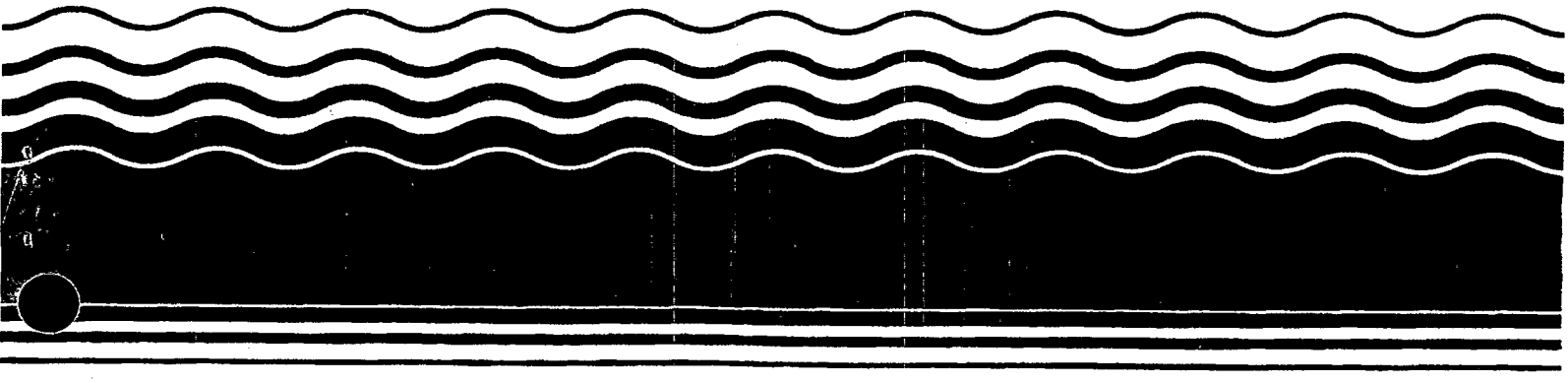
PB99-964502
EPA541-R99-042
1999

EPA Superfund
Record of Decision:

Travis Air Force Base
West/Annexes/Basewide OU (WABOU)
Solano County, CA
3/16/1999



INSTALLATION RESTORATION PROGRAM

West/Annexes/Basewide Operable Unit
Travis Air Force Base

GROUNDWATER INTERIM RECORD OF DECISION FOR THE WABOU

FINAL

60th Air Mobility Wing
Travis Air Force Base, California

2808_04

24 JUNE 1999

SFUND RECORDS CTR
50825

DEPARTMENT OF THE AIR FORCE
60TH AIR MOBILITY WING (AMC)

24 June 1999

MEMORANDUM FOR DISTRIBUTION

FROM: 60 AMW/EMR
580 Hickam Avenue
Travis AFB CA 94535-2176

SUBJECT: Final West/Annexes/Basewide Operable Unit (WABOU) Groundwater Interim Record of Decision (IROD)

1. The attached package provides the change pages needed to convert the draft final WABOU Groundwater IROD into a final version. This IROD presents the Air Force's selected alternatives for the interim remediation of four WABOU groundwater sites. We are sending a complete copy of the IROD to all parties that did not receive a draft final version. We are also sending to all parties the response to EPA comments on the draft final WABOU Groundwater IROD as a separate attachment.

2. If you have any questions concerning the subject document, please contact Mr. Glenn Anderson at (707) 424-4359.

ALLEN L. BRICKEEN, P.E.
Remedial Program Manager

Attachment:
Final WABOU Groundwater IROD (package or complete copy)
Response to EPA comments on the draft final WABOU Groundwater IROD

Distribution: (See attached)

Copy No. 27

Recipient John Lucey

Agency U.S. EPA

West/Annexes/Basewide Operable Unit

Travis Air Force Base

Groundwater Interim Record of Decision for the WABOU

Final

60th Air Mobility Wing

Travis Air Force Base, California

24 June 1999

Contents

Section — Page

Acronyms List vi

Part I Declaration 1
Site Name and Location 1
Statement of Basis and Purpose 1
Assessment of the Site 1
Rationale for Interim Groundwater ROD 1
Description of the Selected Interim Remedies 2
Declaration 4

Part II Decision Summary 9
1.0 Travis AFB Description 9
1.1 Physical Description 9
1.2 Land Use 11
1.3 Ecology 12
1.4 Geology and Hydrogeology 14
1.5 Surface Water 22
2.0 Overview of Travis AFB Environmental Programs 24
2.1 Compliance Branch 24
2.2 Restoration Branch 25
2.3 Pollution Prevention Branch 30
3.0 WABOU Groundwater Remedial Investigation Summary 31
3.1 Nature and Extent of Contamination 31
3.2 Risk Assessments 34
3.3 Chemicals of Concern 35
3.4 Summary 36
4.0 Summary of WABOU Groundwater Feasibility Study 37
4.1 Initial Screening of Alternatives 37
4.2 Detailed Analysis of Alternatives 38
4.3 Comparative Analysis of Alternatives 39
4.4 Conclusion 45
5.0 Interim Groundwater Remedial Actions 46
5.1 Building 755 (DP039) 46
5.2 Landfill 3 (LF008) 50
5.3 Buildings 905 (SS041) and 916 (SD043) 52
5.4 Treatment 52
5.5 Treated Water Disposal 53
5.6 Land Use Restrictions 55
5.7 Groundwater Monitoring 55
5.8 Statutory Determinations 56
5.9 RD/RA Implementation and Schedule 57
5.10 Documentation of Significant Changes 58

Contents, Continued

Page

Section

6.0 List of Applicable or Relevant and Appropriate Requirements and Performance Standards 59
6.1 Overview 59
6.2 ARARs Identification, Development, and Evaluation 60
6.3 Determination of ARARs 61
6.4 ARARs Evaluation and Discussion 61
7.0 Works Cited 88

Part III Responsiveness Summary 90

Appendix A: Site Summary Figures

Contents, Continued

Page

Tables

1	Potential Interim Groundwater Remedial Alternatives	2
2	Selected Interim Groundwater Remedial Actions	3
1-1	Stratigraphic Column of Geologic Units at Travis AFB	16
1-2	Summary of Hydraulic Conductivity Values Derived from Aquifer Tests Conducted at Travis AFB	21
3-1	COC Concentrations and Potential Risks at WABOU Groundwater Sites	35
4-1	Interim Groundwater Remedial Alternatives	39
4-2	Summary of Comparative Analysis of Groundwater Alternatives – by Criterion Long-term Effectiveness and Permanence	42
4-3	Summary of Comparative Analysis of Groundwater Alternatives – by Criterion Reduction of Toxicity, Mobility, and Volume through Treatment	42
4-4	Summary of Comparative Analysis of Groundwater Alternatives – by Criterion Short-Term Effectiveness	43
4-5	Summary of Comparative Analysis of Groundwater Alternatives – by Criterion Implementability	44
4-6	Cost Estimates for WABOU Groundwater Remedial Alternatives	45
5-1	Interim Cleanup Goals for Groundwater COCs	53
6-1	Travis AFB-WABOU Groundwater Sites, Federal ARARs, Waste Transfer, Treatment, and Storage and Disposal Requirements	65
6-2	Travis AFB-WABOU Groundwater Sites, State ARARs, Air Remediation Requirements	69
6-3	Travis AFB-WABOU Groundwater Sites, State ARARs, Water Board Requirements	70
6-4	Travis AFB-WABOU Groundwater Sites, Federal ARARs, Requirements under the US Code and Related Regulations	72
6-5	Travis AFB-WABOU Groundwater Sites, State ARARs, Fish and Game Requirements	76
6-6	NPDES Effluent Limitations for Treated Groundwater	84
6-7	Discharge Limitations	86

Contents, Continued

Page

Tables, Continued

6-8 Effluent Treatment Levels for Beneficial Reuse, Discharges to Land for Irrigation Purposes 87

Figures

1-1 Travis AFB/Annex Location Map 10

1-2 Geologic Map of Travis AFB and Vicinity 15

1-3 Groundwater Contour Map, July 9, 1996 19

3-1 WABOU Groundwater Sites and Extent of Groundwater Contamination 32

4-1 Nine Evaluation Criteria 40

5-1 Alternative G5 – Source Area and Groundwater Extraction/Treatment/Monitored Natural Attenuation, Conceptual Design at Building 755 48

5-2 Alternative G3 – Containment/Treatment/Discharge, Conceptual Design at Building 755 49

5-3 Alternative G4 – Extraction/Treatment/Discharge, Conceptual Design at Landfill 3 51

5-4 Alternative G3 – Containment/Treatment/Discharge, Conceptual Design at Buildings 905/916 54

Acronyms List

AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
AMC	Air Mobility Command
AMW	Air Mobility Wing
ARARs	Applicable or Relevant and Appropriate Requirements
BAAQMD	Bay Area Air Quality Management District
Base	Air Force Base
bgs	below ground surface
CAL-EPA/DTSC	California Environmental Protection Agency/Department of Toxic Substances Control
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFGC	California Fish and Game Code
COC	chemical of concern
COEC	chemical of ecological concern
COPC	chemical of potential concern
CRP	Community Relations Plan
DAA	Detailed Analysis of Alternatives
DCA	dichloroethane
DCE	dichloroethene
DNAPL	dense non-aqueous phase liquid
DPE	Dual-Phase Extraction
EIOU	East Industrial Operable Unit
FFA	Federal Facility Agreement
fpm	feet per minute
FS	Feasibility Study
gpm	gallons per minute
GSAP	Groundwater Sampling and Analysis Program

HHRA	Human Health Risk Assessment
HI	Hazard Index
HWCL	California Hazardous Waste Control Law
IROD	Interim Record of Decision
IRP	Installation Restoration Program
ISA	Initial Screening of Alternatives
LGAC	liquid-phase granular activated carbon
µg/L	micrograms per liter
MAP	Management Action Plan
MCL	maximum contaminant level
MNA	Monitored Natural Attenuation
msl	mean sea level
NAAP	Natural Attenuation Assessment Plan
NCP	National Contingency Plan
NEWIOU	North/East/West Industrial Operable Unit
NOU	North Operable Unit
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List
O&M	operations and maintenance
OU	operable unit
P2 MAP	Pollution Prevention Management Action Plan
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PCG	Preliminary Cleanup Goal
PCWQCA	Porter-Cologne Water Quality Control Act
POCOS	Petroleum-only Contaminated Sites
PP	Proposed Plan
ppb	parts per billion
ppt	parts per trillion

PRG	Preliminary Remediation Goal
RA	remedial action
RAB	Restoration Advisory Board
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RD/RA	remedial design/remedial action
RI	Remedial Investigation
ROD	Record of Decision
RPM	Remedial Project Manager
SARA	Superfund Amendments and Reauthorization Act of 1986
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SIP	State Implementation Plan
SWRCB	State Water Resources Control Board
TBC	to be considered
TCA	trichloroethane
TCE	trichloroethene
TPH-d	total petroleum hydrocarbons-diesel
TPH-g	total petroleum hydrocarbons-gasoline
U.S. EPA	U.S. Environmental Protection Agency
UST	underground storage tank
VGAC	vapor-phase granular activated carbon
VOC	volatile organic compound
WABOU	West/Annexes/Basewide Operable Unit
WIOU	West Industrial Operable Unit

PART I

Declaration

Site Name and Location

Department of the Air Force
Travis Air Force Base
Fairfield, California 94535-5000

Statement of Basis and Purpose

This Interim Record of Decision (IROD) presents the interim groundwater remedial actions in the West/Annexes/Basewide Operable Unit (WABOU) at the Travis Air Force Base (AFB) Superfund site in Solano County, California. The Air Force will develop a separate WABOU Soil Record of Decision (ROD) to present the soil remedial actions in the WABOU. The Air Force selected the interim groundwater remedial actions in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) 42 USC § 9601 *et seq.*, and with the National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR Part 300 (National Contingency Plan [NCP]). The Administrative Record contains the documents used in the selection of the interim groundwater remedial actions. The Administrative Record is available for review at Travis AFB. The Travis AFB information repository also includes copies of these documents for public review and is found in the Vacaville Public Library.

The U.S. Environmental Protection Agency (U.S. EPA), Region IX, concurs with the selected interim groundwater remedies. The State of California, through the California Environmental Protection Agency's Department of Toxic Substances Control (Cal-EPA/DTSC) and the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB), concurs with the selected interim groundwater remedies.

Assessment of the Site

As a result of past industrial activities, releases of volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), and pesticides have contaminated the groundwater at four WABOU sites at Travis AFB. These sites are Building 755, Landfill 3, Building 905, and Building 916. Actual or threatened releases of hazardous substances from these sites, if not addressed by implementing the response actions selected in this Groundwater IROD, may present a potential threat to public health, welfare, or the environment.

Rationale for Interim Groundwater ROD

The Air Force has developed interim remedial actions to address groundwater contamination in the WABOU. The Air Force has prepared this groundwater IROD rather

than a final groundwater ROD in order to allow groundwater remediation to begin quickly to reduce contamination and risk. The groundwater IROD establishes an interim period to evaluate the effectiveness of the interim groundwater remedial actions and to monitor the status of each contaminant plume. The Air Force will use this data to establish final cleanup levels and select technically and economically feasible long-term actions in the final groundwater ROD. The Air Force will publish a public notice, hold a public comment period, and address the public's comments before the regulatory agencies finalize and approve the groundwater ROD. The Air Force will publish a separate Soil ROD to describe the soil remedial actions in the WABOU.

Description of the Selected Interim Remedies

The Air Force considered six potential interim remedial alternatives to address contaminated groundwater in the WABOU. Table 1 presents the potential interim groundwater remedial alternatives.

TABLE 1
Potential Interim Groundwater Remedial Alternatives

Remedial Alternative	Description
G1 - No Action	This serves as a starting point for comparing the other alternatives. No groundwater treatment takes place.
G2- Monitored Natural Attenuation	Monitored Natural Attenuation (MNA) is a groundwater treatment strategy that relies on naturally occurring processes to prevent the spread of contamination. A major part of this strategy is the destruction of contaminants into harmless byproducts by subsurface microorganisms. Groundwater monitoring is used to verify the effectiveness of this strategy.
G3 - Containment/ Treatment/Discharge	This alternative is designed to prevent the migration of the groundwater contamination. Groundwater is pumped from a series of extraction wells that are built near the leading edge of the contaminant plume. The resulting hydraulic barrier removes the contaminated groundwater before it can move past the extraction wells. The removed groundwater is treated using activated carbon and is either discharged to Union Creek or used for irrigation.
G4 - Extraction/ Treatment/Discharge	This alternative uses the extraction wells as described in alternative G3. It also places additional extraction wells in the more highly contaminated part of the plume in order to actively treat the whole plume. The removed groundwater is treated and is either discharged to Union Creek or used for irrigation.
G5 - Source Area and Groundwater Extraction/ Treatment/ Monitored Natural Attenuation	This alternative applies only to Building 755 and is divided into three parts. The first part uses a vacuum-enhanced groundwater technology, known as Dual-Phase Extraction (DPE). A DPE system uses a vacuum to draw contaminated groundwater into an extraction well and at the same time lower the local water table. Exposed pools of solvents would then evaporate, and the vacuum removes the contaminated vapors. The water and vapors are cleansed in a treatment plant. This is designed to remove the source of contamination at this site. The second part uses extraction wells in the center of the plume to remove highly contaminated groundwater. The third part uses MNA to treat the portion of the plume with lower contaminant concentrations. MNA is described in alternative G2.
G6 - Source Area Extraction/ Treatment/ Monitored Natural Attenuation	This alternative also applies only to Building 755 and is divided into three parts. The first part is the DPE system that is described above. The second part uses a reactive wall in the subsurface to treat the contaminated groundwater as it passes through the wall. The third part uses MNA technology to treat the portion of the plume with lower contaminant concentrations. MNA is described in alternative G2.

The Air Force has selected interim remedial alternatives for the four WABOU sites with groundwater contamination. Table 2 presents the selected interim groundwater remedial alternatives.

TABLE 2
Selected Interim Groundwater Remedial Actions

Site Name (Site Designation)	Selected Alternative
Building 755 (DP039)	G5 - Source Area and Groundwater Extraction/ Treatment/ Monitored Natural Attenuation, and G3 - Containment/Treatment/Discharge
Landfill 3 (LF008)	G4 - Extraction/Treatment/Discharge
Building 905 (SS041)	G3 - Containment/Treatment/Discharge
Building 916 (SD043)	G3 - Containment/Treatment/Discharge

The Air Force selected the interim remedies as the most appropriate strategies for containing, monitoring, and treating contaminated groundwater in the WABOU. These remedies address the potential risks to human health and the environment that could result from exposure to groundwater by human (e.g., workers and residents) and ecological (e.g., aquatic) receptors.

Previously the Air Force created a North/East/West Industrial Operable Unit (NEWIOU) Groundwater Remedial Design/Remedial Action (RD/RA) Plan to describe the overall rationale for treatment and discharge of extracted groundwater for all NEWIOU groundwater sites. It also included the NEWIOU RD/RA schedule and a decision matrix for selecting the treatment technologies at each NEWIOU site. The Air Force will add an addendum to this plan to include a detailed description of the treatment and discharge of extracted groundwater for the WABOU sites. The addendum will also include the WABOU RD/RA schedule. The Air Force will provide an opportunity for public participation during the Remedial Design phase.

Previously the Air Force created a Natural Attenuation Assessment Plan (NAAP) to provide the methodology used to evaluate the potential use of Monitored Natural Attenuation (MNA) at NEWIOU sites. The Air Force will add an addendum to the NAAP to include a description of the approach to be used for the evaluation of the MNA component of Alternative G5 at Building 755.

In addition to the addendum to the NEWIOU Groundwater RD/RA Plan, the Air Force will perform a pre-design investigation, as necessary, and then prepare a site-specific RD/RA work plan for each WABOU groundwater site. The purpose of the pre-design investigation is to fill existing data gaps so that the Air Force can successfully implement the remedial action at a site. Examples of data gaps may include the distribution of groundwater contamination in subsurface strata, hydrogeologic conditions that affect remedial action performance, and unusual groundwater analytical results that may indicate the presence of additional groundwater contamination sources. The site-specific RD/RA work plan will present the results of the site-specific pre-design investigation, the preliminary design information including the potential placement of extraction and monitoring wells, groundwater monitoring protocols and frequency, and procedures to determine whether plume migration is occurring. After regulatory approval of the site-specific RD/RA work

plan, the Air Force will submit the RD design package that includes drawings, specifications, and a design report. The site-specific RD/RA work plan and the RD design package are primary documents and are described in the final NEWIOU Interim Groundwater RD/RA Plan. If a contingency action is necessary to control migration, the Air Force will request funding and implement a contingency action as soon as funding becomes available.

No potential for contaminated groundwater to migrate along storm and sanitary sewer lines is indicated by a comparison of the highest measured level of the local water table with the location and depth of the local sanitary and storm sewer lines in the WABOU. However, if future data collection suggests that contaminated groundwater has migrated to an area where interaction with preferential pathways is likely, the Air Force will investigate the potential interaction during the Remedial Design (RD). If the RD investigation reveals an interaction between groundwater and a preferential pathway, then an appropriate remedial action will be proposed for the site and documented in an amendment to this Groundwater IROD

The Air Force will implement interim groundwater remedial actions as described in this WABOU Groundwater IROD. The Air Force will monitor all sites and will measure the change in contaminant concentrations. The Air Force will utilize the monitoring results to evaluate the potential for using the MNA component of Alternative G5 at Building 755. The Air Force and regulatory agencies will periodically review the analytical and performance data from these actions to verify their effectiveness and the need for additional action(s). The Air Force and regulatory agencies will hold a formal program review after the IROD is signed and after sufficient analytical and performance data has been collected. The purpose of the program review will be to determine the final basewide remedial actions and cleanup levels that are technically and economically feasible for each groundwater site at Travis AFB.

Travis AFB will eventually replace this interim ROD with a final ROD as soon as sufficient data has been collected to support the selection of a final remedy. The sites described in the final NEWIOU Groundwater IROD and the WABOU groundwater sites may be addressed in one basewide groundwater ROD if the Travis AFB Cleanup Team decides that this approach is appropriate.

Declaration

These interim groundwater remedial actions are protective of human health and the environment, are compliant with Federal and State Applicable or Relevant and Appropriate Requirements (ARARs) directly associated with these actions, and are cost-effective. These actions utilize permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable given the limited scope of the action. These actions do not constitute the final groundwater remedies for the Travis AFB WABOU sites. The Air Force and the regulatory agencies will address the statutory preference for remedies that reduce toxicity, mobility, or volume as a principal element at the time of the final basewide groundwater ROD. The Air Force will base subsequent actions on the knowledge and experience gained during the interim actions. Any future actions will fully address the principal threats posed by contaminated groundwater in the WABOU at Travis AFB.

