample materials directly into an ion trap mass spectrometer by means of a very simple interface such as a capillary restriction or a polymer membrane. There is very little, if any, sample preparation and no chromatographic separation of the sample constituents meaning that the response to the analytes or contaminants in a sample is instantaneous. Field quality control samples for the mobil laboratory analyses will be collected at the following frequencies:

- 5 percent field duplicates, and
- 2 field blanks.

All samples will be analyzed in the field using a field-ready DSITMS by Tri-Corders Environmental, Inc. (McLean, VA).

3.3 Analytical Results Comparison/Evaluation

Analytical results for groundwater samples collected using the PDBSs will be compared with those results obtained from conventional sampling, and the results will be evaluated. Typically, if maximum concentrations from the PDBSs are higher than concentrations in samples collected using the conventional method, it is probable that the concentrations from the PDBSs are more representative of ambient groundwater chemistry conditions than are the conventional-sampling data (Vroblesky, 2001). If, however, the conventional method produces VOC results that are higher by a predetermined amount than the concentrations reported for the PDBS, then the PDBS may not adequately represent local ambient groundwater conditions. In this case, the difference may be due to a variety of factors, including hydraulic and chemical heterogeneity within the saturated screened interval of the well, vertical flow of groundwater within the well, and/or the relative permeability of the well screen with respect to the surrounding aquifer matrix (Vroblesky, 2001).

Considering the above guidance, if the maximum analytical result obtained using the PDBS is greater than or equal to the conventional sampling result, it will indicate that the PDBS method is appropriate for use in that particular well and no further comparison of results will be performed. However, if the maximum PDBS result is less than the conventional sampling result, further comparison of the two sets of results will be undertaken. In this instance, analytical results for samples collected using the diffusion samplers will be compared to results from the conventional sampling using relative-percent-difference (RPD), as defined by the following equation:

$$RPD = 100*[abs(D-C)]/[(D+C)/2]$$

Where:

abs = absolute value

D = diffusion sampler result

C = conventional sample result.

For this investigation, an RPD of less than 15 (McClellan AFB, 2000) will be considered to demonstrate good correlation between sample results. Calculated RPDs in excess of 15 will be reviewed individually in an attempt to determine the reason for the variance.

4.0 PROJECT ORGANIZATION

Addresses and telephone numbers of the George AFB PDBS management team are as follows:

Name	Title	Address	Phone/Email	Fax
Dr. Javier Santillan	AFCEE COR	AFCEE/ERT 3207 North Road Brooks AFB, TX 78235-5363	(210) 536-5207 email: javier.santillan@hqafcee.brooks.af.mil	(210) 536-4330

Name	Title	Address	Phone/Email	Fax
Mr. Rafael Vazquez	Deputy AFCEE COR	AFCEE/ERT 3207 North Road Brooks AFB, TX. 78235-5363	(210) 536-1431 email: rafael.vazquez@ hqafcee.brooks.af.mil	(210) 536-4330
Mr. Jack Sullivan	Parsons ES Program Manager	Parsons ES, Inc. 901 N.E. Loop 410 Suite 610 San Antonio, TX 78209	(210) 828-4900 email: jack.sullivan@parsons.com	(210) 828-9440
Ms. Linda Murray	Parsons ES TO/Project Manager	1700 Broadway, Suite 900 Denver, Colorado 80290	(303) 764-1904 email: linda.murray@parsons.com	(303) 831-8208
Mr. Doug Downey	Parsons ES Technical Director for PDBS	1700 Broadway, Suite 900 Denver, Colorado 80290	(303) 764-1915 email: doug.downey@parsons.com	(303) 831-8208
Mr. John Hicks	Parsons ES PDBS Task Manager	1700 Broadway, Suite 900 Denver, Colorado 80290	(303) 764-1941 email: john.hicks@parsons.com	(303) 831-8208
Mr. John Tunks	Parsons ES PDBS Deputy Task Manager	1700 Broadway, Suite 900 Denver, Colorado 80290	(303) 764-8740 email: john.tunks@parsons.com	(303) 831-8208
Mr. Daniel Griffiths	Parsons ES Site Manager	1700 Broadway, Suite 900 Denver, Colorado 80290	(303) 764-1940 email: daniel.r.griffiths@parsons.com	(303) 831-8208
Mr. Bradley P. Varhol	PDBS Vendor	EON Products, Inc. P.O. Box 390246 Snellville, GA 30039	(800) 474-2490 web site: www.eonpro.com email: sales@eonpro.com	(770) 978-8661
Mr. Anthony Wong	Primary AFBCA Point of Contact	AFBCA/DM 3411 Olson Street, Room 105 McClellan, CA 95652	(916) 364-4009 alt. (916) 643-6420 alt. (916) 643-1165 email: awong@afbda1.hq.af.mil	(916) 643-0460 alt. (916) 364-4013
Mr. Chip Poalinelli	Montgomery Watson Point of Contact	1340 Treat Blvd., Suite 300 Walnut Creek, CA 94596	(925) 975-3437 email: chip.paolinelli@mw.com	(925) 975-3412