Lead and Support Agency Acceptance
of the Interim Groundwater Record of Decision for
the WABOU, Travis Air Force Base

This signature sheet documents agreement between the United States Air Force and the United States Environmental Protection Agency and the State of California, by the California Environmental Protection Agency, Department of Toxic Substances Control, and the San Francisco Bay Regional Water Quality Control Board on the Interim Groundwater Record of Decision for the WABOU at Travis Air Force Base. The respective parties may sign this sheet in counterparts.

3/16/99
Date

Daniel D. Opalski
Chief
Federal Facilities Cleanup Branch
U.S. Environmental Protection Agency, Region IX

Date

Anthony J. Landis, P.E.
California Environmental Protection Agency
Department of Toxic Substances Control
Chief of Operations
Office of Military Facilities

Date

Loretta K. Barsamian
San Francisco Bay Regional Water Quality Control Board
Executive Officer

Date

Walter S. Hogle, Jr.
Lieutenant General, USAF
Air Mobility Command
Chairperson, Environmental Protection Committee

Lead and Support Agency Acceptance
of the Interim Groundwater Record of Decision for
the WABOU. Travis Air Force Base

This signature sheet documents agreement between the United States Air Force and the United States Environmental Protection Agency and the State of California, by the California Environmental Protection Agency, Department of Toxic Substances Control, and the San Francisco Bay Regional Water Quality Control Board on the Interim Groundwater Record of Decision for the WABOU at Travis Air Force Base. The respective parties may sign this sheet in counterparts.

Daniel D. Opalski — Date
Chief
Federal Facilities Cleanup Branch
U.S. Environmental Protection Agency, Region IX

Anthony J. Landis — 4-1-99
Anthony J. Landis, P.E. — Date
California Environmental Protection Agency
Department of Toxic Substances Control
Chief of Operations
Office of Military Facilities

Loretta K. Barsamian — Date
San Francisco Bay Regional Water Quality Control Board
Executive Officer

Walter S. Hogle, Jr. — Date
Lieutenant General, USAF
Air Mobility Command
Chairperson, Environmental Protection Committee

Lead and Support Agency Acceptance
of the Interim Groundwater Record of Decision for
the WABOU, Travis Air Force Base

This signature sheet documents the agreement between the United States Air Force, the United States Environmental Protection Agency and the State of California, by the California Environmental Protection Agency, Department of Toxic Substances Control, and the San Francisco Bay Regional Water Quality Control Board on the Interim Groundwater Record of Decision for the WABOU at Travis Air Force Base. The respective parties may sign this sheet in counterparts.

Daniel D. Opalski
Chief
Federal Facilities Cleanup Branch
U.S. Environmental Protection Agency, Region IX

Date

Anthony J. Landis, P.E.
California Environmental Protection Agency
Department of Toxic Substances Control
Chief of Operations
Office of Military Facilities

Date

Loretta K. Barsamian

June 2, 1999
Date

Loretta K. Barsamian
San Francisco Bay Regional Water Quality Control Board
Executive Officer

Walter S. Hogle, Jr.
Lieutenant General, USAF
Air Mobility Command
Chairperson, Environmental Protection Committee

Date

Lead and Support Agency Acceptance
of the Interim Groundwater Record of Decision for
the WABOU, Travis Air Force Base

This signature sheet documents agreement between the United States Air Force and the United States Environmental Protection Agency and the State of California, by the California Environmental Protection Agency, Department of Toxic Substances Control, and the San Francisco Bay Regional Water Quality Control Board on the Interim Groundwater Record of Decision for the WABOU at Travis Air Force Base. The respective parties may sign this sheet in counterparts.

Daniel D. Opalski — Date
Chief
Federal Facilities Cleanup Branch
U.S. Environmental Protection Agency, Region IX

Anthony J. Landis, P.E. — Date
California Environmental Protection Agency
Department of Toxic Substances Control
Chief of Operations
Office of Military Facilities

Loretta K. Barsamian — Date
San Francisco Bay Regional Water Quality Control Board
Executive Officer

Walter S. Hogle, Jr. — 10 MAY 1999 — Date
Lieutenant General, USAF
Air Mobility Command
Chairperson, Environmental Protection Committee

PART II

Decision Summary

The Decision Summary includes the findings, evaluations, decision-making process, and selected remedial actions for the West/Annexes/Basewide Operable Unit (WABOU) Groundwater Interim Record of Decision (IROD). Section 1.0 describes the physical and ecological setting of Travis Air Force Base (AFB). Section 2.0 provides an overview of non-Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and CERCLA environmental programs at Travis AFB. Section 3.0 summarizes the nature and extent of groundwater contamination as presented in the WABOU Remedial Investigation (RI). Section 4.0 presents the remedial alternatives that were considered and the comparison of the alternatives to the criteria set forth in the National Contingency Plan (NCP) as presented in the WABOU Feasibility Study (FS). Section 5.0 identifies the selected interim groundwater remedies and the rationale for their selection. Section 6.0 presents the applicable or relevant and appropriate requirements (ARARs) and performance standards for the interim actions. Section 7.0 is the list of references.

1.0 Travis AFB Description

Travis AFB is located midway between San Francisco and Sacramento, California, about 3 miles east of downtown Fairfield in Solano County. The Base occupies 5,025 acres. In addition, the Base maintains ownership of or administrative control over 11 annexes at offbase locations. Approximately 17,000 military and civilian personnel are present daily on the Base (Weston, 1993). Maps of the regional location of Travis AFB and annexes are presented on Figure 1-1.

Travis AFB is currently part of the Air Mobility Command (AMC) and is host to the 60th Air Mobility Wing (AMW). The AMW operates C-5 Galaxy cargo aircraft and KC-10 Extender refueling aircraft. The primary missions of Travis AFB since its establishment have been strategic reconnaissance and airlift of freight and troops.

1.1 Physical Description

Topography at Travis AFB is characterized by a gently sloping to nearly flat ground surface with variations in topographic relief of up to 50 feet. Elevations at Travis AFB range from over 100 feet above mean sea level (msl) near the northern boundary to less than 20 feet above msl near the south gate. The ground surface generally slopes to the south or southeast at about 30 feet per mile. Areas surrounding Travis AFB have a varied topography.

Within the WABOU, the ground surface elevation ranges from more than 100 feet above msl in the northwest to less than 30 feet above msl in the southern area.

The Travis AFB area climate is characterized as Mediterranean, with wet winters and dry summers. The Base is located near the Carquinez Straits, which is the major break in the Coast Range. Travis AFB usually experiences mild temperatures because of its proximity to

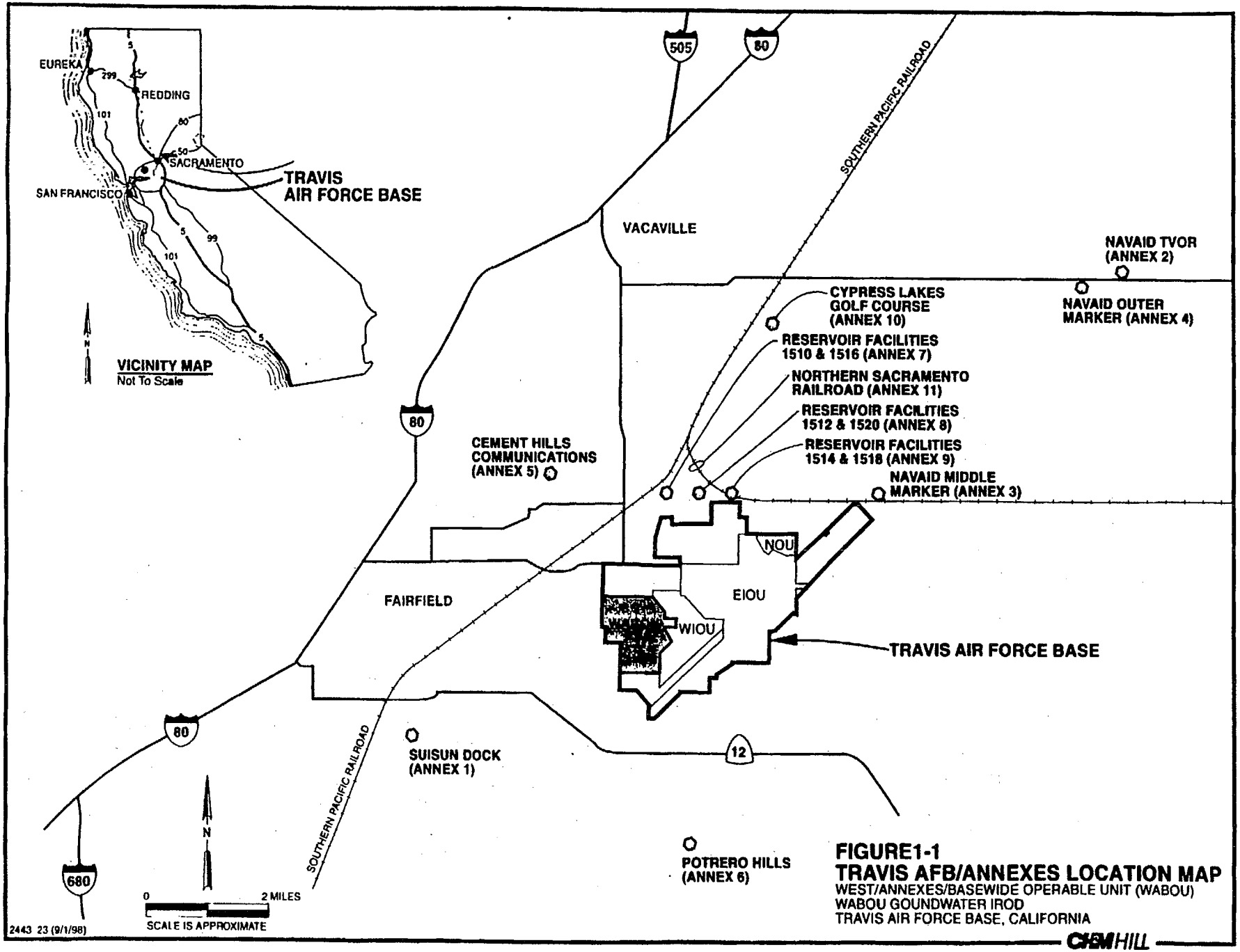


FIGURE1-1
TRAVIS AFB/ANNEXES LOCATION MAP
WEST/ANNEXES/BASEWIDE OPERABLE UNIT (WABOU)
WABOU GOUNDWATER IROD
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

the Carquinez Straits and the coast. The mean annual temperature is 60° F. The lowest temperatures occur in January, with a mean of 46° F. The highest temperatures occur in July and August, with a mean of 72° F. Monthly mean relative humidity typically ranges from a low of 50 percent during June to a high of 77 percent during January. The mean annual relative humidity is 60.5 percent.

Travis AFB averages 17.5 inches of rain annually. Approximately 84 percent of the annual precipitation occurs during the winter season of November through March. January is the wettest month, averaging 3.7 inches of precipitation; July is the driest month averaging 0.02 inch of precipitation.

Evapotranspiration ranges from about 50 to 75 inches per year. However, because most precipitation occurs in the winter, and most evaporation takes place in the summer, this apparent "net annual negative precipitation" has little impact on water infiltration through the soil column or on groundwater recharge.

Travis AFB experiences sea breezes during the summer because of its proximity to the Carquinez Straits. The average annual wind speed is 8 knots, with a winter average of 5 to 6 knots and a summer average of 12 knots. The predominant wind directions are from the southwest and west-southwest.

1.2 Land Use

Travis AFB occupies 5,025 acres of land near the center of Solano County, California, and is located approximately 3 miles east of downtown Fairfield and 8 miles south of downtown Vacaville (see Figure 1-1). Solano County's population in 1990 was 340,421 (U.S. Department of Commerce/U.S. Bureau of the Census; 1990). This population was estimated to have grown to 373,923 by 1994 (State of California, Department of Finance, 1994). During the 1980s, the population of Solano County increased nearly 45 percent (U.S. Department of Commerce/U.S. Bureau of the Census, 1990). However, the rate of growth has declined since 1990. The projected population growth between 1990 and 2000 is 47.4 percent for the City of Fairfield and 33.6 percent for Solano County overall (Association of Bay Area Governments, 1990).

According to the Travis AFB Office of Public Affairs, currently 7,750 active military personnel and 3,323 reservists are employed at Travis AFB. Approximately 5,613 people live in 3,466 onbase housing units. There are 3,006 civilians employed at Travis AFB. Approximately 17,000 people are onbase on a daily basis.

The land use areas of Travis AFB are grouped into eight functional categories:

- **Mission**—Uses are closely associated with the airfield and include facilities such as maintenance hangars and docks, avionics facilities, and other maintenance facilities. Aircraft operations facilities include control towers, Base operations, flight simulators, and other instructional facilities.

- **Administrative**—Uses include personnel, headquarters, legal, and other support functions.

- **Community**—Uses include both commercial and service activities. Examples of commercial uses include the Base Exchange, dining halls, service station, and clubs; service uses include the schools, chapel, library, and the family support center.
- **Housing**—Uses include both accompanied housing for families and unaccompanied housing for singles, temporary personnel, and visitors.
- **Base Support/Industrial**—Uses are for the storage of supplies and maintenance of Base facilities and utility systems.
- **Medical**—Uses include facilities for medical support, including the David Grant Medical Center.
- **Outdoor Recreation**—Uses include ball fields, golf course, equestrian center, swimming pools, and other recreational activities.
- **Open Space**—These areas are used as buffers between Base facilities and to preserve environmentally sensitive areas.

The lands surrounding Travis AFB on the northeast and east are primarily used for ranching and grazing. Areas to the south are a combination of agricultural and marshland. A few commercial/light industrial areas are present to the north of the Base. The area west of Travis AFB is predominantly residential.

Land use within the WABOU consists of open grasslands, light industrial support areas, administrative areas, personnel training areas, ammunition storage, and service/storage areas. Land use at and surrounding the annexes component of the WABOU is varied.

1.3 Ecology

Travis AFB has a variety of terrestrial and aquatic/wetland habitats and wildlife that are typical of the region. The information used in identifying biological resources was taken from field studies and reports produced by Biosystems (1993a, 1993b, 1994), CH2M HILL (1995, 1996), Jacobs Engineering Group (JEG) (1994a, 1994b), Radian (1994), and Weston (1995a, 1995b).

1.3.1 Terrestrial Habitats

The terrestrial habitats at Travis AFB and adjacent areas consist of herbaceous-dominated habitats (annual grassland, pasture, and early ruderal habitat) and urban habitat (industrial areas, lawns, and ornamental plants) according to the California Department of Fish and Game (CDFG) classification system (Mayer and Laudenslayer, 1988). Aquatic/wetland habitats at Travis AFB include riverine (Union Creek) and riparian habitat, lacustrine (Duck Pond), and herbaceous-dominated wetlands marshes, and vernal pools.

In general, annual grassland habitat is dominated by non-native plant species such as slender wild oat (*Avena fatua*), fescues (*Festuca*), soft chess (*Bromus hordeaceus*), field bindweed (*Convolvulus arvensis*), and yellow star-thistle (*Centaurea solstitialis*). Some native plants, such as bunchgrass (*F. viridula*) and johnny-tuck (*Triphysaria eriantha*) may also be found, usually associated with undisturbed areas.

Mowed/disced grassland is generally composed of soft chess, Italian ryegrass (*Lolium multiflorum*), and wild oats. Pasture grassland can contain varying frequencies of filaree (*Erodium* sp.), ripgut brome (*Bromus diandrus*), soft chess, Italian ryegrass, and yellow star-thistle. Ruderal grasslands, on the other hand, contain higher numbers of perennial species and, in some areas, woody species such as coyote brush (*Baccharis pilularis*), eucalyptus (*Eucalyptus* sp.), Peruvian pepper-tree (*Schinus molle*), and black locust (*Robinia pseudoacacia*).

The urban habitat onbase contains maintained lawns as well as trees and shrubs such as eucalyptus, Fremont cottonwood (*Populus fremontii*), arroyo willow (*Salix lasiolepis*), and coyote brush. Most isolated stands of shrubs or trees are located within or near urban areas, permanent water sources, or near artificial surface mounds (for example, rail lines, blast protection, and building/road foundations.

1.3.2 Aquatic/Wetland Habitats

Herbaceous wetland vegetation is found along the permanent (natural or artificial) drainages onbase and can also occur seasonally within vernal pools, swales, and ditches. Native species include salt grass (*Distichlis spicata*); non-native species include meadow fescue (*Festuca elatior*), sickle grass (*Parapholis incurva*), and cattails (*Typha* sp.). Vernally inundated areas support seasonal vegetation such as non-native Mediterranean barley (*Hordeum murinum* ssp. *leporinum*) and brass buttons (*Cotula coronopifolia*) and native plants such as downingia (*Downingia* sp.) and toad rush (*Juncus bufonius*).

Vernal pools are shallow depressions or small, shallow pools that fill with water during the winter rainy season, then dry out during the spring and become completely dry during the summer. The vernal pools at Travis AFB contain indicator species such as goldfields (*Lasthenia fremontii*), coyote thistle (*Eryngium vaseyi*), dwarf woolly-heads (*Psilocarphus brevissimum*), water pygmy-weed (*Crassula aquatica*); and one or more species of downingia and popcornflower (*Plagiobothrys* sp.).

Although a few willows and coyote brush can be found along Union Creek, the dominant plant species found in the riparian zone of Union Creek are mainly herbaceous and consist of beardless wild rye (*Leymus triticoides*), broad-leaved pepperwort (*Lepidium latifolium*), Harding grass (*Phalaris aquatica*), and saltgrass. Hydrophytes such as cattails and rushes are also common.

1.3.3 Wildlife

Terrestrial vertebrates associated with non-native annual grasslands are commonly found onbase. Typical avian species include ring-necked pheasant (*Phasianus colchicus*), American kestrel (*Falco sparvarius*), American robin (*Turdus migratorius*), and the western meadowlark (*Sturnella neglecta*). Reptiles observed, or potentially occurring, at the Base include the western fence lizard (*Sceloporus occidentalis*), gopher snake (*Pituophis melanoleucus*), and California red-sided garter snake (*Thamnophis sirtalis* ssp. *infernalis*). Common mammals identified include deer mouse (*Peromyscus maniculatus*), California ground squirrel (*Spermophilus beecheyi*), Botta's pocket gopher (*Thomomys bottae*), black-tailed hare (*Lepus californicus*), and red fox (*Vulpes vulpes*).

Permanent wetlands and seasonally wet areas support aquatic invertebrates, fish, amphibians, reptiles, birds, and mammals. Some aquatic invertebrate species observed in herbaceous wetlands and vernal pools at Travis AFB include vernal pool fairy shrimp

(*Branchinecta lynchi*), damselflies, crayfish, and aquatic snails. Amphibian species identified include bullfrog (*Rana catesbeiana*), Pacific tree frog (*Hyla regilla*), and California tiger salamander (*Ambystoma californiense tigrinum*). Aquatic birds observed on or near the Base include mallard (*Anas platyrhynchos*), great egret (*Casmerodiuis albus*), and great blue heron (*Ardea herodias*).

Because wildlife use riverine and riparian habitat somewhat similarly, these habitats are discussed together. Many aquatic invertebrates and amphibians are the same as those discussed above in herbaceous wetlands and vernal pools. These include damselflies, crayfish, aquatic snail, bullfrog, Pacific tree frog, and California tiger salamander. Fish species include mosquitofish (*Gambusia affinis*), fathead minnow (*Pimephales promelas*), threespine stickleback (*Gasterosteus aculeatus*), and bluegill (*Lepomis macrochirus*). Riverine/riparian habitats are also used extensively by birds and terrestrial mammals for forage, shelter, and as a source of water. These include red-winged blackbird (*Agelaius phoenicus*), raccoon (*Procyon lotor*), muskrat (*Ondatra zibethicus*), and beaver (*Castor canadensis*).

Habitats that support special-status species are considered sensitive habitats. Aquatic/wetland areas that are considered sensitive include vernal pools, swales, and ditches that can support special-status plants and animals. Urban environments, scattered throughout the Base, can also support special-status species. For example, burrowing owls (*Speotyto cunicularia*) may use man-made culverts, perches, and bare earth areas that contain burrows provided by ground squirrels. Loggerhead shrikes (*Lanius ludovicianus*) may nest on antenna wires and forage in grasslands. Both owls and shrikes are typical species of the grassland habitats onbase. Also, vernal pool fairy shrimp have been found in artificially created depressions that seasonally fill with water.