Name	Title	Address	Phone/Email	Fax
Dan Dishner	Applied Physics and Chemistry Laboratory (APCL)	13760 Magnolia Ave. Chino, CA 90710	(909) 590-1828 extension 203 email:	909-590-1498
Kent Mull	Tricorders Point of Contact	1800 Old Meadow Rd. Suite, 102 Mclean, VA 22102	1-800-770-5557 cell: 571-278-0413 email: ekmull@tri-corders.com	703-448-1010

5.0 SCHEDULE

Work performed as part of this demonstration at George AFB will be completed according to the schedule summarized below.

- Submittal of the Draft George AFB PDBS Work Plan to commenting parties: August 24, 2001
- Receipt of Draft George AFB PDBS Work Plan Comments: September 5, 2001
- Submittal of the Final George AFB PDBS Work Plan to commenting parties: September 19, 2001
- Install PDBS samplers at George AFB: September 24-27, 2001
- Retrieve PDBS samplers from George AFB: October 15-17, 2001
- Preparation of the Draft George AFB PDBS Report: January 1 - February 1, 2001.

6.0 REPORTING

The site-specific results report will provide a map and accompanying table identifying the location and depth for each PDBS sample collected. Analytical results collected as part of this study will be compared to conventional-sampling analytical results collected by Montgomery Watson in a scientifically defensible manner using statistical analyses. The results of the statistical comparisons will be presented in a clear and logical manner in the results report. Statistical methods will include calculation of RPDs between PDBS and conventional sampling results, and possibly parametric or non-parametric analysis of variance (ANOVA) tests.

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Vroblesky, D.A., 2001. *User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells*. US Geological Survey Water-Resources Investigations Report 01-4060. Columbia, South Carolina.

APPENDIX A

HEALTH AND SAFETY PLAN ADDENDUM

ADDENDUM TO THE PROGRAM HEALTH AND SAFETY PLAN FOR THE EVALUATION OF PASSIVE DIFFUSION BAG SAMPLERS (PDBS)

AT

GEORGE AIR FORCE BASE
VICTORVILLE, CALIFORNIA

August 2001

Prepared by

PARSONS ENGINEERING SCIENCE, INC.
1700 Broadway, Suite 900
Denver, Colorado 80290

Reviewed and Approved By:

	Name	Date
Project Manager	John R. Hicks	8/23/01
Office Health and Safety Representative	JABlakemore for Timothy S. Mustard	08.23.01

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1.0 INTRODUCTION

This addendum modifies the existing program health and safety plan entitled *Program Health and Safety Plan for the Evaluation of Passive Diffusion Bag Samplers (PDBSs)* (Parsons Engineering Science, Inc., [Parsons] 2001) for the evaluation of the use of PDBSs in existing groundwater monitoring programs at selected Department of Defense installations across the United States. This work is being performed under contract number F41624-00-D-8024 Task Order 0024, Air Force Center for Environmental Excellence (AFCEE), Brooks Air Force Base.

This addendum to the program health and safety plan was prepared to address the upcoming tasks at George Air Force Base (AFB) in California. Included or referenced in this addendum are the scope of services, site specific description and history, project team organization, hazard evaluation of physical hazards and of known or suspected chemicals, and emergency response information. All other applicable portions of the program health and safety plan remain in effect.

2.0 SCOPE OF SERVICES

Site activities will involve the placement of a water-filled diffusive membrane capsule in a well installation device at a specific depth in an existing groundwater monitoring well. The wells are located in various areas throughout the base. After a specified period of time, the water in the sampler is transferred to a sample container and submitted for laboratory analysis. No drilling or ground-intrusive activities are anticipated under the current scope of work.

3.0 SITE SPECIFIC DESCRIPTION HISTORY

The descriptions, history, and maps for the various sites are contained in the work plan entitled *Work Plan for a Passive Diffusion Bag Sampler Demonstration, George Air Force Base* (Parsons, 2001).