1.4 Geology and Hydrogeology

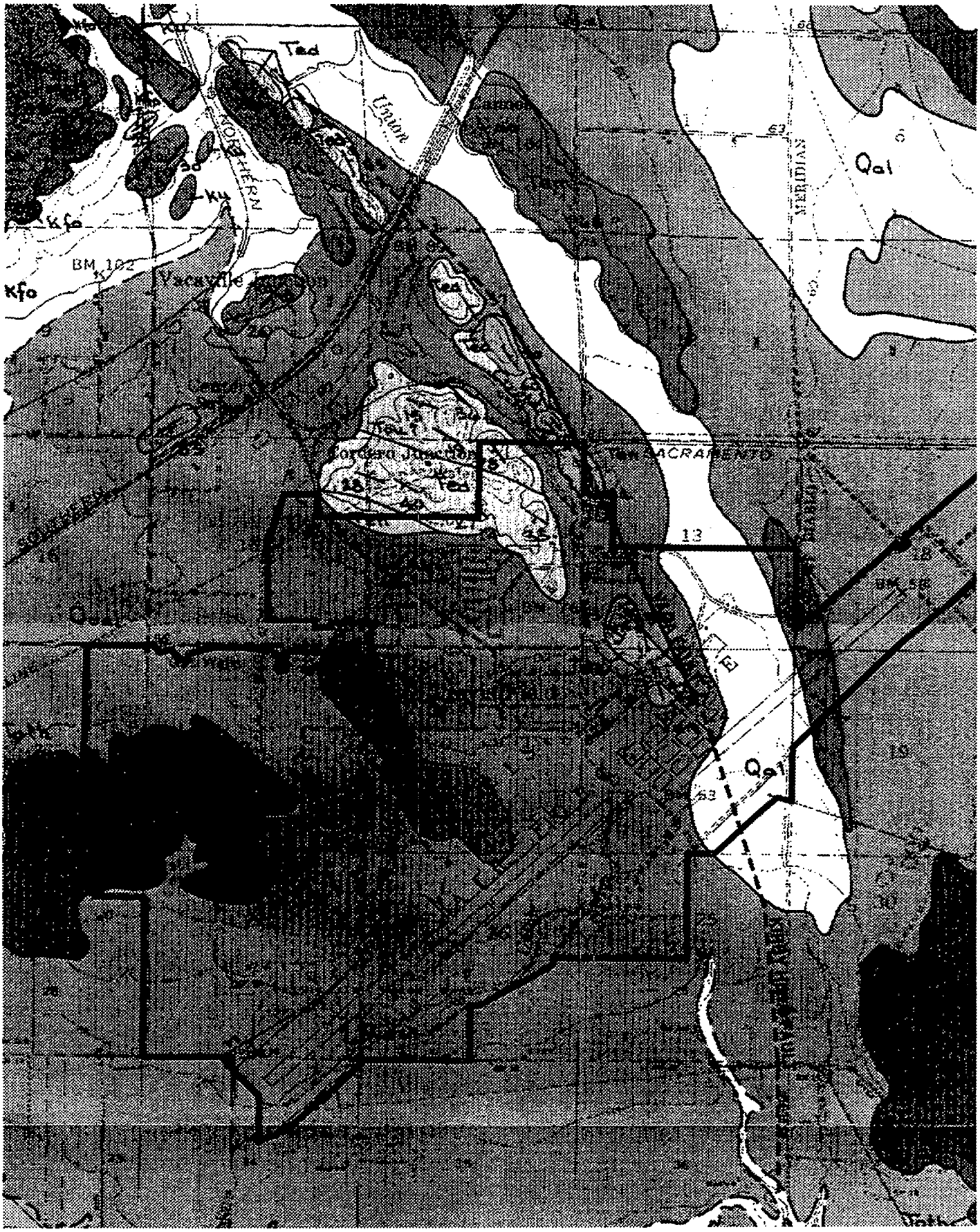
This section provides a discussion of the regional geologic setting in the vicinity of Travis AFB, as well as specific geologic conditions in the WABOU. This information is presented to provide a context for discussions on the potential migration of contaminants through the soil column and in groundwater.

1.4.1 Geology

Travis AFB is located on the western edge of the Sacramento Valley segment of the Great Valley Geomorphic Province. This province is a sediment-filled synclinal basin with a northwest-to-southeast-oriented axis. The Coast Range Geomorphic Province, which consists of folded and uplifted bedrock mountains, lies just to the west of Travis AFB (Thomasson et al., 1960; Olmsted and Davis, 1961).

The WABOU is located on the western flank of the truncated anticline that traverses Travis AFB in a northwesterly to southeasterly direction. The axis of the anticline runs through the EIOU in the vicinity of Facility 363, about 2 miles east of the WABOU boundary. Early Eocene Epoch Domengine Sandstone, which is the oldest sedimentary unit exposed at the Base, is exposed along the axis of the anticline.

Bedrock units that outcrop in the vicinity of Travis AFB include (from oldest to youngest) the Domengine Sandstone, the Nortonville Shale, the Markley Sandstone, the Neroly Sandstone, and the Tehama Formation, as shown on Figure 1-2. Bedrock at the


Ted
Union
NORTHERN
Kfo
BM 102
Vacaville
Cordero Junction
SACRAMENTO
MERIDIAN
Qal
13
Qal

North/East/West Industrial Operable Unit (NEWIOU) has been defined as consisting of consolidated to semi-consolidated sedimentary rock. It has been distinguished from the overlying unconsolidated sediment by such criteria as fissility, cementation, bedding, blow counts, color, texture, and gradation into competent rock (Weston, 1995a). Because of its lower permeability relative to the unconsolidated alluvium that overlies it, the bedrock may form a boundary for groundwater flow and therefore influence the migration of contaminants in groundwater. Table 1-1 is a stratigraphic column that summarizes the lithology and age of the geologic units in the area.

TABLE 1-1
Stratigraphic Column of Geologic Units at Travis AFB

Million Years Ago	Era	Period	Epoch	Geologic Unit	Lithologic Description	Possible Range of Thickness
1.8	Cenozoic	Quaternary	Pleistocene and Recent	Younger Alluvium	Interbedded clays, silts, sands and gravels, continental	0-70 feet
				Older Alluvium	Interbedded clays, silts, sands, and gravel, continental	0-100 feet
				Bay Mud	Interbedded clays, silts, sands and gravel, continental	
5			Pliocene	Tehama Formation	Interbedded gravels, sands, silts and clays, partially consolidated, occasional volcaniclastic sediments; continental	
					Unconformity	
27.5		Tertiary	Miocene	Neroly Sandstone (San Pablo Group)	Interbedded sandstone, siltstone, and shale, distinctive bluish color; marine	0-60 feet
					Unconformity	
38			Oligocene			
55			Eocene	Markley Sandstone	Massive micaceous, arkosic sandstone, interbeds of siltstone and shale, marine	0-60 feet
				Nortonville Shale	Predominantly dark gray marine shale and siltstone, minor sandstone, coal and glauconitic sandstone unit	80 feet
				Domengine Sandstone	Coarse-grained sandstone, minior siltstone and shale interbeds, gray to brown, marine (in outcrop only as mapped by Sims et al., 1973).	50 feet
			Paleocene	Unnamed Formation (?)	Interbedded shale, siltstone, and thinly laminated friable sandstone, marine (as mapped by Sims et al., 1973)	

Source: Sims et al., 1973.

The Tehama Formation consists of poorly sorted deposits of clay, silt, clayey silt, sandy silt and clay, and silty sand, containing generally thin lenses of gravel and sand. In areas of outcrop, it consists chiefly of siltstone, sandstone, and conglomerate. The Tehama Formation is widespread in the northern, northwestern, and western Sacramento Valley, and averages about 2,000 feet in thickness (Page, 1986). However, the thickness of the formation beneath the WABOU is unknown.

Travis AFB is located on the northeastern margin of the Fairfield-Suisun Basin astride the Vaca Fault. Travis AFB lies on alluvial fans that extend from the Vaca Mountains to the Suisun Marsh. These fans were deposited by the Ulatis, Union, Alamo, Laurel, and Suisun Creeks. Most of the alluvial material was deposited prior to the last period of glaciation during the Pleistocene Epoch, and is referred to as Older Alluvium. The parent rocks for the alluvium at Travis AFB include metasediments, serpentinites, ultramafic rocks, and the Sonoma Volcanics (Olmsted and Davis, 1961; Wagner and Bortugno, 1982). The drainages cut through the alluvial fans during the last glaciation, in response to the global lowering of the sea level. As the sea level has risen during the last 15,000 years, the drainages have filled again with alluvium. This material is referred to as Younger Alluvium. At Travis AFB, the overall thickness of the alluvium ranges from 0 to approximately 70 feet, but is generally less than 50 feet. West of Travis AFB, the thickness of the alluvium increases to over 200 feet (Thomasson et al., 1960). Some topographic relief in the form of very low ridges is provided by outcrops of sedimentary rocks characterized as bedrock in the Travis AFB area.

The younger and older deposits are distinguished at the surface by the difference in maturity of their soil profiles. The portion of the alluvium near the ground surface has been altered, or weathered over time by physical, chemical, and biological actions. The Younger Alluvium generally has an immature soil profile; the Older Alluvium generally has a well-developed, mature soil profile. Most of the sediment encountered at Travis AFB consists of Older Alluvium. The Younger Alluvium overlies the Older Alluvium and is found only in the northeastern portion of the Base.

Soil develops within geologic material exposed at the Earth's surface as the material is altered through physical, chemical, and biological processes. The nature of a soil is in part a function of climate, surface slope, time of exposure at the surface, and the type of original (parent) material. Soils in the vicinity of Travis AFB are primarily silt and clay loams that exhibit low permeabilities and poor drainage characteristics.

The majority of the Base, including the WABOU, is covered with soils derived from Pleistocene Epoch Older Alluvium designated as the Antioch-San Ysidro Complex. This complex comprises about 45 to 50 percent Antioch soil series and 35 to 45 percent San Ysidro soil series, with the remaining percentage composed of the Solano soil series and Pescadero soil series. The soils are old and are characterized by a well-developed soil profile.

1.4.2 Hydrogeology

Travis AFB is located along the eastern edge of the Fairfield-Suisun Hydrogeologic Basin. The Fairfield-Suisun Basin is a hydrogeologically distinct structural depression adjacent to the Sacramento Valley segment of the Central Valley Province. The basin is bordered to the north by the Vaca Mountains and to the east by the ridge that runs along the eastern portion of the North Operable Unit (NOU) and East Industrial Operable Unit (EIOU). The basin

slopes south toward the Suisun Marsh; consequently, groundwater and surface water at Travis AFB tend to flow south to Suisun Marsh (California Department of Water Resources, 1994).

The primary water-bearing deposits in the region surrounding Travis AFB are the coarse-grained sediments (sand and gravel) within the Older Alluvium and Younger Alluvium. The bedrock units generally do not yield groundwater of usable quantity or quality in the Fairfield-Suisun Basin (Thomasson et al., 1960).

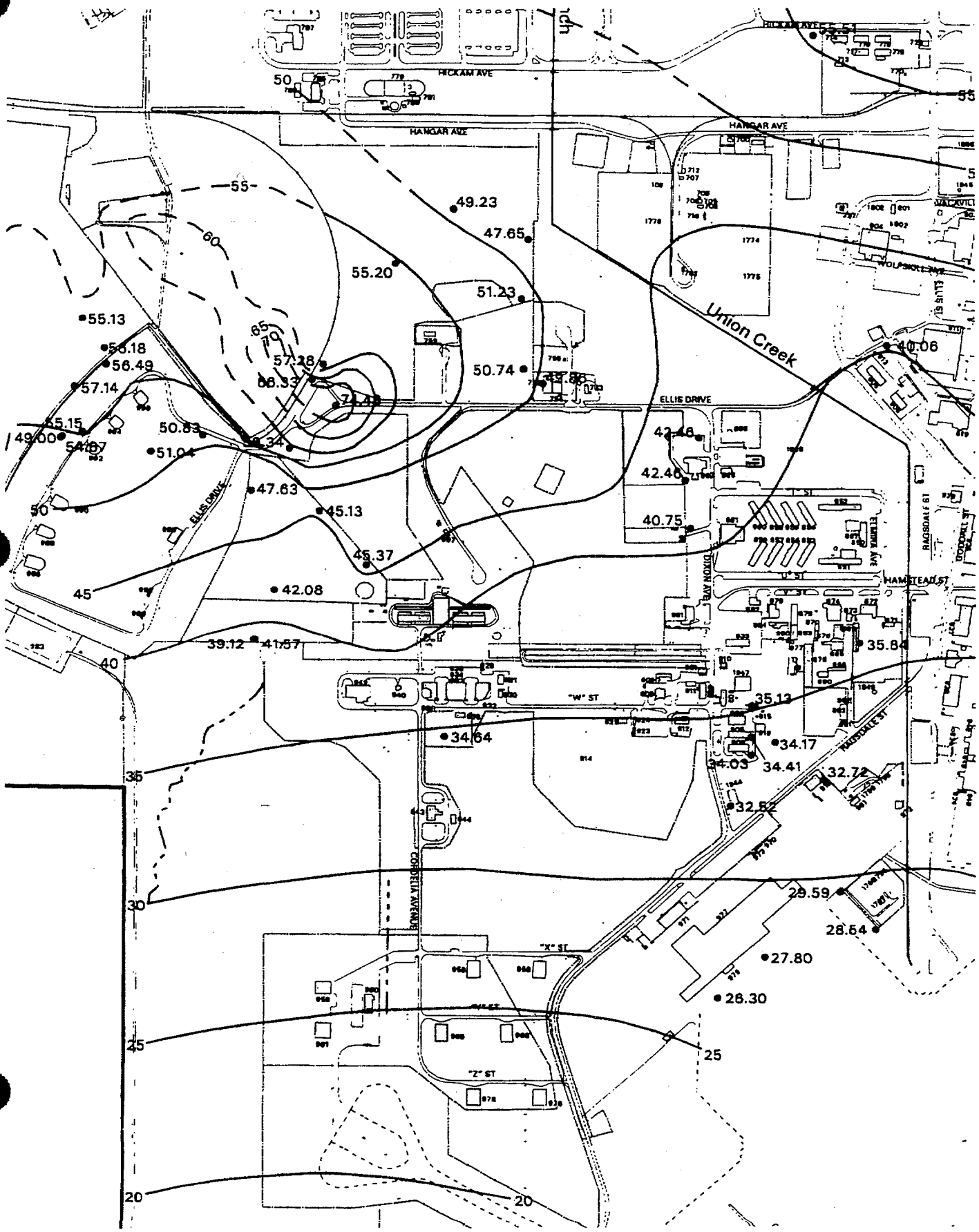
1.4.3 Groundwater Gradient and Flow

The groundwater gradient describes the differences in hydraulic potential that result in groundwater flow. The direction of the regional groundwater gradient is generally toward the south or southeast. Groundwater recharge occurs from the direct infiltration of rainfall on the valley surface and from the infiltration of runoff through local stream and creek beds. Natural groundwater discharge occurs at the marshlands located near the Potrero Hills, south of Travis AFB (Thomasson et al., 1960).

The general direction of groundwater flow at Travis AFB is toward the south, similar to the regional gradient. However, local variations (groundwater mounds and depressions) exist within the boundaries of Travis AFB. Changes in the groundwater gradient are normally related to the presence of lower permeability consolidated materials ("bedrock") in the subsurface, and the distribution of alluvium with relatively higher permeability. Groundwater typically flows away from the bedrock ridges, and toward the subbasins that contain thicker sequences of alluvial materials. Therefore, the bedrock ridges bordering the subbasins correspond with potentiometric highs in the groundwater elevation map.

The maximum horizontal hydraulic gradient in the shallow groundwater at Travis AFB outside of the WABOU is approximately 0.02 foot/foot at the groundwater mound near the old Base hospital. The minimum horizontal gradient in the upper portion of the aquifer is approximately 0.002 foot/foot near the southern border of Travis AFB. The average magnitude of the groundwater gradient in the shallow groundwater is approximately 0.005 foot/foot. The horizontal hydraulic gradients in the deeper zones of the alluvial aquifer range from approximately 0.003 to 0.01 foot/foot (Radian, 1996a).

Groundwater flows in a generally southerly direction in the WABOU, as shown on Figure 1-3. Variations in this flow regime are most pronounced in the north-central portion of the WABOU, in the vicinity of the topographic high point where the Tehama Formation outcrops. Groundwater flows radially away from the topographic high point in this area, and then curves back to the south. A subsurface ridge of the Tehama Formation that extends south from the outcrop also affects the groundwater flow direction (Figure 1-3). Groundwater flowlines appear to curve away from this ridge in the vicinity of sites such as Building 755. The groundwater gradient in the WABOU ranges from about 0.005 foot/foot near the mound to about 0.06 foot/foot at the southern end of the WABOU.



HICKAM AVE
HANGAR AVE
ELLIS DRIVE
Union Creek
WOLFSKILL AVE
DIXON AVE
ELMIRA AVE
RAGSDALE ST
HAMSTEAD ST
"W" ST
"X" ST
"Z" ST
CORDELIA AVENUE
49.23
47.65
55.20
51.23
55.13
56.18
56.49
57.14
55.15
49.00
54.87
50.83
51.04
57.28
66.33
74.48
50.74
49.86
47.63
45.13
45.37
42.08
39.12
41.57
42.46
40.75
40.06
35.84
35.13
34.64
34.17
34.03
34.41
32.72
32.52
29.59
28.54
27.80
26.30
55
60
65
70
50
45
40
35
30
25
20

Landfill 3 is located on a bedrock ridge near a groundwater divide. Groundwater here recharges the adjacent basins, and the vertical gradient is downward, ranging from about 0.2 foot/foot to about 0.35 foot/foot. Annual fluctations in the piezometric surface averaged about 2 to 5 feet. Water levels reached their low point just prior to the rainy season in late 1994, at the end of a multi-year drought. After 1994, the groundwater levels rose in the wells 5 to 6 feet during the wetter years of 1995 and 1996.

As previously mentioned, the Older Alluvium is the source of most of the groundwater supply in the Fairfield-Suisun Basin. The consolidated bedrock units that underlie the Older Alluvium do not yield groundwater of usable quantity or quality. The Older Alluvium reaches a maximum thickness of only about 200 feet (Thomasson et al., 1960). Investigations at Travis AFB indicate that the maximum thickness of the Older Alluvium at the Base is only about 70 feet (Radian, 1996b).

The Older Alluvium is extremely heterogeneous, and no discrete aquifer units were observed during the WABOU RI that could be correlated from site to site. In addition, a consistent vertical gradient up or down does not appear to be present in the WABOU. The Older Alluvium, therefore, should be regarded as a single hydrogeologic unit. In this regard, "shallow" and "deep" groundwater have little meaning in the WABOU. Groundwater is found under water table or semi-confined conditions, and flows in a predominantly horizontal direction.

Groundwater will flow preferentially through sediments with relatively higher permeability, such as silty sands and sands.

1.4.4 Aquifer Tests

The hydrogeologic parameters of hydraulic conductivity and porosity are needed to calculate groundwater flow velocities. To estimate the hydrogeologic parameters of the alluvial deposits and bedrock, aquifer slug tests and aquifer pumping tests have been conducted at Travis AFB between 1988 and 1996. Table 1-2 summarizes the values of hydraulic conductivity that have been calculated from these tests. The results of these aquifer tests indicate the horizontal hydraulic conductivity (K) of the alluvium beneath Travis AFB ranges from about 0.0001 foot per minute (fpm) to about 0.08 fpm, with an average of about 0.02 fpm. Vertical hydraulic conductivities calculated from aquifer pumping test data collected at MW245 and MW214 within the EIOU ranged from 1.21×10^{-4} fpm to 2.29×10^{-3} fpm (Radian, 1996a).

The wide range of hydraulic conductivities calculated from pump tests conducted at Travis AFB reflects the natural variability in permeability of the geologic units that are present. The lower range of hydraulic conductivities calculated for the vertical direction relative to the horizontal direction indicates that groundwater will flow more easily in the horizontal direction than in the vertical direction. Even in the presence of a vertical gradient, if the ratio of horizontal to vertical hydraulic conductivity is approximately 100 or more, groundwater flow will essentially be horizontal (Freeze and Cherry, 1979).

TABLE 1-2
Summary of Hydraulic Conductivity Values Derived from Aquifer Tests Conducted at Travis AFB

		Hydraulic Conductivity (K fpm)		
Geologic Unit	Number of Tests[a]	Minimum	Maximum	Mean
Younger Alluvium	9	0.0005	0.079	0.020
Older Alluvium	30	0.0001	0.074	0.027
(vertical K)	(2)	(0.000121)	(0.00229)	(0.0012)
Sandstone Bedrock	2	0.0025	0.021	0.0088
Shale or Siltstone Bedrock	4	0.0006	0.0415	0.020

[a]Identity of wells provided in Radian (1996b).

This fact is reinforced in the vicinity of Travis AFB by the fact that the regional discharge points for groundwater in the Fairfield-Suisun Basin are nearby Union Creek or Suisun Marsh. Therefore, dissolved contaminants that reach the water table will tend to migrate horizontally, with little opportunity for vertical migration before discharging. Dissolved contaminants in groundwater will also tend to migrate preferentially in geologic layers of higher permeability.

Based on the mean hydraulic conductivity in the Older Alluvium (Table 1-2), with an average groundwater gradient of 0.005 foot/foot and an assumed average effective porosity of 0.20, the average linear velocity of groundwater flow within the Older Alluvium is about 350 feet per year. Using the maximum value of hydraulic conductivity, the groundwater flow velocity in the Older Alluvium ranges up to about 970 feet per year. The average groundwater velocity calculated in the EIOU from pump tests performed in a variety of geologic settings was 110 feet per year (Weston, 1995b).

1.4.5 Groundwater Use

Intensive extraction of groundwater generally occurs only to the west of Travis AFB and Fairfield where the alluvium is thicker and contains a greater abundance of coarse-grained sediment. Groundwater wells in the area of Travis AFB are limited to domestic, stock-watering, and irrigation wells with typical screened depths of within 100 feet of ground surface (Weston, 1995b). Domestic wells, several of which are downgradient from Travis AFB, are used typically for households and gardens (Weston, 1995b). Based on the large distance (more than 4,500 feet) between the contaminated groundwater in the WABOU and the nearest domestic well, and the local groundwater flow velocity, it is highly unlikely that the downgradient domestic wells will ever be impacted by the contaminated groundwater. The groundwater cleanup actions of the four WABOU sites protect these offbase wells. However, if the contaminated groundwater from these sites reached an offbase domestic well, an alternative water supply would be provided.

No onbase wells are used for potable water production. However, several wells located 4 miles north of Travis AFB, at the Cypress Lakes Golf Course (Annex 10), produce 400 to 500 million gallons of water per year. This well water is mixed with surface water purchased from the City of Vallejo to supply potable water to Travis AFB. The Fairfield public water supply field is located approximately 3 miles west of Travis AFB. The large

production wells at the golf course and in Fairfield tend to be deeper than the nearby domestic wells, ranging up to 1,000 feet in depth.

1.5 Surface Water

Travis AFB is located in the northeastern portion of the Fairfield-Suisun Hydrologic Basin. Within the basin, water generally flows south to southeast toward Suisun Marsh, an 85,000-acre tidal marsh that is the largest contiguous estuarine marsh, as well as the largest wetland, in the continental United States. Suisun Marsh drains into Grizzly and Suisun bays. Water from these bays flows through the Carquinez Straits to San Pablo Bay and San Francisco Bay, and ultimately discharges into the Pacific Ocean near the City of San Francisco.

Union Creek is the primary surface water pathway for runoff at Travis AFB. The head-waters of Union Creek are located approximately 1 mile north of the Base, near the Vaca Mountains, where the creek is an intermittent stream. Union Creek splits into two branches north of the Base, with the main (eastern) branch being impounded into a recreational pond designated as the Duck Pond. At the exit from the Duck Pond, the creek is routed through a storm sewer to the southeastern Base boundary, where it empties into open creek channel.

The West Branch of Union Creek flows south and enters the northwestern border of Travis AFB east of the David Grant Medical Center in an excavated channel. This channel flows south to the northeast corner of the WABOU. The channel forms the boundary between the WIOU and the WABOU and parallels Ragsdale Street for about 4,000 feet, shown on Figure 1-3. Flow in the channel is then directed to a culvert under the runway and discharges to the main channel of Union Creek at Outfall II. From Outfall II, Union Creek flows southwest and discharges into Hill Slough, a wetland located 1.6 miles from the Base boundary. Surface water from Hill Slough flows into Suisun Marsh.

Local drainage patterns have been substantially altered within the Base by the rerouting of Union Creek, the construction of the aircraft runway and apron, the installation of storm sewers and ditches, and general development (e.g., the Base Exchange, industrial shops, maintenance yards, roads, housing, and other facilities). Surface water is collected in a network of underground pipes, culverts, and open drainage ditches. The surface water collection system divides the Base into eight independent drainage areas. The eastern portion of the Base is served by one of the drainage systems that collects runoff from along the runway and the inactive sewage treatment plant area and directs it to Denverton Creek and Denverton Slough. Denverton Creek is an intermittent stream in the vicinity of the Base. The northwestern portion of the WABOU drains to the west toward the McCoy Creek drainage area. McCoy Creek is also an intermittent stream in the vicinity of the Base. With the exception of these drainages, the remaining six drainage areas at the Base empty into Union Creek.

Travis AFB has limited topographic relief, and the clayey soils prevent rapid drainage. This swale topography leads to the formation of vernal pools. The annual cycle of vernal pools includes standing water during the winter and spring and desiccation during the summer and fall. During the time that the vernal pools contain water, biotic communities develop over relatively restricted areas. In the larger areas, grasslands form; in more confined, deeper areas, wetlands form. The vernal wetlands are concentrated along the western, southern, and southeastern boundaries of the Base. All of the surface water bodies on and in

the vicinity of the Base empty into the Suisun Marsh. No springs have been recorded within the confines of Travis AFB.

Surface water pathways, as defined in this WABOU Groundwater IROD, include Union Creek, drainage channels, the storm and sanitary sewer system, and the backfill material surrounding underground sewer lines. These pathways are a potential means for groundwater to interact with surface water. Based on the locations and depths of the sewer lines in the WABOU and the groundwater level measurements in the vicinity of the four WABOU sites, there is no interaction between surface water and contaminated groundwater in the WABOU.

2.0 Overview of Travis AFB Environmental Programs

The Travis AFB Environmental Management Office is divided into three branches: Compliance, Restoration, and Pollution Prevention. This section describes each branch and the programs that are designed to comply with current federal and state environmental regulations.

2.1 Compliance Branch

Travis AFB maintains several active environmental compliance programs that are described below.

2.1.1 Air Force Regulations

The Air Force has developed a parallel set of environmental regulations to the federal environmental regulations. These Air Force regulations are designed to ensure that federal requirements are implemented in an appropriate manner at Air Force installations. Air Force instruction AFI 32-7005 sets up an Environmental Protection Committee to oversee management of all environmental programs at each installation. The Air Force environmental compliance regulations that parallel the federal environmental regulations are divided into the following subject areas:

- Air Quality Compliance
- Water Quality Compliance
- Solid and Hazardous Waste Compliance
- Storage Tank Compliance
- Environmental Impact Analysis Process
- Integrated Natural Resource Management
- Cultural Resource Management

2.1.2 Management Action Plan and Base General Plan

The Travis AFB Management Action Plan (MAP) summarizes the current status of the Travis AFB environmental compliance, restoration, and pollution prevention programs, and presents a comprehensive strategy for implementing response actions necessary to protect human health and the environment. Travis AFB produced the most recent version of the MAP in January 1997. Travis AFB environmental staff and Air Force headquarters use the MAP to direct and monitor environmental response actions and to schedule activities needed to resolve technical, administrative, and operational issues.

The Travis AFB General Plan (the Plan), also known as the Base Comprehensive Plan, a companion document to the MAP, provides an organized, systematic, and comprehensive approach to current and future planning and development. The Base General Plan is a tool that addresses a multitude of installation requirements and assists in the long-range growth of the Base, including natural resources, environmental protection, land use, airfield operation, utilities, transportation, and architectural compatibility. Of particular importance is its role in environmental protection. The Plan addresses proper hazardous waste management and recognizes CERCLA-related activities through proper land use at Travis AFB.

Section 5.6 addresses the implementation of land use restrictions to the Plan based on CERCLA-related activities.

2.1.3 Resource Conservation and Recovery Act and Hazardous Waste Management Program

Travis AFB operates as a generator and facility for hazardous waste management under the Resource Conservation and Recovery Act (RCRA) and State of California hazardous waste management programs. Travis AFB received a Part B hazardous waste facility storage permit from the California Department of Toxic Substances Control Division (DTSC) and the U.S. Environmental Protection Agency (U.S. EPA) on 5 March 1993.

2.1.4 Petroleum-only Contaminated Sites Program

The Travis AFB Petroleum-only Contaminated Sites (POCOS) program is designed to manage on base petroleum-related contamination sites. Travis AFB and the regulatory agencies agreed to remove the POCOS from the Travis AFB CERCLA program because the law excludes petroleum as a CERCLA contaminant. The Air Force will address petroleum contamination under CERCLA if it is commingled with CERCLA contaminants.

POCOS are typically associated with surface and sub-surface releases from fuel spills, piping leaks, oil-water separators, or underground storage tanks (USTs). The POCOS program includes the removal of leaking USTs and the remediation of petroleum-only contaminated soil and groundwater. An example of a POCOS that was removed from the CERCLA program by the regulatory agencies and the Air Force is the North/South Gas Station site. The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) is the lead oversight agency for this program.

2.1.5 Stormwater Discharge Permit

Travis AFB monitors stormwater outfalls in compliance with its California National Pollution Discharge Elimination System (NPDES) permit. The ongoing monitoring program was developed in 1992. The Air Force conducts surface water sampling and reporting according to the permit requirements. The SFBRWQCB is the lead oversight agency for stormwater discharges.

2.2 Restoration Branch

The Restoration Branch manages the Travis AFB Installation Restoration Program (IRP) which was initiated in 1983 to investigate the nature and extent of reported hazardous waste releases to the surrounding environment (Engineering-Science, 1983). On the basis of the evaluation of IRP data by the U.S. EPA, Travis AFB was placed on the National Priorities List (NPL) on November 21, 1989 (54 Federal Register 48187).

The Air Force, U.S. EPA, DTSC, and SFBRWQCB negotiated and signed a Federal Facility Agreement (FFA) in September 1990. The FFA is a legally binding document that establishes the framework and schedules for the environmental cleanup at Travis AFB. This document also requires Air Force compliance with the NCP, CERCLA, RCRA guidance and policy, and state laws and regulations.

2.2.1 CERCLA Process

CERCLA was passed in 1980 and amended by the Superfund Amendments and Reauthorization Act (SARA) in 1986. This law established a program to remediate sites contaminated with hazardous constituents to protect public health and the environment. CERCLA established a series of steps to investigate site contamination and design and implement appropriate remedial actions at these sites. The major steps are described below.

2.2.1.1 CERCLA Steps

Remedial Investigation (RI)—The RI is used to collect data to characterize site conditions, to determine the nature of the waste, and to assess risk to human health and the environment. The WABOU RI used a phased and sequenced approach to minimize collection of unnecessary data and maximize data quality. Initial data collection efforts provided a basic understanding of site characteristics. As this basic understanding was achieved, subsequent data collection efforts focused on filling identified data gaps in the conceptual site model and gathering the information necessary to support evaluations of remedial alternatives. The results and conclusions of this investigation were published in the *West/Annexes/-Basewide Operable Unit Remedial Investigation Report (Volumes 1-4), 60th Air Mobility Wing, Travis Air Force Base, California* (CH2M HILL, 1997).

Feasibility Study (FS)—The FS is divided into three general phases: development of alternatives, screening of alternatives and detailed analysis of alternatives. In the first phase the technology types and process options available to implement the general response actions for contaminated soil and groundwater were defined. A technology implementability screening was conducted which provided the basis for the selection of representative process options for soil and groundwater remediation. In the second phase the remedial alternatives were assembled using the representative process options and the site-specific conditions in the WABOU. In the last phase the alternatives were evaluated against seven of the nine CERCLA criteria. The WABOU FS provided a comparative analysis of alternatives to identify the advantages and disadvantages of each alternative to assist the decision-making process. The results of this study were published in the *West/Annexes/Basewide Operable Unit Feasibility Study, 60th Air Mobility Wing, Travis Air Force Base, California* (CH2M HILL, 1998).

Proposed Plan (PP)—The PP presents to the public the preferred alternative for each site and the rationale for the preferences. The WABOU Groundwater PP (Travis AFB, 1998) gave the public an opportunity to comment on the preferred groundwater alternatives during a 30-day public comment period (April 8, 1998 to May 8, 1998). It was published and mailed to all community members on the Travis AFB Community Relations list just prior to the start of the public comment period. The Air Force formally presented the preferred groundwater alternatives to the public at the April 23, 1998 public meeting. The Air Force also published a WABOU Soil PP to present to the public the preferred alternatives for the WABOU soil sites. A separate 30-day public comment period (July 8, 1998 to August 8, 1998) and public meeting (July 23, 1998) were held to promote public participation in the decision-making process.

Record of Decision (ROD)—The ROD presents the selected alternative and final cleanup levels at each site. It summarizes all CERCLA activities at each site and documents that the Air Force and the regulatory agencies are in agreement as to how the cleanup is to take place. Travis AFB and the regulatory agencies have agreed to use an IROD to quickly start

the groundwater cleanup actions. This IROD will not specify final cleanup levels and/or the final selected alternative. It will allow Travis AFB to conduct the actions needed to reduce groundwater contamination and associated potential risk as well as gather the data needed to select the final groundwater actions to close out each site. Travis AFB anticipates that a basewide groundwater ROD will be used to document the final actions for all groundwater sites in both the NEWIOU and the WABOU. A WABOU Soil ROD will be written to document the selected alternatives and the final soil cleanup levels at the WABOU soil sites.

Remedial Design (RD)—The RD specifies the engineering design of the treatment system used to implement the selected alternative at each site. The approach used to implement the groundwater action at each WABOU groundwater site is similar to that found in the final NEWIOU Groundwater Remedial Design/Remedial Action Plan and the Final Natural Attenuation Assessment Plan. Therefore, the Air Force will add an addendum to these two documents to describe the development of the remedial designs for the WABOU groundwater sites. The Air Force will prepare a site-specific RD/RA work plan for each WABOU groundwater site.

Remedial Action (RA)—The RA is the construction and operation of the selected alternatives specified in the ROD and designed in the RD. The Air Force will submit a schedule for the RD/RA activities to the regulatory agencies 21 days after the WABOU Groundwater IROD is signed. The Air Force will also submit a RD/RA schedule to the regulatory agencies 21 days after the WABOU Soil ROD is signed.

2.2.2 Operable Units

Initially, Travis AFB was treated as a single entity with one associated comprehensive cleanup schedule. In May 1993, the FFA was amended and the Base was divided into the four Operable Units (OUs) listed below to facilitate the overall cleanup program:

- East Industrial Operable Unit (EIOU)
- West Industrial Operable Unit (WIOU)
- North Operable Unit (NOU)
- West/Annexes/Basewide Operable Unit (WABOU)

Operable unit boundaries are shown in Figure 1-1. In October 1995, the first three OUs were combined into the North, East, West Industrial Operable Unit.

The WABOU has three main components:

- The western portion of the installation. All four groundwater sites are located within the western portion of the Base.

- The annexes or noncontiguous parcels of property that are under the jurisdiction of the Travis installation commander. The boundaries of each annex are defined in the official records of the Travis AFB Real Property Office.

- Other sites within the installation not being addressed by the other three OUs. These sites were included to ensure that all portions of the Base had been addressed. This is the "Basewide" component of the WABOU.

2.2.3 Removal Actions

In April 1993 a RCRA corrective action was conducted to close the acid neutralization sump at Building 755. This sump was identified in the WABOU RI report as the most probable source of the trichloroethene (TCE)-contaminated groundwater that is migrating from the site. Pacifica Services, Inc. accomplished the sump removal. The cobblestones were decontaminated prior to disposal, and the residual liquids and solids at the bottom of the sump were sampled and analyzed for hazardous characteristics. All hazardous waste was contained, transported and disposed in accordance with federal, state and local environmental regulations. The concrete sump and associated piping were demolished and removed from the site. Soil samples were analyzed for hazardous constituents. A plastic liner was placed into the excavation. The excavation was lined with a plastic membrane and backfilled with clean soil.

Travis AFB has initiated several groundwater removal actions in the NEWIOU which are described in the *Travis Air Force Base Groundwater Interim Record of Decision for the NEWIOU* (Radian, 1997).

2.2.4 Treatability and Pilot Studies

To date no groundwater treatability or pilot studies have been conducted in the WABOU. However, Building 755 may be the focus of three Air Force Center for Environmental Excellence (AFCEE) funded treatability studies that would test the ability of innovative technologies to treat volatile organic compound (VOC)-contaminated groundwater in a faster or cost-effective manner. The three technologies that are being considered for testing at Building 755 are Dual-Phase Extraction, Reactive Wall or Barrier, and Phytoremediation. The regulatory agencies will receive briefings on these studies as more details become available and will be able to review all treatability study work plans and reports.

Travis AFB has conducted several groundwater treatability and pilot studies in the NEWIOU which are described in the *Travis Air Force Base Groundwater Interim Record of Decision for the NEWIOU* (Radian, 1997).

2.2.5 Risk Assessment

A human health risk assessment and an ecological risk assessment were conducted in the WABOU RI. The results of these assessments are summarized in Section 3.0. In addition, the potential ecological risks to plants and animals were quantified on a basewide perspective and were presented in the *Final Comprehensive Basewide Ecological Risk Assessment - Tier 2: Screening Assessment* (CH2M HILL, 1996).

2.2.6 Community Participation

Travis AFB has had a community relations program since 1990. This program is designed to inform the public and involve the community in the environmental decision-making process.

The highlights of the community relations activities taken by Travis AFB are presented below:

- **Federal Facilities Agreement (FFA).** The Air Force, U.S. EPA, California Department of Health Services (now Department of Toxic Substances Control), and SFBRWQCB have

negotiated an interagency agreement, which includes requirements for community relations activities based on provisions in federal (and where applicable, state) statutes, regulations, and guidelines.

- **Restoration Advisory Board (RAB).** In 1994, Travis AFB established a RAB comprised of representatives of the community and the regulatory agencies. Through its quarterly meetings and its focus groups, the RAB has provided valuable input about community concerns regarding the Restoration Program. The Technical Document Review focus group has reviewed and commented on the draft version of every major report. The Relative Risk focus group has provided input on the project prioritization, and the Community Relations focus group is working to reach out to all community members. The RAB replaced the Technical Review Committee, which met periodically to review program progress.

- **Administrative Record/Information Repository.** The Air Force established an Administrative Record to support Air Force decisions related to the Travis AFB IRP. In addition, the Air Force established a public information repository for the relevant portion of the Administrative Record at the Vacaville Public Library. Copies of RI reports, FS reports, Proposed Plans and decision documents for both OUs are available for public review.

- **Community Relations Plan (CRP).** The Air Force implemented the first Travis AFB CRP in 1991. The Air Force revised the CRP in 1998. The Travis AFB Remedial Project Manager (RPM) is currently implementing the CRP.

- **Mailing List.** A mailing list of all interested parties in the community is maintained by Travis AFB and updated regularly. The mailing list currently totals more than 1,300 names.

- **Fact Sheets and Newsletters.** The Air Force has been publishing fact sheets describing activities and milestones in the restoration program occasionally since 1993. Since 1995 the Air Force has published and mailed quarterly newsletters to everyone on the mailing list. The newsletters contain information about public participation, issues of potential concern to the public, and program updates. The RAB co-chairs also write columns in each newsletter.

- **Proposed Plans.** The Air Force has mailed copies of NEWIOU and WABOU Groundwater Proposed Plans to all parties on the Travis AFB mailing list, government officials, representatives of interested community groups, and members of the media. Copies are available at three Solano County libraries for public review.

- **Public Meetings.** The Air Force held a 30-day public comment period for the WABOU Groundwater Proposed Plan (April 8, 1998 –May 8, 1998). The Air Force held a public meeting on the evening of April 23, 1998 to present the proposed remedial alternatives for WABOU groundwater sites. At this meeting, representatives from the Air Force, Cal-EPA/DTSC, and U.S. EPA were present to answer questions about the groundwater contamination. Questions and comments from the public and responses are included in Part III, the Responsiveness Summary.

2.2.7 Remedial Design/Remedial Action

The RD/RA will include the design and implementation of all actions specified in the Groundwater IROD. The regulatory agencies will be involved in the approval and oversight of the design and construction of the interim remedial actions. Experience gained through implementation of the interim remedial actions will allow for technically and economically feasible long-term remedial options in the final ROD for groundwater at Travis AFB.