4.0 PROJECT TEAM ORGANIZATION

The project team assigned to the PDBS demonstration activities at Buckley AFB is identified in the program health and safety plan. The following personnel will also be involved in this project.

Ms. Linda Murray	Project Manager
Mr. John Hicks	Task Manager
Mr. Dan Griffiths	Site Manager
Mr. Randy Brand	Alternate Site Manager
Mr. Dennis Mahafie	Site Health and Safety Officer
Messrs. Chris Spitzer, Jason Gross, Jason Bidgood, Ms. Lynette Lamenskie	Alternate Site Health and Safety Officers
Mr. Chip Paolinelli (Montgomery Watson)	George AFB Site Contact

5.0 HAZARD EVALUATION

5.1 Chemical Hazards

The primary contaminants of concern at the various sites are chlorinated solvents including trichloroethene (TCE), 1,1-dichlorethane (1,1-DCA), 1,1-dichloroethene (1,1-DCE), 1,2-DCE, methylene chloride, and chloroform, and the volatile hydrocarbon constituents benzene, toluene, and xylenes. Health hazard qualities for these and other compounds are presented in Table 5.1 at the end of this addendum. If other contaminants are found to exist at the site, this addendum will be modified to include the necessary information that will then be communicated to the onsite personnel.

5.2 Physical Hazards

Potential physical hazards at George AFB include hazards associated motor vehicles; slip, trip, and fall hazards; noise; and heat exposure. These hazards are discussed in the program health and safety plan.

6.0 EMERGENCY RESPONSE PLAN

6.1 Emergency Contacts

In the event of any emergency situation or unplanned occurrence requiring assistance, the appropriate contacts should be made from the list below. A list of emergency contacts must be posted at the site.

Contingency Contacts	**Telephone Number**
Site/Medical Emergency	911
George AFB Security	911
Site Contact: Chip Paolinelli	(925) 975-3412

Medical Emergency (on-base facility for minor care)

Base Clinic	St. Mary's Regional Medical Center
Address	11424 Crippen Avenue Adelanto, CA 92301
Telephone Number	911 or (760) 246-6670
Ambulance	911

Directions to the Hospital:

Exit the Base at South Perimeter Road. Turn right (west), and the road becomes Bartlet Avenue. Turn right (north) onto Adelanto Road. Turn left (west) onto Crippen Avenue, and proceed to the hospital.

Parsons ES Contacts	Telephone Number
Linda Murray Project Manager	(303) 831-8100 or 764-1904 (Work) (303) 279-9129 (Home)
John Hicks Task Manager	(303) 831-8100 or 764-1941 (Work) (303) 279-3698 (Home)
Tim Mustard, CIH Program Health and Safety Manager	(303) 831-8100 or 764-8810 (Work) (303) 450-9778 (Home)
Ed Grunwald, CIH Corporate Health and Safety Manager	(678) 969-2394 (Work) (404) 299-9970 (Home)
Judy Blakemore Assistant Program Health and Safety Manager	(303) 831-8100 or 764-8861 (Work) (303) 828-4028 (Home) (303) 817-9743 (Mobile)

7.0 LEVELS OF PROTECTION AND PERSONAL PROTECTIVE EQUIPMENT REQUIRED FOR SITE ACTIVITIES

The personal protection level prescribed for field activities at George AFB is Occupational Safety and Health Administration (OSHA) Level D with a contingency for the use of OSHA Level C or B, as site conditions require. The flow chart presented in Figure 7.1 of the program health and safety plan and this addendum will be used to select respiratory protection with the following comments and additions.

Since there is no Dräger® tube for 1,1-DCE, the following will occur. If sustained air monitoring readings in the worker breathing zone indicate vapor concentrations greater than or equal to 1 part per million (ppm) above background for 30 seconds or longer, the field crew will be forced to evacuate and ventilate the area until readings are less than 1 ppm in the worker breathing zone. If ventilation is inadequate, air samples will be taken to confirm or deny the existence of the contaminants of concern and/or the crew will upgrade to Level B respiratory protection. These air samples will be sent to a lab to be analyzed by US Environmental Protection Agency (USEPA) Compendium Method TO-14 or the equivalent. Method TO-14 will also analyze for the other volatile contaminants of concern at the site as listed in Table 5.1 of this addendum.

If 1,1-DCE is found to exist in the worker-breathing zone at concentrations above 1 ppm above background, additional work must be performed in OSHA Level B personal protective equipment (PPE) due to the inadequate warning properties of the compounds. If other volatile compounds listed in Table 5.1 are present as indicated by the TO-14 analytical results, the following will be used to check for the additional compounds.