The Air Force will submit the RD/RA schedule for implementing the IROD 21 days after signing the IROD in accordance with the FFA. The regulatory agencies will review and approve the RD/RA schedule, as well as all reports and actions specified in the RD/RA schedule. Section 5.4 presents the elements that will be included in the RD/RA schedule.

2.3 Pollution Prevention Branch

Travis AFB has an active Pollution Prevention Program that strives to reduce the generation of wastes through a hierarchy of actions. The actions range from the most preferred choice of source reduction, to recycling, treatment, and finally disposal as a last resort. The Pollution Prevention MAP (P2 MAP) defines the framework to accomplish these actions. The P2 MAP analyzes all processes that generate hazardous waste streams and performs opportunity assessments of potential pollution prevention options to reduce the volume and/or toxicity of generated wastes. This program includes minimizing wastes generated by sampling activities in the IRP.

3.0 WABOU Groundwater Remedial Investigation Summary

The primary objectives of the RI were to evaluate the nature and extent of contamination in the WABOU and assess the potential risks to human health and the environment posed by the contamination. Following the RI field activities, the data were evaluated and human health and ecological risk assessments were performed for each site. A quantitative human health risk assessment (HHRA) resulted in the identification of chemicals of concern (COC) for each site. Site-related excess lifetime cancer risks, as well as Hazard Indexes (for non-cancer-causing chemicals) were computed for each COC. Similarly, the ecological risk assessment resulted in the identification of chemicals of ecological concern (COEC) for each site. Hazard Quotients for various ecological receptors (selected indicator species of plants and animals) were computed for each COEC.

3.1 Nature and Extent of Contamination

There are four WABOU sites with groundwater contamination. This section presents a brief description of each groundwater site. Figure 3-1 shows the locations of the WABOU groundwater sites and the extent of groundwater contamination.

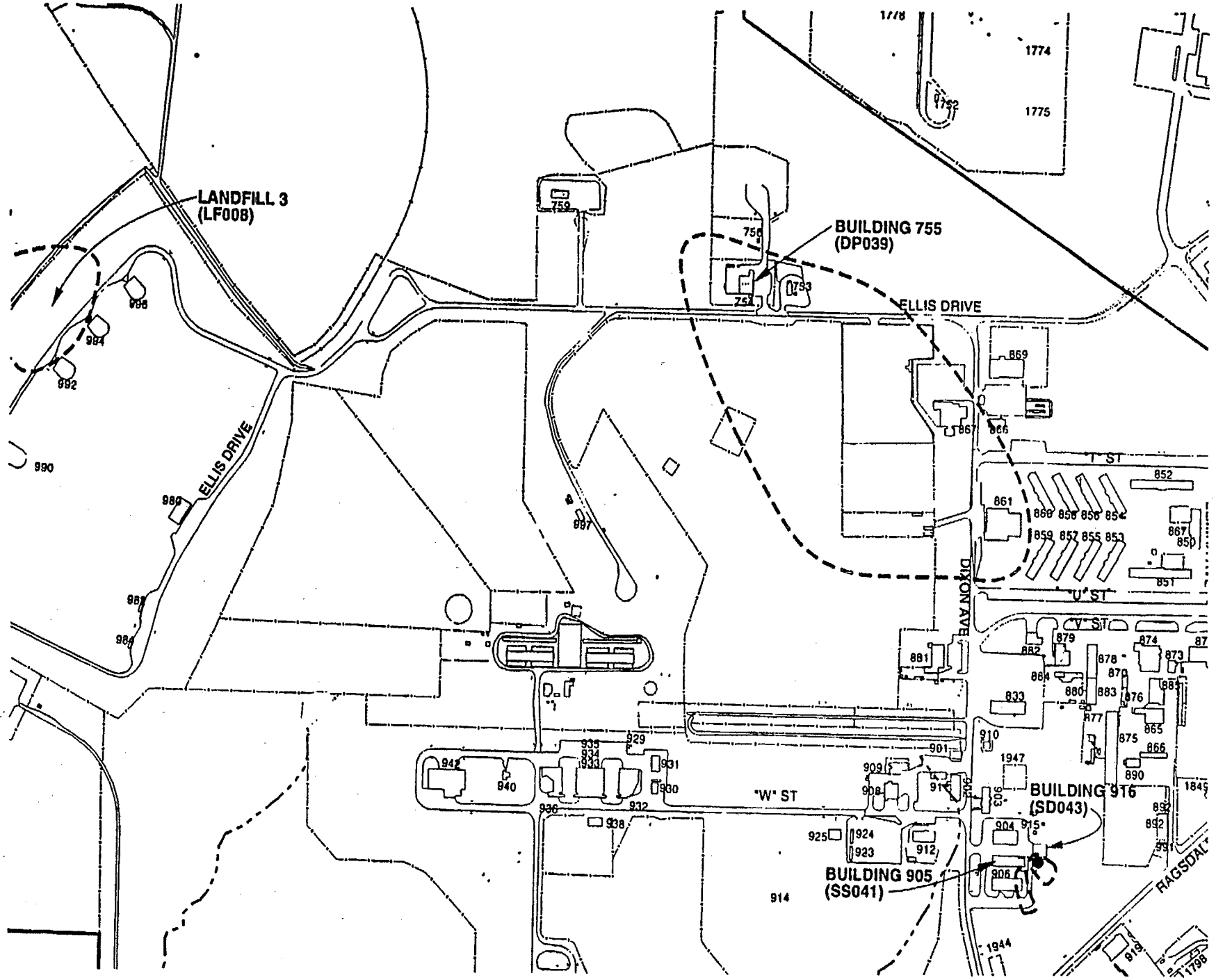
Appendix A provides a brief summary of the description of each WABOU groundwater site, the nature and extent of contamination, the alternatives evaluated in the FS, the selected interim groundwater action, and the conceptual design for the selected interim remedy.

Reservoir Facilities 1514/1518 is a WABOU site that did not continue into the WABOU FS. This active facility has fluoride contamination in groundwater as a result of an above-ground fluoridation tank leak. Because the leak occurred after the IRP funding eligibility date (1 January 1984), the site was transferred to the Compliance Branch of the Travis AFB Environmental Management Office. A description of this site is found in Section 4.17 of the *West/Annexes/ Basewide Operable Unit Remedial Investigation Report (Volumes 1-4), 60th Air Mobility Wing, Travis Air Force Base, California* (WABOU RI) (CH2M HILL, 1997).

3.1.1 Building 755 (DP039)

Building 755 is the Travis AFB Battery and Electric Shop. The site consists of Building 755 and a former battery neutralization sump. Past operations have included the recharging and dismantling of lead-acid and nickel-cadmium batteries. Before 1978, lead-acid solutions were discharged into a sink inside Building 755. The pipeline from the sink led to a rock-filled sump approximately 65 feet northwest of the building. This practice was discontinued in 1978 when the pipeline was dismantled and reconnected to the sanitary sewer system. The sump was removed in 1993.

Electrical equipment maintenance also took place in this building, and it is apparent that industrial solvents used in the maintenance, such as TCE, were discharged into the sump. The highest VOC concentrations were found in samples from beneath the former sump and suggest the presence of undissolved TCE beneath the water table. Subsequent groundwater sampling was used to determine the extent of the VOC plume. The plume has migrated 1,400 feet to the southeast, consistent with the local groundwater flow direction, and is 800 feet wide. TCE is the contaminant that poses the greatest potential risk at this site. Figure A-1 of Appendix A presents the Building 755 site and a conceptual diagram of the TCE plume.


LANDFILL 3
(LF008)
BUILDING 755
(DP039)
ELLIS DRIVE
ELLIS DRIVE
DIXON AVE
"T" ST
"U" ST
"V" ST
"W" ST
BUILDING 916
(SD043)
BUILDING 905
(SS041)
RAGSDAL
1774
1775
1778
1752
759
756
754
753
869
867
866
852
861
860
858
856
854
859
857
855
853
867
850
851
881
882
879
874
873
878
870
884
880
883
876
885
833
877
865
875
866
890
910
901
1947
909
908
916
903
904
915
892
891
925
924
923
912
906
914
1944
919
1798
942
940
935
934
933
929
931
930
936
932
938
997
990
980
982
984
992
994
996

There are no discrete surface water drainage pathways at this site. A sanitary sewer line runs in an east-west direction just south of Ellis Drive. This 8-inch vitrified clay line is located 4 feet below ground surface (bgs). Based on the depth of the water table in the vicinity of this sewer line (>15 feet bgs), there is no interaction between the groundwater and the sewer line.

3.1.2 Landfill 3 (LF008)

Landfill 3 consists of trenches used in the 1970s for the disposal of rinsed pesticide containers, bags, and possibly pesticide container rinsewater (JEG, 1994b). Landfill 3 is located within the Weapons Storage Area (Bunker A) in the western portion of the WABOU. Bunker A is a secured area and is surrounded by fences. The LF03 site comprises about 1 acre of land, based on the trenches excavated during the WABOU RI. The trenches are currently covered with fill material. There are no storm or sanitary sewer lines in the vicinity of this site.

Approximately 30 cubic yards of materials were reportedly buried in trenches with varying dimensions. Geophysical surveys were used to identify the locations of these trenches. Six out of nine exploration trenches encountered buried debris during the RI. The depth of waste observed was from 5 to 8 feet, and no lining was visible beneath the waste. Materials excavated during the RI included 1- and 5-gallon metal containers, plastic and paper bags, other paper and plastic debris, 1-gallon glass bottles, and two 55-gallon drums. Labels found on some of the containers indicated that the containers originally held pesticides and herbicides. No evidence that other contaminants were disposed of at the landfill was discovered.

The results of groundwater sampling indicated that pesticides have migrated from the disposal trenches to the groundwater. Figure A-2 of Appendix A presents a conceptual diagram of the pesticide plume. Because the trenches are located on a topographic high, the plume has migrated slowly in a radial direction around the source area.

3.1.3 Building 905 (SS041)

Building 905 is the Travis AFB Entomology Shop that was used to prepare pesticide and herbicide mixtures from 1983 to 1992. A 3,000-square-foot fenced enclosure outside on the east side of the building contains a washrack and a storage area. The washrack was formerly used to wash down tractors used for towing bowsers filled with pesticides and herbicides. The washrack consisted of a concrete pad with a perimeter berm (i.e., curb) and a drain that discharged to a tank. The surface soil appears to have received pesticide residue from spray generated during the washing of pesticide applicator vehicles under windy conditions. The results of groundwater sampling indicated that pesticides have migrated from the surface soil to the groundwater. There are no storm or sanitary sewer lines in the vicinity of the groundwater contamination at Building 905. The sanitary sewer line that supports Building 905 is upgradient of the contaminant plume and is not considered a preferential pathway. Figure A-3 of Appendix A presents a conceptual diagram of the pesticide plume.

3.1.4 Building 916 (SD043)

Building 916 was constructed in 1953 to provide emergency electrical power. The diesel-powered generators inside the building are located in a cellar, or sump area, that also

houses sump pumps. Prior to 1991, diesel fuel that had spilled from the generators was washed down with water and pumped out of the building through one of four pipes. The pipes discharged onto small concrete spillways constructed for erosion control on the side slope of the trapezoidal drainage channel that lies east of the building. From the spillways, wastewater flowed down the side-slope and into the drainage channel. This method of sump water disposal was discontinued in 1991.

A TCE plume has been identified beneath the drainage channel adjacent to the building. The source of this plume appears to be the spillway that was used to drain the sump within the building, although this possibility has not been confirmed. In addition, leaks at a former transformer pad resulted in deposition of a PCB isomer (PCB-1254) in the nearby soil and migration to the local groundwater. There are no storm or sanitary sewer lines in the vicinity of the groundwater contamination at Building 916. The sanitary sewer line that supports Building 916 is upgradient of the contaminant plume and is not considered a preferential pathway. Figure A-3 of Appendix A presents a conceptual diagram of the TCE and PCB plumes.

3.2 Risk Assessments

An HHRA and an ecological risk assessment were conducted using the data collected during the WABOU RI. The objective of a risk assessment is to evaluate the potential risks resulting from exposure to chemicals detected in environmental media. Since there is no exposure pathway of the contaminated groundwater at the four WABOU sites to ecological habitats, these sites pose no ecological risk to the local habitats. Therefore, this section will address the results of the WABOU HHRA that pertain to groundwater.

The WABOU HHRA was conducted in two phases: a screening risk assessment and a quantitative risk assessment. Each risk assessment follows the following four steps:

- Identification of Chemicals of Potential Concern (COPC)—chemical concentrations were compared to U.S. EPA Preliminary Remediation Goals (PRGs) and WABOU inorganic reference concentrations
- Exposure Assessment—potential pathways by which exposure could occur were identified, potentially exposed populations were characterized, and the magnitude, frequency , and duration of exposure were estimated
- Toxicity Assessment—the toxicity of the COPC and the relationship between magnitude of exposure and adverse health effects were summarized
- Risk Characterization—the toxicity and exposure assessments were integrated to estimate the potential risks to human health from exposure to site chemicals.

The screening HHRA evaluated chemicals detected in groundwater by comparing them to chemical-specific water PRGs developed by U.S. EPA Region IX (EPA, 1995). These water PRGs were developed using default exposure factors for a residential scenario and U.S. EPA or Cal/EPA toxicity values (whichever are more stringent) to estimate concentrations which are protective of humans, including sensitive groups, over a lifetime. This is a very conservative screening assessment because no current or future residential land use is planned for sites within the WABOU. In addition, onsite groundwater is not currently being used for agricultural, industrial, or domestic purposes.

The purpose of the quantitative HHRA was to evaluate site-specific exposure scenarios. Because no current or future residential land use is planned in the WABOU, this is an unlikely future exposure scenario. On the basis of actual current and future planned site uses, the most likely future exposure scenario is a commercial/industrial worker exposure scenario. Therefore, a worker exposure scenario was used in the quantitative HHRA.

Table 3-1 presents the potential human health risks posed by the contaminated groundwater at the four WABOU groundwater sites. The human health risk calculations are presented in Appendix G1 of the WABOU RI.

3.3 Chemicals of Concern

Based on the results of the WABOU HHRA, COCs were identified at each WABOU site. Table 3-1 presents the groundwater COCs at the four WABOU groundwater sites. The general criteria for the identification of groundwater COCs are presented below:

1. The contaminant creates a potential human health risk over 1×10^{-6}; or
2. The contaminant has a Hazard Index (HI) exceeding 1.0.

TABLE 3-1
COC Concentrations and Potential Risks at WABOU Groundwater Sites

Site Name	Groundwater COC	Maximum Concentration (µg/L)	Human Health Risk Value
Building 755	1,1-DCE (1,1-dichloroethene)	7,800	2×10^{-2}
	1,2-DCA (1,2-dichloroethane)	440	1×10^{-4}
	1,1,1-TCA (1,1,1-trichloroethane)	26,000	Hazard Index (HI) = 3
	1,1,2-TCA (1,1,2-trichloroethane)	240	5×10^{-5}
	acetone	45,000	HI = 4
	bromodichloromethane	10	3×10^{-6}
	methylene chloride	200	1×10^{-5}
	PCE (perchloroethene)	20	5×10^{-6}
	TCE	210,000	1×10^{-2}
Landfill 3	aldrin	0.11	7×10^{-6}
	alpha-chlordane	0.27	2×10^{-6}
	heptachlor	0.084	3×10^{-6}
	heptachlor epoxide	0.033	2×10^{-6}
Building 905	heptachlor epoxide	0.023	2×10^{-6}
Building 916	PCB-1254	22	5×10^{-5}
	TCE	71	5×10^{-6}

The approach to evaluating pesticide concentrations in the WABOU is based on comparisons with the concentrations found at other locations on Travis AFB. The WABOU RI used the Inorganic Constituent Evaluation Methodology (Radian, 1996b) to determine whether compounds detected in samples are naturally occurring or are contaminants from past industrial practices. Statistical analysis of the pesticide detections from non-pesticide sites resulted in the establishment of WABOU reference concentrations for pesticides. More detailed discussion of the WABOU pesticide evaluation is provided in Appendix I of the WABOU RI report (CH2M HILL, 1997).

3.4 Summary

Groundwater at four out of 41 WABOU sites is contaminated with VOCs (Building 755 and 916), PCBs (Building 916), and pesticides (Building 905 and Landfill 3). Table 3-1 presents the groundwater contaminants at each site, the maximum concentrations, and the human health risk values associated with each contaminant. No groundwater COECs were identified in the WABOU. One additional groundwater site (Reservoir Facilities 1514/1518) was transferred to the Compliance Branch of the Travis AFB Environmental Office for disposition. The four WABOU sites were evaluated in the WABOU FS.

4.0 Summary of WABOU Groundwater Feasibility Study

Travis AFB conducted an FS in the WABOU to assist in selecting remedial actions for the four contaminated groundwater sites. The primary objectives of this study were to:

1. Identify potential response actions, technologies, and process options to address the potential risks in the WABOU
2. Screen the technologies and process options
3. Assemble feasible and appropriate remedial alternatives
4. Provide detailed evaluations of the remedial alternatives
5. Perform a comparative analysis of the alternatives

The FS can be divided into three main phases:

1. The Initial Screening of Alternatives
2. The Detailed Analysis of Alternatives
3. The Comparative Analysis of Alternatives

4.1 Initial Screening of Alternatives

The Initial Screening of Alternatives (ISA) was used to develop an appropriate range of remedial alternatives that would protect human health and the environment at the four groundwater sites identified in the WABOU RI. This was necessary because of the large number of remedial technologies available to handle a wide variety of contaminants under various site conditions.

With all of the combinations of treatment options available, the evaluation process could easily become too complicated and cumbersome. To prevent this, the ISA removed from consideration those technologies that were not appropriate for the contaminants and site conditions found in the WABOU. Then, it used the remaining technologies to develop the most promising remedial alternatives.

The screening process is divided into the following seven steps:

Step 1: Establish Remedial Action Objectives. Remedial Action Objectives (RAOs) specify the extent of cleanup required to protect human health and the environment. The RAO for a site takes into account the contaminant that poses the potential risk, the exposure routes and receptors, and an acceptable contaminant level or range of levels for each exposure route. This contaminant level or range of levels is called a Preliminary Cleanup Goal.

Step 2: Develop General Response Actions. General response actions describe the broad range of actions that will satisfy the RAOs.

Step 3: Identify Potential Remedial Technologies and Process Options. There are many potentially applicable technology types available to remediate all categories of contaminants under various site conditions. Some technologies have a proven record of performance, while others are promising but have not been tested under all field conditions. General technology types that can be used to implement a general response action are referred to as remedial technologies. Specific technology types within a remedial

technology are called process options. An example of a remedial technology for an administrative action is access restrictions; an example of a process option within this remedial technology is fencing. Information on remedial technologies and process options is acquired through data base searches and technical journal reviews. This review of all potentially applicable technologies ensures that the best technologies are not overlooked early in the FS process.

Step 4: Screen Process Options for Technical Implementability. In this step the evaluation of technical implementability reduces the list of technology and process options. Technical implementability refers to the ability of the remedial technology or process option to meet an RAO. The result of this step is a list of technologies and process options that are capable of addressing contaminant types found in the WABOU under existing site conditions.

Step 5: Technology Evaluation and Selection of Representative Process Options. The process options that survived the above screening are evaluated for administrative implementability, effectiveness and cost. Examples of administrative implementability are the ability to obtain the necessary permits and the availability of necessary equipment and workers to implement the process option. This evaluation further reduces the list of process options to those that can be implemented, are effective in treating the contaminants in the WABOU, and are not cost prohibitive.

Even after the above evaluations are completed, there may be a number of process options that could be used to meet the RAOs. From the list of remaining process options within each remedial technology, a representative process option is selected. The representative process option is used to develop the alternatives, but the other equally promising process options are retained.

Step 6: Assemble Remedial Alternatives. The representative process options are used to assemble remedial alternatives that represent a range of general response actions specifically for the WABOU sites.

Step 7: Screen Remedial Alternatives. In this final step of the ISA the remedial alternatives are screened to ensure that they are protective of human health and the environment, implementable and cost-effective. This is to verify that the combined groups of process options meet these three criteria.

The ISA resulted in the development of seven groundwater remedial alternatives. Table 4-1 provides a brief description of these alternatives

4.2 Detailed Analysis of Alternatives

The purpose of the Detailed Analysis of Alternatives (DAA) is to analyze the alternatives identified in the ISA and present the relevant information needed to select the appropriate remedies. This is accomplished by evaluating each alternative against seven of the nine criteria provided under CERCLA. Figure 4-1 defines the nine evaluation criteria. The other two criteria (Community Acceptance and State Acceptance) are addressed in this Interim Groundwater Record of Decision based on the acceptance of the WABOU Groundwater Proposed Plan and the evaluation of comments received during the April 8, 1998 – May 8, 1998 public comment period.

TABLE 4-1
Interim Groundwater Remedial Alternatives

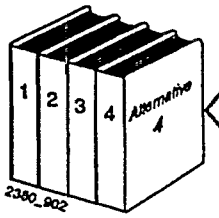
Remedial Alternative	Description
G1 - No Action	This serves as a starting point for comparing the other alternatives. No groundwater treatment takes place.
G2- Monitored Natural Attenuation (MNA)	MNA is a groundwater treatment strategy that relies on naturally occurring processes to prevent the spread of contamination. A major part of this strategy is the destruction of contaminants into harmless by-products by subsurface microorganisms. Groundwater monitoring is used to verify the effectiveness of this strategy.
G3 - Containment/ Treatment/Discharge	This alternative is designed to prevent the migration of the groundwater contamination. Groundwater is pumped from a series of extraction wells that are built near the leading edge of the contaminant plume. The resulting hydraulic barrier removes the contaminated groundwater before it can move past the extraction wells. The removed groundwater is treated using activated carbon and is either discharged to Union Creek or used for irrigation.
G4 - Extraction/ Treatment/Discharge	This alternative uses the extraction wells as described in alternative G3. It also places additional extraction wells in the more highly contaminated part of the plume in order to actively treat the whole plume. The removed groundwater is treated and is either discharged to Union Creek or used for irrigation.
G5 - Source Area and Groundwater Extraction/ Treatment/Monitored Natural Attenuation	This alternative applies only to Building 755 and is divided into three parts. The first part uses a vacuum-enhanced groundwater technology, DPE. A DPE system uses a vacuum to draw contaminated groundwater into an extraction well and at the same time lower the local water table. Exposed pools of solvents would then evaporate, and the vacuum removes the contaminated vapors. The water and vapors are cleansed in a treatment plant. This is designed to remove the source of contamination at this site. The second part uses extraction wells in the center of the plume to remove highly contaminated groundwater. The third part uses MNA to treat the portion of the plume with lower contaminant concentrations. MNA is described in Alternative G2.
G6 - Source Area Extraction/Treatment/ Monitored Natural Attenuation	This alternative also applies only to Building 755 and is divided into three parts. The first part is the DPE system that is described above. The second part uses a reactive wall in the subsurface to treat the contaminated groundwater as it passes through the wall. The third part uses MNA technology to treat the portion of the plume with lower contaminant concentrations. MNA is described in Alternative G2.

4.3 Comparative Analysis of Alternatives

In this final phase of the FS, the groundwater alternatives were evaluated based on how well they meet the individual CERCLA criteria. This analysis identified the advantages and disadvantages of each alternative, relative to each other, so that key tradeoffs could be used to select the preferred alternatives at each site. A sensitivity analysis was included in the Cost Comparative Analysis to determine how various uncertainties might affect the cost estimates. The following subsections present summaries of the comparison of the strengths and weaknesses of each alternative at each WABOU groundwater site.

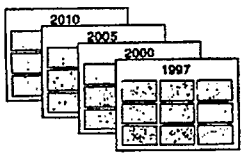
Alternatives G5 and G6 were designed specifically for Building 755, because this is the only WABOU groundwater site where pools of undissolved TCE are likely to be present beneath the local water table. This conclusion is based on the high TCE concentrations detected at the former sump area (source area).

Buildings 905 and 916 are evaluated together, because computer modeling of the groundwater capture zones indicated that a single groundwater extraction well would be capable of hydraulically containing the plumes at both buildings. As a result, Alternatives G1, G2, and G3 are the only alternatives that apply to these buildings.



1. **Overall Protection of Human Health and the Environment**
   Addresses whether a remedy provides adequate protection of human health and the environment and describes how risks are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

2. **Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)**
   Addresses whether a remedy will meet all ARARs [federal and state environmental statutes] and/or provide grounds for invoking a waiver.



3. **Long-term Effectiveness and Permanence**
   Refers to the ability of a remedy to maintain reliable protection of human health and the environment over time, once clean up goals have been met.

4. **Reduction of Toxicity, Mobility, or Volume (TMV) Through Treatment**
   Refers to the anticipated ability of a remedy to reduce the TMV of the hazardous components present at the site.

5. **Short-term Effectiveness**
   Addresses the period of time needed to complete the remedy, and any adverse impacts on human health and the environment that may be posed during the construction and implementation period, until the clean up goals are achieved.

6. **Implementability**
   Refers to the technical and administrative feasibility of a remedy, including the availability of materials and services needed to carry out a particular option.

7. **Cost**
   Evaluates the estimated capital and operation and maintenance costs of each alternative.

8. **State Acceptance**
   Indicates whether, based on its review of the information, the state concurs with, is opposed to, or has no comment on the preferred alternative.

9. **Community Acceptance**
   Indicates whether community concerns are addressed by the remedy and whether the community has a preference for a remedy. Although public comment is an important part of the final decision, EPA is compelled by law to balance community concerns with all of the previously mentioned criteria.

NOTE
The nine criteria are from the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988) and provide support for the selected Remedial Alternative.

FIGURE 4-1
NINE EVALUATION CRITERIA
WEST/ANNEXES/BASEWIDE OPERABLE UNIT (WABOU)
WABOU GROUNDWATER IROD
TRAVIS AIR FORCE BASE, CALIFORNIA

2443_902 (9/1/06)

CH2MHILL

4.3.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment serves as a threshold determination that must be met by any alternative for it to be selected as a remedy. Each of the groundwater alternatives, except for Alternative G1 (No Action), are protective of human health and the environment.

4.3.2 Compliance with ARARs

Compliance with ARARs also serves as a threshold determination that must be met by any alternative for it to be selected as a remedy. Each of the groundwater alternatives, except for Alternative G1 (No Action), will comply with ARARs.

4.3.3 Long-Term Effectiveness and Permanence

The *Long-term Effectiveness and Permanence* criterion is a measure of two principal factors: (1) the magnitude of residual risk; and (2) the adequacy and reliability of controls used to manage treatment residuals. Each of the groundwater alternatives, except for Alternative G1 (No Action), achieve some measure of long-term effectiveness and permanence. However, none of the alternatives as presently constituted achieve a high degree of effectiveness and permanence at Building 755. Table 4-2 provides a summary qualitative evaluation of the performance of each of the groundwater alternatives against this criterion on a site-by-site basis.

4.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Each of the groundwater treatment alternatives, including Alternative G1 (No Action), will achieve varying degrees of contaminant Reduction, Toxicity, Mobility, or Volume. However, Alternative G1 will not achieve reduction through treatment. Table 4-3 provides a summary qualitative evaluation of the performance of each of the groundwater alternatives against this criterion on a site-by-site basis.

TABLE 4-2
Summary of Comparative Analysis of Groundwater Alternatives – by Criterion Long-term Effectiveness and Permanence

	Groundwater Alternative					
Site	G1	G2	G3	G4	G5	G6
Building 755	O	O	✇	✇	✇	✇
Landfill 3	O	✇	✇	●	-	-
Building 905	O	✇	●	-	-	-
Building 916	O	O	●	-	-	-

Legend: Relative performance of the alternative at each site.

- ● Better satisfies criterion
- ✇ Moderately satisfies criterion
- O Poorly satisfies criterion
- \- Alternative not applicable at this site

Alternative G1 – No Action

Alternative G2 – Monitored Natural Attenuation

Alternative G3 – Containment/Treatment/Discharge

Alternative G4 – Extraction/Treatment/Discharge

Alternative G5 – Source Area and Groundwater Extraction/ Treatment/Monitored Natural Attenuation

Alternative G6 – Source Area Extraction/Treatment/ Monitored Natural Attenuation

TABLE 4-3
Summary of Comparative Analysis of Groundwater Alternatives – by Criterion Reduction of Toxicity, Mobility, and Volume through Treatment

	Groundwater Alternative					
Site	G1	G2	G3	G4	G5	G6
Building 755	O	O	✇	✇	●	●
Landfill 3	O	✇	✇	●	-	-
Building 905	O	✇	●	-	-	-
Building 916	O	✇	●	-	-	-

Legend: Relative performance of the alternative at each site.

- ● Better satisfies criterion
- ✇ Moderately satisfies criterion
- O Poorly satisfies criterion
- \- Alternative not applicable at this site

Alternative G1 – No Action

Alternative G2 – Monitored Natural Attenuation

Alternative G3 – Containment/Treatment/Discharge

Alternative G4 – Extraction/Treatment/Discharge

Alternative G5 – Source Area and Groundwater Extraction/ Treatment/Monitored Natural Attenuation

Alternative G6 – Source Area Extraction/Treatment/ Monitored Natural Attenuation

4.3.5 Short-Term Effectiveness

The *Short-term Effectiveness* criterion is a measure of the protection afforded by each alternative during the construction and implementation process. As such, the time until the remedial action objectives are achieved is an important component of the criterion. Each of the groundwater alternatives, except for Alternative G1 (No Action), is effective in the short term to some degree. Table 4-4 provides a summary qualitative evaluation of the groundwater alternatives against this criterion on a site-by-site basis.

TABLE 4-4
Summary of Comparative Analysis of Groundwater Alternatives – by Criterion Short-Term Effectiveness

	Groundwater Alternative					
Site	G1	G2	G3	G4	G5	G6
Building 755	O	O	✇	✇	✇	✇
Landfill 3	O	✇	✇	●	-	-
Building 905	O	✇	●	-	-	-
Building 916	O	✇	●	-	-	-

Legend: Relative performance of the alternative at each site.

- ● Better satisfies criterion
- ✇ Moderately satisfies criterion
- O Poorly satisfies criterion
- \- Alternative not applicable at this site

Alternative G1 – No Action
Alternative G2 – Monitored Natural Attenuation
Alternative G3 – Containment/Treatment/Discharge
Alternative G4 – Extraction/Treatment/Discharge
Alternative G5 – Source Area and Groundwater Extraction/ Treatment/Monitored Natural Attenuation
Alternative G6 – Source Area Extraction/Treatment/ Monitored Natural Attenuation

4.3.6 Implementability

The *Implementability* criterion evaluates the technical and administrative difficulties associated with implementing each alternative. An important component of technical implementability is consideration of the reliability of the technology. Each of the groundwater alternatives are implementable. Table 4-5 provides a summary qualitative evaluation of the groundwater alternatives against this criterion on a site-by-site basis.

TABLE 4-5
Summary of Comparative Analysis of Groundwater Alternatives – by Criterion Implementability

Site	Groundwater Alternative					
	G1	G2	G3	G4	G5	G6
Building 755	O	✇	●	●	●	●
Landfill 3	O	●	●	●	-	-
Building 905	O	●	●	-	-	-
Building 916	O	✇	●	-	-	-

Legend: Relative performance of the alternative at each site.

- ● Better satisfies criterion
- ✇ Moderately satisfies criterion
- O Poorly satisfies criterion
- \- Alternative not applicable at this site

Alternative G1 – No Action

Alternative G2 – Monitored Natural Attenuation

Alternative G3 – Containment/Treatment/Discharge

Alternative G4 – Extraction/Treatment/Discharge

Alternative G5 – Source Area and Groundwater Extraction/ Treatment/Monitored Natural Attenuation

Alternative G6 – Source Area Extraction/Treatment/ Monitored Natural Attenuation

4.3.7 Cost

Table 4-6 presents the total project cost estimates for each groundwater alternative at each site. These *Cost* criterion estimates are a total of the site-specific capital and annual Operations and Maintenance (O&M) cost estimates for implementing the alternative. The annual O&M cost estimates for Alternatives G2, G3, and G4 are based on a 30-year period of groundwater treatment plant operation. The annual O&M cost estimates for Alternatives G5 and G6 are based on a 10-year period of DPE operation and a 30-year period of groundwater treatment.

Detailed cost summary tables are provided in Appendix A of the *West/Annexes/Basewide Operable Unit Feasibility Study, 60th Air Mobility Wing, Travis Air Force Base* (CH2M HILL, 1998). The assumptions that were used to create the site-specific cost estimates are described in Section 8 of the above-cited document. These assumptions are divided into general project assumptions, such as well construction details and monitoring frequency, and site-specific assumptions, such as the selected treatment technology and the number of extraction and monitoring wells for each site.

TABLE 4-6
Cost Estimates for WABOU Groundwater Remedial Alternatives

Alternative	Site-Specific Total Project Cost Estimate ($)		
	Building 755	Landfill 3	Buildings 905/916
G1 – No Action	0	0	0
G2 – Monitored Natural Attenuation	510,300	565,400	532,800
G3 – Containment/Treatment/ Discharge	929,700	582,300	568,100
G4 – Extraction/Treatment/ Discharge	2,277,000	819,800	-
G5 – Source Area and Groundwater Extraction/Treatment/Monitored Natural Attenuation	4,950,000	-	-
G6 – Source Area Extraction/ Treatment/Monitored Natural Attenuation	7,406,000	-	-

4.4 Conclusion

The Comparative Analysis did not recommend the implementation of a specific alternative for each WABOU site. It described the overall performance and cost of each groundwater alternative at each site. The paragraphs below summarize the findings of this analysis.

At Building 755, Alternatives G3 through G6 were all comparable in the way they satisfy the criteria. Alternative G4-Extraction/Treatment/Discharge appeared to do a slightly better job at meeting the criteria, because it achieves capture of the contaminated groundwater at this site faster than the other alternatives. The main drawback with this alternative is that it does not address the source of the contamination. Suspected solvent pools beneath this site may release dissolved contaminants to the groundwater for a long time. Alternatives G5 and G6 address the source of the contamination, but rely on MNA to remediate the downgradient end the plume. Without the data needed to evaluate the capability of local natural attenuation processes, it was necessary to use conservative assumptions in the computer modeling which indicated that natural attenuation would need more than 100 years to remediate the contamination.

At Landfill 3, Alternative G4-Extraction/Treatment/Discharge was evaluated to best satisfy the criteria. Alternative G4 was judged superior to Alternative G3 because it included extraction at the source and thereby captured the plume more quickly. Pump-and-treat options were considered superior to MNA mainly because of lack of natural attenuation data. Alternatives G5 and G6 are not applicable at Landfill 3.

At Buildings 905 and 916, Alternative G3-Containment/Discharge/Discharge was evaluated to best satisfy the criteria. Alternative G2 (MNA) was the only viable alternative to compare to Alternative G3, and Alternative G2 does not compare well because of the lack of natural attenuation data at these sites. Alternatives G4, G5, and G6 did not apply at these sites.

5.0 Interim Groundwater Remedial Actions

Travis AFB has selected interim groundwater remedial actions for the four WABOU groundwater sites. Each of the selected remedies will protect human health and the environment and comply with ARARs. They are effective at reducing contamination, are implementable and cost-effective, and are acceptable to the public and the State of California. These decisions are based on the environmental conditions and the nature and extent of groundwater contamination found at each site. They are also based on the technology and U.S. EPA criteria evaluations from the WABOU FS. The following subsections present these selected actions and the rationale for the decisions.

5.1 Building 755 (DP039)

Alternatives G5—Source Area and Groundwater Extraction/Treatment/Monitored Natural Attenuation and **G3—Containment/Treatment/Discharge** are the selected alternatives for Building 755. The Air Force believes that a combination of these two alternatives offers the best opportunity to achieve the groundwater cleanup in an efficient and cost-effective manner.

5.1.1 Alternative G5—Source Area and Groundwater Extraction/Treatment/ Monitored Natural Attenuation

Alternative G5 is a three-part strategy that starts with an aggressive approach toward removing the groundwater contamination source. The former battery acid neutralization sump was used for the disposal of chlorinated solvents, and the high solvent concentrations found in the former sump area (210,000 ppb of TCE) are indicative of the presence of dense non-aqueous phase liquid (DNAPL) beneath the water table. Since solvents tend to dissolve into water very slowly, it is likely that the groundwater alternatives that rely on standard pump-and-treat methods would take a very long time to reduce these high solvent concentrations.

The Air Force will construct a DPE system to remove the highly concentrated VOC contamination beneath the former sump area. A DPE system applies a vacuum to the subsurface soil layers and draws contaminated water into the extraction well, thereby lowering the local water table in the vicinity of the solvent pools. The vacuum also stirs up the air between the soil particles. Any undissolved solvent pools that are exposed to the air by the lowered water table will evaporate, and the vacuum will draw contaminated vapors out of the extraction well. Air is more efficient in removing solvents than water, because the solvents evaporate quickly. So, the goal of using a DPE system is to remove the source area in less time than by using standard groundwater pump-and-treat methods.

The second part of the cleanup consists of the installation of at least one extraction well in the central portion of the groundwater plume. This will reduce the high concentrations of dissolved solvents and the potential risk that they pose. The actual number and placement of the well(s) will be determined after taking into account the effect of the DPE system on the groundwater plume. Figure 5-1 shows the conceptual design of Alternative G5 at Building 755.

To ensure that the plume will not migrate any further, the Air Force has added Alternative G3 to the Alternative G5 cleanup strategy. Alternative G3 uses a row of extraction wells

around the plume to prevent its further expansion. Figure 5-2 presents the conceptual layout of this alternative. The Air Force will then test the MNA component of Alternative G5 through the collection of analytical data in accordance with U.S. EPA and California guidelines. This data will be used to determine whether the subsurface microorganisms are active and capable of breaking down the contaminants and preventing the spreading of the plume.

The implementation of the groundwater treatment strategy at Building 755 will be designed to remove the maximum amount of contamination as quickly as possible and not promote the migration of highly contaminated groundwater to areas with lower contaminant concentrations. As a result, the Air Force will use a phased approach to build the treatment system and collect groundwater data. In general, the remedial activities will start at the source area (former sump area) and continue in the downgradient direction.

5.1.1.1 Phase 1—DPE Construction

The groundwater remedial actions will begin with the construction and operational testing of the DPE system. This system will be designed to lower the local water table and volatilize the DNAPL pools that are exposed to the air. The objective of this phase is to remove the source of the existing plume and thus prevent the future generation of contaminated groundwater.

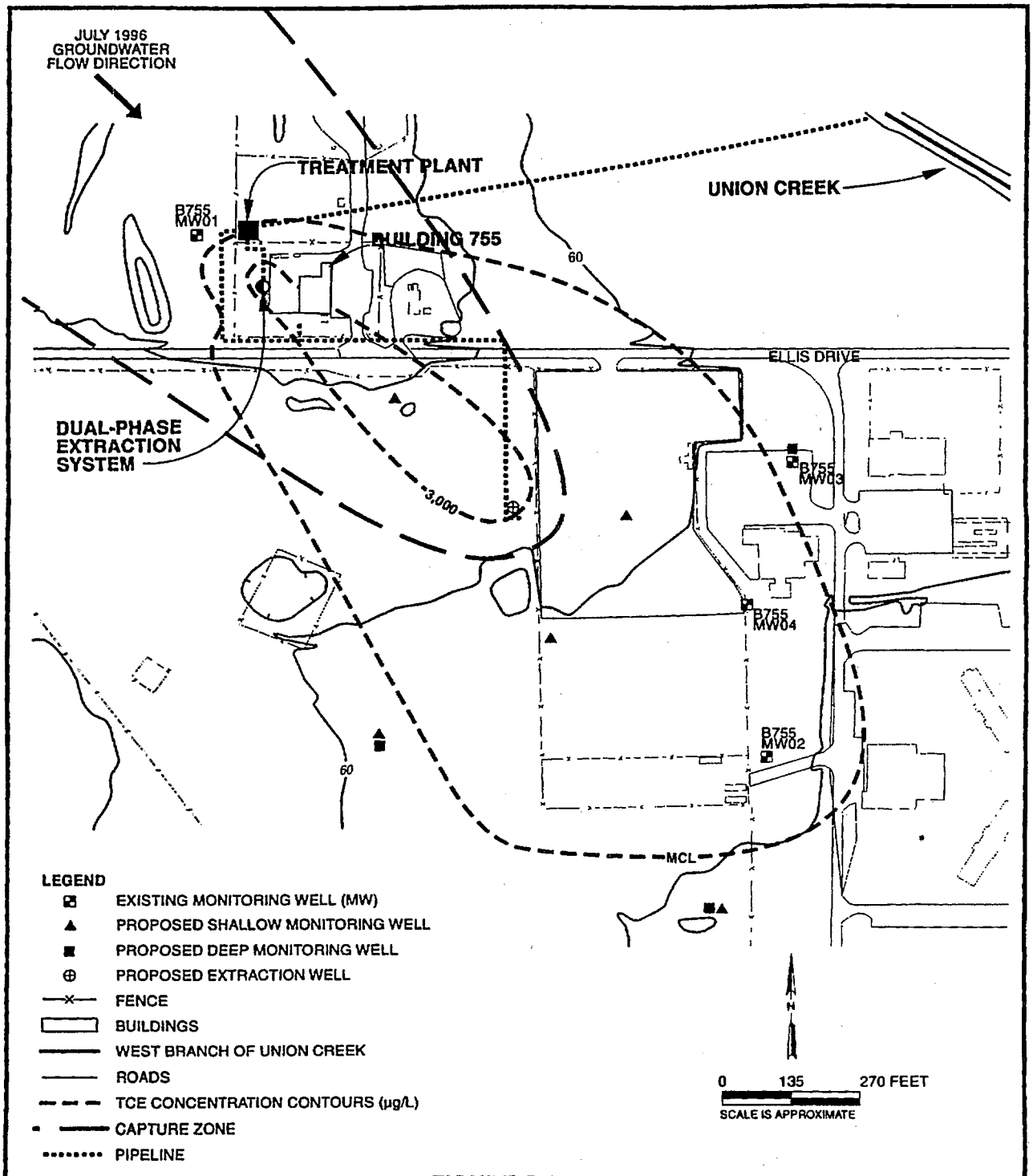
One important aspect of the DPE system operational test is the measuring of the system's radius of influence. Monitoring wells and piezometers will be adapted and installed to measure the impact of the vacuum on the downgradient strata and the local groundwater flow. This information is needed to properly design and place the downgradient extraction well(s) in the next phase.