A reading of 2 ppm above background in the worker-breathing zone will require the use of Dräger® tubes or the equivalent to determine if chloroform is present. Level B protection must also be used if concentrations of chloroform meet or exceed 2 ppm above background in the worker-breathing zone.

If the above compounds are not present, and field activities continue with Level D protection, a reading of 5 part per million (ppm) above background in the worker breathing zone as indicated by the photoionization detector will require the use of a

Dräger® tube or the equivalent to determine if benzene is present at a concentration greater than or equal to the PEL of 1 ppm. The flow chart presented in Figure 7.1 and appropriate text in the Program Health and Safety Plan (HASP) then will be used to select respiratory protection against volatile hydrocarbon constituents.

If sustained air-monitoring readings in the worker-breathing zone persist at or above 25 ppm, Dräger® tubes or the equivalent must be used to confirm or deny the presence of tetrachloroethene (PCE) and/or methylene chloride. Due to the inadequate warning properties of both compounds, Level B protection must be used if concentrations of PCE and/or methylene chloride exceed 25 ppm above background in the worker-breathing zone.

If PCE and/or methylene chloride are/is not present, continue to monitor the air in the worker-breathing zone. If concentrations in the worker-breathing zone persist above 25 ppm above background as indicated by the PID, periodic use of the PCE and methylene chloride Dräger® tubes must be used to confirm the absence of the compounds.

If the PID indicates concentrations at or above 50 ppm above background in the worker-breathing zone, the screening process must be repeated with trichloroethene (TCE) Dräger® tubes to confirm or deny the presence of TCE.

Section 7 of the Program HASP contains guidelines for selection of PPE. PPE will be required when handling contaminated samples and when working with potentially contaminated materials. See Page 7-4 of the HASP for PPE to be used.

8.0 FREQUENCY AND TYPES OF AIR MONITORING

A photoionization detector (PID) with an 11.7 electron volts (eV) (HNU®) or equivalent lamp will be used for air monitoring during this project since the ionization potentials of the contaminants of concern are below 11.7 eV.

TABLE 5.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN

Compound	PEL [a] (ppm)	TLV [b] (ppm)	IDLH [c] (ppm)	Odor Threshold[d] (ppm)	Ionization Potential[/] (eV)	Physical Description/Health Effects/Symptoms
Benzene	1 (29 CFR 1910.1028) [f]	0.5 (skin) [g]	500	4.7	9.24	Colorless to light-yellow liquid (solid<42°F) with an aromatic odor. Eye, nose, skin, and respiratory system irritant. Causes giddiness, headaches, nausea, staggered gait, fatigue, anorexia, exhaustion, dermatitis, bone marrow depression, and leukemia. Mutagen, experimental teratogen, and carcinogen.
Chloroethane (Ethyl Chloride)	1,000	100 (skin)	3,800	NA [h]	10.97	Colorless gas or liquid (<54°F) with a pungent, ether-like odor and burning taste. Irritates eyes, skin, and mucous membranes. Causes incoordination, drunkenness, stomach cramps, cardiac arrhythmia, cardia arrest, and liver and kidney damage.
Chloroform (Trichloromethane)	2	10	500	205 [i]	11.42	Colorless, heavy liquid with pleasant odor. Irritates eyes and skin. Anesthetic. Causes dizziness, mental dullness, nausea, confusion, headache, fatigue, anesthesia, and enlarged liver. Also attacks kidneys and heart. In animals, causes liver and kidney cancer. Mutagen, experimental teratogen, and carcinogen.
1-Chlorohexane	NA	NA	NA	NA	NA	Colorless liquid with an ether-like odor. Irritates eyes, skin, mucous mer and respiratory system. Causes conjunctivitis, corneal damage, dermatiti cyanosis of the extremities, nausea, vomiting, diarrhea, CNS depression, dizziness, pulmonary edema, suffocation, burning sensation in chest, and liver and kidneys.
1,1-Dichloroethane (DCA)	100	100	3,000	120	11.06	Colorless, oily liquid with chloroform-like odor and hot saccharine taste. Irritates skin. Causes CNS depression and kidney, lung, and liver damag Experimental teratogen and questionable carcinogen.
1,1-Dichloroethene (DCE) (Vinylidene Chloride)	1	5	NA	NA	10.00	Colorless liquid or gas (>89°F) with a mild, sweet, chloroform-like odor. Irritates eyes, skin, and throat. Causes dizziness, headaches, nausea, shortness of breath, liver and kidney dysfunctions, and lung inflammatior Mutagen and carcinogen.
1,2-Dichloroethene (DCE) (cis- and trans-isomers)	200	200	1,000	0.085-500	9.65	Colorless liquid (usually a mixture of cis- and trans- isomers), with a slightly acrid, chloroform-like odor. Irritates eyes and respiratory system. CNS depressant. Cis- isomer is a mutagen.
Methylene Chloride (Dichloromethane, Methylene Dichloride)	25	50	2,300	25-320	11.32	Colorless liquid (gas>104°F) with a sweet, chloroform-like odor (not noticeable at dangerous concentrations). Irritates eyes and skin. Causes nausea, vomiting, fatigue, weakness, unnatural drowsiness, light-headedness, numbness, tingling limbs, and nausea. In animals, causes lung, liver, salivary and mammary gland tumors. Mutagen, experimental teratogen, and carcinogen.
Perchlorethylene	25 [j]	25	150	5-50	9.32	Colorless liquid with a mild chloroform odor. Eye, nose, skin and

TABLE 5.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN

Compound	PEL [a/] (ppm)	TLV [b/] (ppm)	IDLH [c/] (ppm)	Odor Threshold[d/] (ppm)	Ionization Potential[/] (eV)	Physical Description/Health Effects/Symptoms
(Tetrachloroethene or PCE)						throat irritant. Causes nausea, flushed face and neck, vertigo, dizziness, headaches, hallucinations, incoordination, drowsiness, coma, pulmonary changes, and skin redness. Cumulative liver, kidney, and CNS damage. In animals, causes liver tumors. Mutagen, experimental teratogen, and carcinogen.
Toluene	100	50 (skin)	500	0.2-40 [i/]	8.82	Colorless liquid with sweet, pungent, benzene-like odor. Irritates eyes and nose. Causes fatigue, weakness, dizziness, headaches, hallucinations or distorted perceptions, confusion, euphoria, dilated pupils, nervousness, tearing, muscle fatigue, insomnia, skin tingling, dermatitis, bone marrow changes, and liver and kidney damage. Mutagen and experimental teratogen.
Trichloroethene (TCE)	50	50	1,000	21.4-400	9.45	Clear, colorless or blue liquid with chloroform-like odor. Irritates skin and eyes. Causes fatigue, giddiness, headaches, vertigo, visual disturbances, tremors, nausea, vomiting, drowsiness, dermatitis, skin tingling, cardiac arrhythmia, and liver injury. In animals, causes liver anc kidney cancer. Mutagen, experimental teratogen, and carcinogen.
Xylene (o-, m-, and p-isomers)	100	100	900	0.05-200 [i/]	8.56 8.44 (p)	Colorless liquid with aromatic odor. P-isomer is a solid <56°F. Irritates eyes, skin, nose, and throat. Causes dizziness, drowsiness, staggered gait, incoordination, irritability, excitement, corneal irregularities, conjunctivitis, dermatitis, anorexia, nausea, vomiting, abdominal pain, and olfactory and pulmonary changes. Also targets blood, liver, and kidneys. Mutagen and experimental teratogen.

a/ PEL = Permissible Exposure Limit. OSHA-enforced average air concentration to which a worker may be exposed for an 8-hour workday without harm. Expressed as parts per million (ppm) unless noted otherwise. PELs are published in the *NIOSH Pocket Guide to Chemical Hazards*, 1997. Some states (such as California) may have more restrictive PELs. Check state regulations.
b/ TLV = Threshold Limit Value - Time-Weighted Average. Average air concentration (same definition as PEL, above) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH), *TVLs® and BEIs®* (2001).
c/ IDLH = Immediately Dangerous to Life or Health. Air concentration at which an unprotected worker can escape without debilitating injury or health effects. Expressed as ppm unless noted otherwise. IDLH values are published in the *NIOSH Pocket Guide to Chemical Hazards*, 1997.
d/ When a range is given, use the highest concentration.
e/ Ionization Potential, measured in electron volts (eV), used to determine if field air monitoring equipment can detect substance. Values are published in the *NIOSH Pocket Guide to Chemical Hazards*, June 1997.
f/ Refer to expanded rules for this compound.
g/ (skin) = Refers to the potential contribution to the overall exposure by the cutaneous route.
h/ NA = Not available.
i/ Olfactory fatigue has been reported for the compound and odor may not serve as an adequate warning property.
j/ NIOSH recommends reducing exposure to the lowest feasible concentration, and limiting the number of workers exposed.

APPENDIX B

HISTORIC SITE DATA