Another activity in this phase will be the data collection for the evaluation of MNA in the downgradient portion of the plume. Monitoring wells will be installed throughout the plume, and groundwater sampling and analysis will take place. The Air Force anticipates that the operational testing of the DPE system will have no impact on this groundwater sampling effort. The first (and possibly second) round of data collection will serve as a baseline for existing environmental conditions and the status of the plume. Subsequent sampling rounds will be used to demonstrate any changes to the plume, either by MNA or by the engineered activities.

5.1.1.2 Phase 2—Groundwater Extraction

Once the DPE system is fully functional, the first groundwater extraction well will be installed. The purpose of this well is to remove the highly contaminated dissolved portion of the plume. The placement of this well will be based on the calculated capture zone of the well, taking into account the impact of the operational DPE system. The piping system will be designed to allow for flexibility in case additional downgradient extraction wells are needed. It is possible that the decision for additional extraction wells may be made once the DPE system is operational, depending on the evaluation of the collected data.

Once the groundwater extraction well(s) is/are installed, data collection will continue to determine the revised radius of influence of the overall extraction system. An attempt will be made to design and place the installed monitoring wells so that they can be used for both system monitoring and natural attenuation data collection.

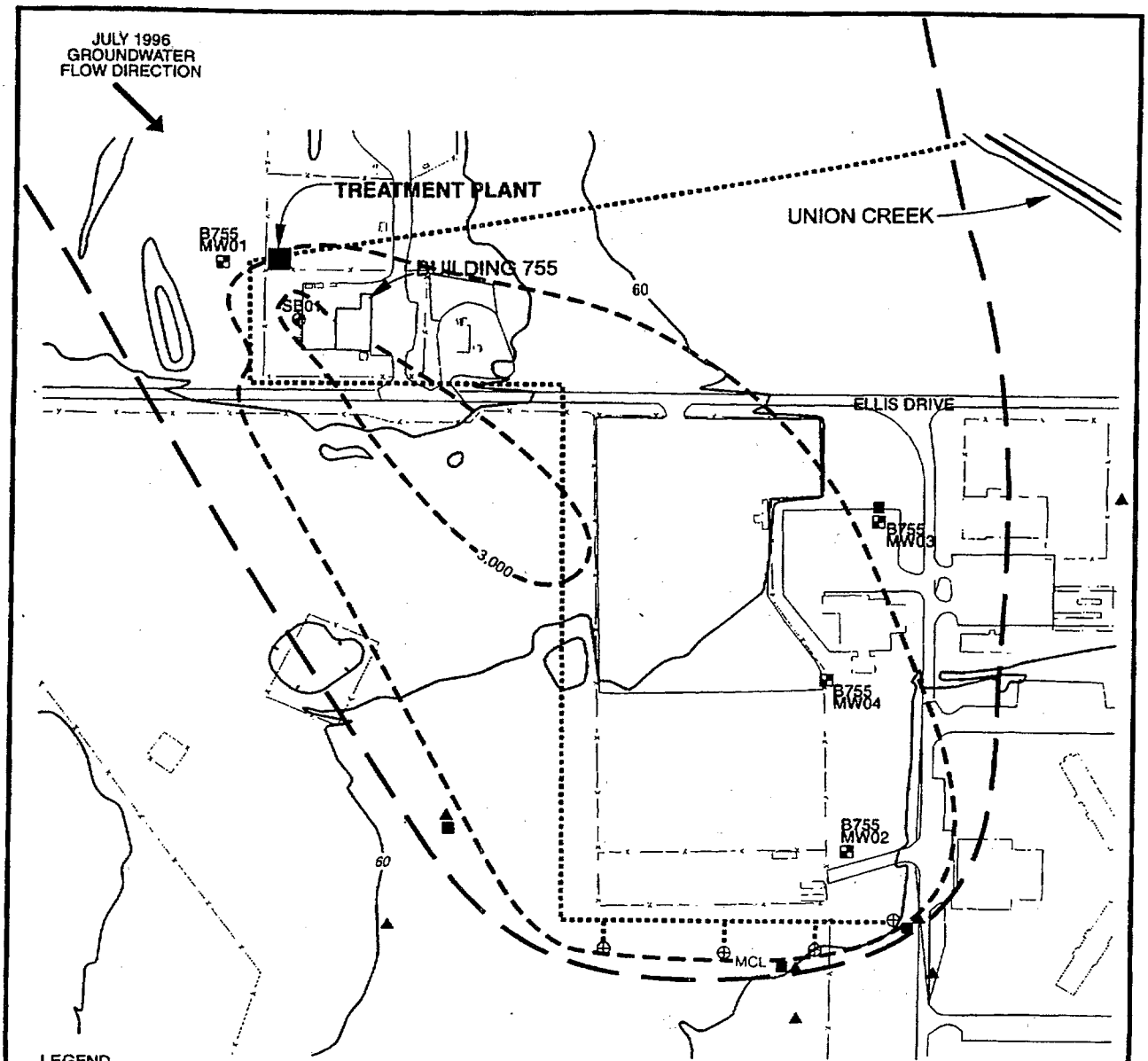


NOTE
MCL FOR TCE IS 5 µg/L.

FIGURE 5-1
ALTERNATIVE G5 —
SOURCE AREA AND GROUNDWATER EXTRACTION/ TREATMENT/ MONITORED NATURAL ATTENUATION CONCEPTUAL DESIGN AT BUILDING 755
WEST/ANNEXES/BASEWIDE OPERABLE UNIT (WABOU)
WABOU GROUNDWATER IROD
TRAVIS AIR FORCE BASE, CALIFORNIA

2443_916 (9/1/98)

CH2MHILL



NOTE
MCL FOR TCE IS 5 µg/L

FIGURE 5-2
ALTERNATIVE G3 — CONTAINMENT/TREATMENT/ DISCHARGE CONCEPTUAL DESIGN AT BUILDING 755
WEST/ANNEXES/BASEWIDE OPERABLE UNIT (WABOU)
WABOU GROUNDWATER IROD
TRAVIS AIR FORCE BASE, CALIFORNIA

2443_814 (9/1/98)
/b/travis/plots/tce2.aml

CH2MHILL

5.1.2 Alternative G3—Containment/Treatment/Discharge

The Air Force added this alternative to the Alternative G5 treatment strategy to comply with specific State ARARs that are concerned with groundwater and plume migration. The purpose of Alternative G3 is to prevent plume migration by constructing a hydraulic barrier of extraction wells near the leading edge of the plume. By definition, containment is achieved when groundwater along a flow line that originates at any location within the plume, at any depth in the aquifer, is moving toward and into an extraction well.

5.1.2.1 Phase 3—Installation of the Alternative G3 Wells

In this last construction phase the extraction wells on the outer downgradient edge of the plume will be installed. The number and placement of these wells will be based on the revised calculated capture zone of the Alternative G5 system that is already in operation. Figure 5-2 shows the conceptual design of Alternative G3 at Building 755.

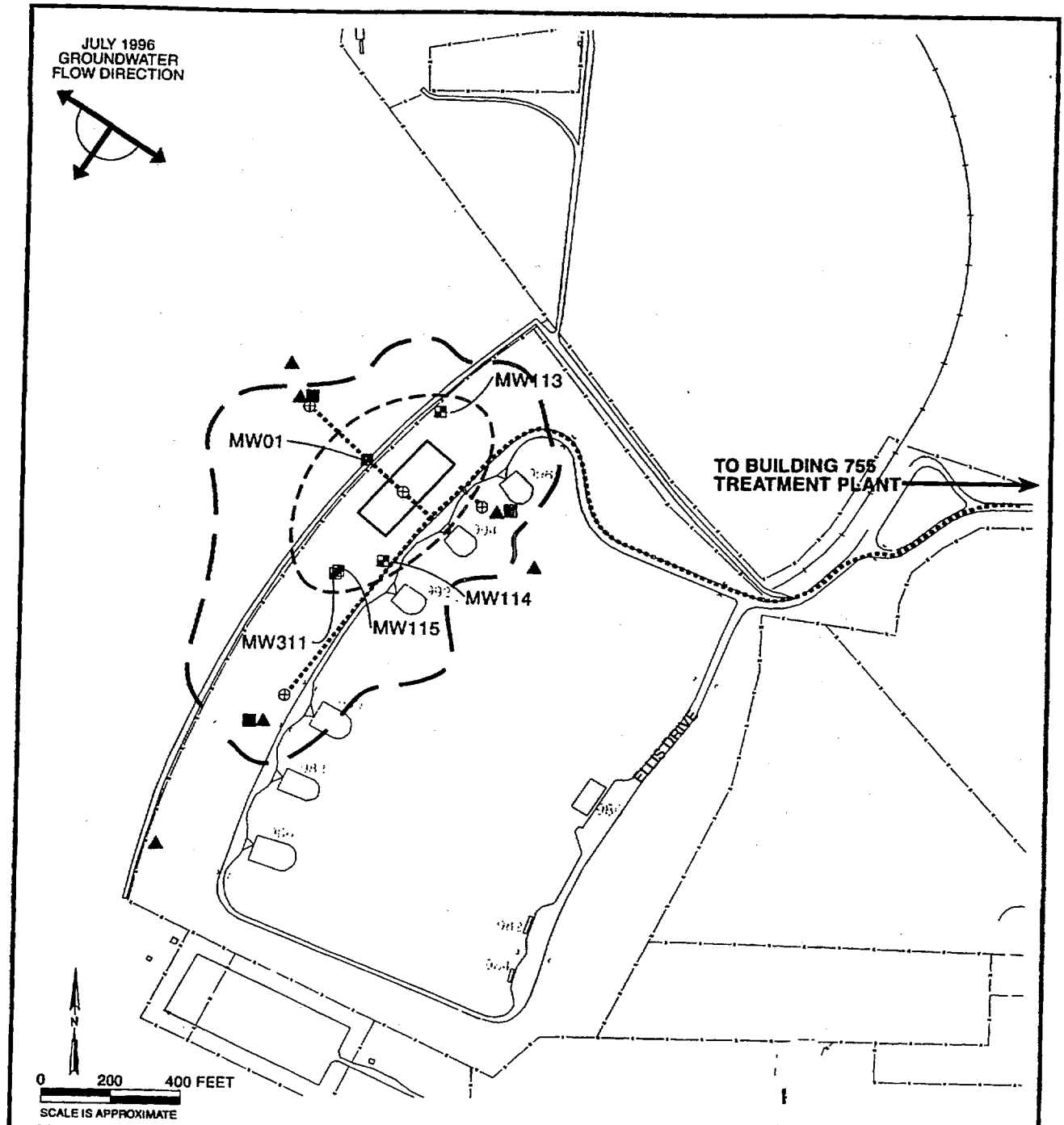
There is a possibility that the Air Force will look at innovative technologies for the migration control wells. For example, researchers at the University of California, Davis, have developed a multistage in-well aeration system that is designed to remove VOCs from groundwater in an effective and inexpensive manner. The regulatory agencies will be involved in any treatability study that may be conducted to demonstrate the abilities of these types of innovative systems.

5.2 Landfill 3 (LF008)

Alternative G4—Extraction/Treatment/Discharge is the selected alternative for Landfill 3. This alternative uses standard pump-and-treat technology. Three extraction wells are placed around the pesticide trenches to prevent contaminated groundwater from moving away from the site. An additional extraction well is placed in the center of the pesticide trenches to remove contaminated groundwater from beneath the trenches. Figure 5-3 shows the conceptual design of Alternative G4 at Landfill 3.

This is the most aggressive cleanup strategy for this site. The older pesticides at this landfill are resistant to natural breakdown processes, so Alternative G2 may not be successful in stopping future plume migration. Alternative G3 would eventually meet cleanup goals, but it is not as effective at removing contamination and may have a longer cleanup time.

Before the groundwater cleanup can begin, the pesticide-contaminated debris and soil in the trenches that contribute to the groundwater contamination need to be removed. This portion of the site remediation is discussed in greater detail in the WABOU Soil Proposed Plan. It is possible that the soil remediation may not be scheduled prior to the start of the Alternative G4 treatment plant construction due to programming or funding limitations. In this case, the Air Force and the regulatory agencies will review all schedule options and select the most appropriate approach to conducting the soil and groundwater remedial actions without causing a significant project cost increase.



2443_919 (9/1/98)

FIGURE 5-3
ALTERNATIVE G4 — EXTRACTION/TREATMENT/DISCHARGE CONCEPTUAL DESIGN AT LANDFILL 3
WEST/ANNEXES/BASEWIDE OPERABLE UNIT (WABOU)
WABOU GROUNDWATER IROD
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

5.3 Buildings 905 (SS041) and 916 (SD043)

Alternative G3—Containment/Treatment/Discharge is the selected alternative for Buildings 905 and 916. As mentioned in previous sections, these sites are discussed together, because the two buildings are located close together, and a groundwater modeling computer program used in the WABOU FS predicted that a single extraction well would capture the contaminated groundwater from *both* sites.

The groundwater contaminants found beneath Buildings 905 and 916 are TCE, PCB-1254, and pesticides. The older pesticides at Building 905 and the PCB 1254 at Building 916 are resistant to natural degradation processes, so Alternative G2 may not be successful in stopping future plume migration.

Since the results of the computer modeling indicate that Alternative G3 is capable of capturing the groundwater plumes from both sites with only one extraction well, it is the selected alternative. Figure 5-4 presents the conceptual layout of Alternative G3 at Buildings 905 and 916.

5.4 Treatment

For Building 755, treatment of the vapor-phase VOCs generated from the DPE system will be conducted at an on-site Vapor-Phase Granular Activated Carbon (VGAC) treatment plant. Treatment of the extracted groundwater will be accomplished locally using a Liquid-Phase Granular Activated Carbon (LGAC) treatment system or through a centrally located groundwater treatment system that would be capable of treating contaminated groundwater from multiple sites.

For Landfill 3 and Buildings 905 and 916, treatment of the extracted groundwater will be by LGAC locally or by a centrally located groundwater treatment system that would be capable of treating contaminated groundwater from multiple sites.

The rationale for the selection of the treatment technologies mentioned above is found in Appendix C of the *West/Annexes/Basewide Operable Unit Feasibility Study, 60th Air Mobility Wing, Travis Air Force Base, California* (CH2M HILL, 1998).

The Air Force developed Interim Cleanup Goals for the WABOU to measure the performance of each groundwater treatment system. These goals are chemical concentrations that are defined as protective of human health and the environment. These goals are similar to the final cleanup levels that will be presented in the basewide groundwater ROD but are not enforceable standards. Table 5-1 presents the interim cleanup goals for the WABOU groundwater sites.

The Air Force will treat the extracted groundwater until contaminants have been reduced to the discharge standards presented in Section 6.0.

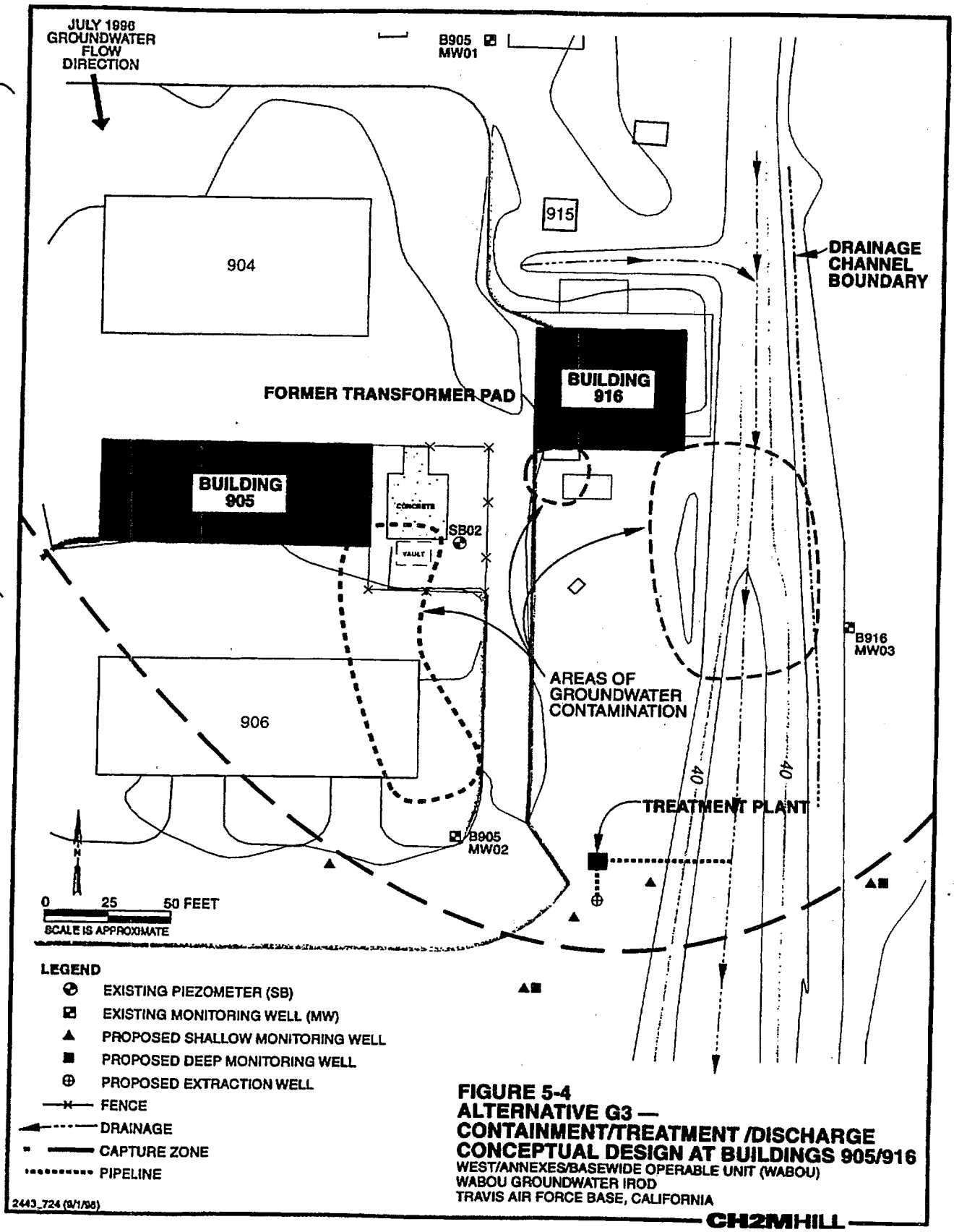
TABLE 5-1
Interim Cleanup Goals for Groundwater COCs

Site Name	Groundwater COC	Interim Cleanup Goal (µg/L)	California MCL[a] (µg/L)	Federal MCL (µg/L)	WABOU Reference Concentration[b]
Building 755 (DP039)	1,1-DCE	6	6	7	NA[c]
	1,2-DCA	0.5	0.5	5	NA
	1,1,1-TCA	0.5	0.5	5	NA
	1,1,2-TCA	0.5	0.5	5	NA
	acetone	5110	-	-	NA
	bromo-dichloromethane	100	100	100	NA
	methylene chloride	5	5	5	NA
	PCE	5	5	5	NA
	TCE	5	5	5	NA
Landfill 3 (LF008)	aldrin	0.023	-	-	0.023
	alpha-chlordane	0.1	0.1	2	0.02
	heptachlor	0.01	0.01	0.4	0.02
	heptachlor epoxide	0.01	0.01	0.2	0.024
Building 905 (SS041)	heptachlor epoxide	0.01	0.01	0.2	0.024
Building 916	PCB-1254	1.02	-	-	NA
(SD043)	TCE	5	5	5	NA

[a] MCL = Maximum Contaminant Level (RWQCB, 1995) for drinking water
[b] The discussion of the WABOU reference concentration is found in Section 3.3.
[c] NA – Not Applicable

5.5 Treated Water Disposal

In general, treated water from the groundwater treatment systems at all four WABOU groundwater sites will be used as beneficial use water during the dry summer months and will be discharged into Union Creek during the wet winter months. Three possible beneficial uses of the treated water are landscape irrigation of installation grassland, industrial uses such as aircraft or car washing, and dust suppression for construction activities. Travis AFB will use most of the reused treated groundwater for landscape irrigation. Travis AFB will discharge treated groundwater that cannot be beneficially used to the sanitary sewer operated by the Fairfield-Suisun Sewer District, if feasible, or to Union Creek. At times treated water may need to be discharged into Union Creek during the dry summer months if the need arises.



2443_724 (9/1/98)

FIGURE 5-4
ALTERNATIVE G3 — CONTAINMENT/TREATMENT /DISCHARGE CONCEPTUAL DESIGN AT BUILDINGS 905/916
WEST/ANNEXES/BASEWIDE OPERABLE UNIT (WABOU)
WABOU GROUNDWATER IROD
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

The NEWIOU Groundwater RD/RA Plan uses the Treated Groundwater Use Plan to strategize the specific use of treated groundwater and to estimate irrigation and industrial needs for the Base. This Plan also contains a decision matrix that outlines the rationale and method for treated groundwater discharge at Travis AFB. The WABOU addendum to this Plan will follow this approach.

The volumes of treated groundwater discharged to Union Creek will be estimated and measured during the RD/RA phase to ensure there are no adverse impacts to Union Creek. Groundwater extraction and treatment will take place in phases, which will gradually increase the amount of treated water available for use. By 1999, Travis AFB might extract and treat approximately 413 gallons per minute (gpm) from both NEWIOU and WABOU groundwater sites. The Treated Groundwater Use Plan presents the assumptions used to derive this rate.

Before the treated water reaches Union Creek, it is sampled and analyzed to verify that it meets appropriate water quality standards. The Air Force will meet the discharge requirements for treated groundwater as presented in Section 6.0. Additional NPDES substantive requirements for sampling, monitoring, and reporting will be established for each new discharge. These requirements will be based on the descriptions of treatment units with schematic drawings and design criteria, operation and maintenance procedures, results of chemical analyses of untreated groundwater (influent) at each site, projected maximum concentrations, projected flow rates, topographic maps showing exact locations of proposed discharges, and other appropriate data. These NPDES substantive requirements will be presented in each site-specific WABOU RD/RA work plan. Discharges of treated water to Union Creek are subject to approval by the SFBRWQCB.

5.6 Land Use Restrictions

The Air Force has land use restrictions in place at the four WABOU groundwater sites. These administrative actions restrict the use of onbase groundwater from these contaminated sites. Travis AFB does not currently use its onbase groundwater for drinking water. These actions also restrict soil excavation and other subsurface work where the excavation worker will encounter contaminated groundwater or vapors. These subsurface activities are only allowed after environmental and worker safety control measures are in place. Travis AFB uses its digging permit program to coordinate, and if necessary, restrict contractor and Base personnel access to contaminated areas. In addition, Travis AFB will amend its General Plan to document additional land use restrictions, once the final remedial actions are selected in the basewide groundwater ROD. A detailed description of the existing land use restrictions at the four WABOU groundwater sites will be included in the addendum to the NEWIOU Groundwater RD/RA Plan.

Groundwater beneath Travis AFB is not used to provide potable water to the Base; so the Air Force does not need a contingency plan to replace the onbase water supply.

5.7 Groundwater Monitoring

Groundwater monitoring will be used at all WABOU groundwater sites to document the effectiveness of the interim actions. The details of the groundwater monitoring strategy at each site, such as monitoring well locations and sampling interval, will be presented in the site-specific RD/RA work plans. Groundwater monitoring of each treatment system will be

initiated during the RA and will be transferred to the Travis AFB Groundwater Sampling and Analysis Program (GSAP) after a period of at least one year.

5.8 Statutory Determinations

This section discusses the applicability and compliance of the following statutory determinations:

- Protectiveness
- Applicable or Relevant and Appropriate Requirements
- Cost-Effectiveness
- Use of Permanent Solutions, Alternative Treatment, or Resource Recovery Technologies
- Preference for Treatment as a Principal Element
- State and Community Acceptance

5.8.1 Protectiveness

These selected remedies are protective of human health and the environment in the short term and are designed to increase protection until the final basewide groundwater ROD is signed. They achieve protection by removing source areas of contamination that can cause the degradation of the local groundwater for a long time. They also prevent the migration of contaminated groundwater beyond the current plume boundaries.

5.8.2 Applicable or Relevant and Appropriate Requirements

The selected remedies comply with state and federal ARARs. The groundwater ARARs are presented in Section 6.0.

5.8.3 Cost-Effectiveness

The technologies selected in implementing the groundwater remedial actions at each site are the most cost-effective technologies that can meet the WABOU Remedial Action Objectives. The details of the technology selection are presented in Appendix C of the WABOU FS.

5.8.4 Use of Permanent Solutions, Alternative Treatment, or Resource Recovery Technologies

The selected remedies utilize permanent solutions to the potential threats posed by groundwater contamination at each site to the maximum extent practicable. The use of innovative technologies such as DPE is designed to remove large quantities of contaminant mass before they are able to dissolve into the local groundwater. Standard pump-and-treat systems will be used to prevent plume migration and remove dissolved contamination. MNA of dissolved chlorinated solvents is an innovative and cost-effective treatment strategy that may be capable of remediating contaminated groundwater.

5.8.5 Preference for Treatment as a Principal Element

Each remedy will effectively use active treatment to address the principal potential threats posed by contaminated groundwater. The evaluation of MNA, an in-situ treatment technology, is included as a component of the selected alternative for Building 755. The Air Force will use the groundwater treatment systems at each WABOU site to maximize contaminant

removal from the groundwater to the extent practicable. The Air Force will also determine whether MNA is an appropriate treatment technology for Building 755.

5.8.6 State and Community Acceptance

The State of California (DTSC and SFBRWQCB) concurs with the Air Force and the U.S. EPA in the selection of the interim actions described in this section for the WABOU groundwater sites.

Based on the comments received during the April 8, 1998 to May 8, 1998, public comment period, the public has no preference of alternatives. The public comments received and the Air Force response is provided in Part III (Responsiveness Summary).

5.9 RD/RA Implementation and Schedule

The Air Force will implement the RD/RA in accordance with this IROD. In accordance with the Travis AFB FFA, the Air Force will present a schedule for completing and submitting the site-specific RD/RA work plans and RDs to the regulatory agencies within 21 days of signing the WABOU Groundwater IROD.

The WABOU RD/RA schedule is based on the Travis AFB IRP Priority Model. This model is a planning tool used by Travis AFB to prioritize funding and schedule remedial actions for IRP sites. Factors considered in this model include human health risk, offbase migration, ecological risk, public interest, MNA, mass of contaminants, groundwater concentration, capital cost, project execution, and projected funding levels.

Previously the Air Force created a NEWIOU Groundwater Remedial Design/Remedial Action Plan to describe the overall rationale for treatment and discharge of extracted groundwater for all NEWIOU groundwater sites. It also included the NEWIOU RD/RA schedule and a decision matrix for selecting the treatment technologies at each NEWIOU site. The Air Force will add an addendum to this work plan to include a detailed description of the treatment and discharge of extracted groundwater for the WABOU sites. The addendum will also include the WABOU RD/RA schedule. The Air Force will provide an opportunity for public participation during the Remedial Design phase.

Previously, the Air Force created a NAAP to provide the methodology used to evaluate the potential use of MNA at NEWIOU sites. The Air Force will add an addendum to the NAAP to include a description of the approach to be used for the evaluation of the MNA component of Alternative G5 at Building 755.

In addition to the addendum to the Groundwater NEWIOU RD/RA Plan, the Air Force will prepare a site-specific RD/RA work plan for each WABOU groundwater site. The site-specific RD/RA work plans will present the placement of monitoring wells, groundwater monitoring protocols and frequency, and procedures to determine whether plume migration above water quality objectives is occurring. The regulatory agencies will review each of the site-specific WABOU RD/RA work plans. If a contingency action is necessary to control migration, the Air Force will request funding and implement a contingency action as soon as funding becomes available.

If the RD investigation reveals an interaction between groundwater and a preferential pathway, then an appropriate remedial action will be proposed for the site and documented in an amendment to this Groundwater IROD. There is no potential for contaminated

groundwater to migrate along storm and sanitary sewer lines, based on a comparison of the highest measured level of the local water table with the location and depth of the local sanitary and storm sewer lines the WABOU. However, if future data collection suggests that contaminated groundwater has migrated to an area where interaction with preferential pathways is likely, the Air Force will investigate the potential interaction during the RD. At locations where the Air Force has verified the migration of contaminated groundwater to the storm sewer or Union Creek, the Air Force will expand the interim remedial action to control migration. The Air Force will continue to monitor the effectiveness of its interim actions to ensure that plume migration is controlled.

The Air Force will implement interim groundwater remedial actions as described in this WABOU Groundwater IROD. The Air Force will monitor all sites and will measure the change in contaminant concentrations. The Air Force will utilize the monitoring results to evaluate the potential for using the MNA component of Alternative G5 at Building 755. The Air Force and regulatory agencies will periodically review the analytical and performance data from these actions to verify their effectiveness and the need for additional action(s). The Air Force and regulatory agencies will hold a formal program review after the IROD is signed and after sufficient analytical and performance data have been collected. The purpose of the program review will be to determine the final basewide remedial actions and cleanup levels that are technically and economically feasible for each groundwater site at Travis AFB.

5.10 Documentation of Significant Changes

There have not been any significant changes to the selected remedies since the Air Force submitted the WABOU Groundwater Proposed Plan for public comment on April 8, 1998.

6.0 List of Applicable or Relevant and Appropriate Requirements and Performance Standards

6.1 Overview

Under CERCLA, remedial actions designed to clean up or abate contaminants in the groundwater or in soils, must be designed, constructed and operated to comply with all federal and more stringent state ARARs. ARARs include both federal requirements under any federal environmental law and state requirements under state environmental or facility-siting laws which are more stringent than federal requirements and that have been identified by the State of California in a timely manner.

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. Relevant and appropriate requirements include those that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, nevertheless address problems or situations sufficiently similar to those encountered at the CERCLA site to indicate their use is well suited to the particular site. If a given requirement is both relevant and appropriate to a particular site, it constitutes a valid legal requirement for that site. A requirement must either be applicable or both relevant and appropriate to be an ARAR. If no ARAR addresses a particular situation, or if an ARAR is insufficient to protect human health or the environment, then non-promulgated standards, criteria, guidance, and to be considered (TBC) advisories are identified as additional performance standards in the ROD.

In general, onsite actions need to comply only with the substantive aspects of these requirements, not with corresponding administrative requirements (such as, but not limited to, permits, recordkeeping, and reporting).

All laws and statutes identified as ARARs for a particular site or action must be considered and applied during the design, construction, and operation of any remedial action at the particular site. ARARs are identified on a site-specific basis from data and information concerning that site. Data and information concerning the objectives of site remediation, specific actions that are being considered as remedies at that site, the hazardous substances located upon the site, the physical and geological characteristics of the site, and the potential human and ecological receptors at or near the site must be analyzed and considered in order to properly identify ARARs at a particular site. All federal and more stringent state requirements that address or impact any of these conditions must be included as site ARARs.

The three categories of ARARs are described below:

Chemical-Specific ARARs establish numerical values or provide methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. The Air Force developed these ARARs by identifying the contaminants at a site which pose a threat to human health or the environment and must be remediated. Chemical-specific ARARs determine acceptable concentrations of specific hazardous substances, pollutants,

and contaminants in the environment and establish the levels to which the soil or groundwater at the affected site must be cleaned or restored in order to protect human health and the environment. Chemical specific ARARs also establish the levels at which certain actions must be taken while transporting, treating, or storing hazardous wastes recovered during remediation. .

Location-Specific ARARs are designed to protect the unique characteristics of the site or other areas potentially affected by site activities during the design, construction, or operation of remedial activities. Location-specific ARARs place restrictions on the concentration of hazardous substances or the conduct of activities solely because the site occurs in, or may affect, a special location. Some examples include the protection of wetlands and vernal pools; protection of endangered or threatened species and their habitats; and the protection of fish and game from unauthorized taking.

Action-Specific ARARs are technologically or activity-based requirements or limitations on the particular remedial actions at the site. Some examples include prohibitions or restrictions against the discharge of chemicals or contaminants to the air, water, or soil and the proper transfer, treatment or storage of chemicals and contaminants.

6.2 ARARs Identification, Development, and Evaluation

6.2.1 Methodology

As lead agency, the Department of the Air Force has performed each of the following actions consistent with CERCLA and the NCP:

Identified federal ARARs for each remedial action alternative addressed in the WABOU FS, taking into account site-specific conditions found in the WABOU.

Reviewed potential state ARARs identified by the state in order to determine whether each potential ARAR satisfied CERCLA and NCP criteria that must be met in order to qualify as state ARARs.

Evaluated and compared federal ARARs and their state counterparts in order to determine which state ARARs are more stringent or are in addition to the federal ARARs.

Reached a conclusion as to which federal and state requirements were the most stringent ARARs for each alternative.

6.2.2. Solicitation, Identification, and Evaluation of State ARARs

The Department of the Air Force followed the procedures of the process set forth in 40 CFR Section 300.515 and the Travis AFB FFA for remedial actions in seeking state assistance in identification of state ARARs.

The CERCLA, NCP, and FFA requirements for remedial actions provide that the lead federal agency request that the state identify chemical-specific and location-specific state ARARs. The Air Force requested chemical-, location-, and action-specific ARARs from DTSC on 20 February 1997. The request letter included as an attachment the ARARs tables developed during the NEWIOU FS. These tables were developed using responses from:

- California Integrated Waste Management Board
- Department of Toxic Substances Control Board

- State Water Resources Control Board
- California Regional Water Resources Control Board
- Bay Area Air Quality Management District
- California Department of Fish and Game

With few exceptions, the site conditions at both operable units are similar, so this approach was used to simplify the WABOU ARARs selection process for both the state and the Air Force. The tables were made available so that the state could identify additional requirements, if any, to be included as ARARs, or identify those requirements which were not applicable to the WABOU. The state did identify additional requirements that address radiological remediation sites and actions.

During the review and analysis of ARARs identified by the state, and following considerable discussion with the representatives from the various state agencies, many of the requirements identified by the state as potential ARARs were determined to be valid ARARs by the Air Force. These ARARs are presented in this section of the WABOU Interim Groundwater ROD. However, there are a few issues between the Air Force and the State concerning final groundwater cleanup levels based on the scope and/or applicability of several potential groundwater ARARs which have not yet been resolved. These potential ARARs may impact the duration of cleanup activity at the four WABOU groundwater sites and are discussed in more detail in Section 6.4.3.

6.3 Determination of ARARs

6.3.1 Methodology

The ARARs identified in this section have been used to establish the requirements for WABOU sites and interim remedial alternatives. The ARARs in this section identify those requirements that are applicable or relevant and appropriate to groundwater remediation, those that had no relevancy were excluded. Specifically excluded were:

1. Location-specific requirements addressing conditions not present at WABOU remediation sites.
2. Chemical-specific requirements for COCs not present at WABOU remediation sites.
3. Action-specific requirements for remedial alternatives not utilized at WABOU remediation sites.

The list of ARARs for WABOU sites and groundwater remedial actions is provided in Tables 6-1 through 6-5.

6.4 ARARs Evaluation and Discussion

6.4.1 Action-Specific ARARs

These ARARs place restrictions on remedial activities that may negatively impact the surrounding environment. The WABOU groundwater remedial alternatives were analyzed to identify potential impacts to the environment. Considered were:

- **Hazardous Waste Treatment, Storage and Disposal Requirements**—These requirements are technology or activity-based requirements that place limitations on actions taken with respect to the hazardous waste. Regulations promulgated under the

applicable provisions of the state authorized federal RCRA and more stringent provisions of the California Hazardous Waste Control Law (HWCL) are relevant and appropriate to RCRA-permitted storage facilities and proper characterization of hazardous waste, and storage and disposal of such waste. If any hazardous wastes are identified which will be transported offsite, they will be disposed of and handled under applicable provisions of the state authorized federal RCRA program.

Many of the HWCL provisions are either applicable or relevant and appropriate because they describe requirements for the safe handling of contaminated materials and precautions for preventing further contamination. These requirements are identified in Table 6-1.

- **Air Resources Requirements**—State legislation divides the state into local air pollution control districts and allows each district to enforce the requirements of the California Clean Air Act within its jurisdictional boundaries. Travis AFB is located in the Bay Area Air Quality Management District (BAAQMD). The applicable air regulations incorporated into the WABOU Groundwater IROD as ARARs are identified in Table 6-2. In addition, most of the rules in the State Implementation Plan (SIP), adopted pursuant to the Federal Clean Air Act, are federal ARARs. Table 6-2 contains a brief description of the substantive requirements and their applicability to the site, remedial action, or technology used to clean up the site.

- **Water Resources Requirements**—Several California statutes and regulations that protect the waters of the State have been identified and incorporated as ARARs. These ARARs establish the remedial objectives and requirements for COCs present at WABOU groundwater remediation sites.

  The Porter-Cologne Water Quality Control Act (PCWQCA) is one of the statutory bases for regulation of discharges of waste to land that could impair either surface water or groundwater quality in California. It establishes the authority of the state through its regional water quality control boards to protect the quality of surface water and groundwater. Regulations promulgated pursuant to the PCWQCA are identified in Table 6-3. A further discussion of water remediation requirements is included in the chemical-specific ARARs section to follow.

- **Groundwater Extraction Treatment and Discharge Requirements**—The extraction of groundwater at LF008, DP039, and SS041/SD043 will result in a reduction in the local groundwater levels. However, these changes in groundwater levels have been determined to not have a significant impact on the local vernal pools surrounding these sites. The increase flow rates in Union Creek due to the surface discharge of treated water was also considered and determined to not significantly impact Union Creek.

6.4.2 Location-Specific ARARs

These ARARs place restrictions on remedial activities that may be conducted onsite because of the presence of unique site features. The location of the WABOU groundwater sites and surrounding areas were analyzed for unique site features to identify ARARs. The unique site features considered were:

- **Habitats of Rare, Threatened, Endangered, and Special-Status Species**—Vernal pools which may contain an endangered species, including the Vernal Pool Tadpole Shrimp and the Vernal Pool Fairy Shrimp, have been identified. Other endangered species, including the Black-Shouldered Kite, Boggs Lake Dodder, Burrowing Owl, Coopers Hawk, California Gull, Golden Eagle, Loggerhead Shrike, Northern Harrier, Red Fox, Tri-colored Blackbird, Contra Costa Goldfields, Northwestern Pond Turtle, San Francisco Forktail Damselfly have been observed at least once at Travis AFB and have the potential to be found at WABOU sites.

  Several federal ARARs were identified which impact site ecology. The Endangered Species Act and implementing regulations set forth in Table 6-4 apply to those remedial actions at WABOU sites where impacts to endangered wildlife could occur. The operation of groundwater treatment facilities is not expected to impact any endangered species; however, the construction of pipelines for groundwater extraction and other intrusive remedial support activities could affect those resources that are present. To ensure that regulatory requirements are followed and impacts are avoided or mitigated, all sites will be surveyed in consultation with the U.S. Fish and Wildlife Service for the presence of these resources prior to the commencement of remedial activities. This consultation will begin after all necessary site-specific data concerning the construction and operation of the groundwater treatment equipment become available.

  Several more stringent state ARARs protective of site ecology have also been identified. The California Fish and Game Code (CFGC) and regulations promulgated under this Code, which protect rare, endangered, or threatened species or habitats, require alternative actions at sites where impacts have the potential to occur. These requirements are provided in Table 6-5. In addition to these state counterparts to the Endangered Species Act, the CFGC also establishes several requirements to protect site wildlife by prohibiting or restricting the unauthorized taking of other wildlife. The CFGC also regulates to protect aquatic life living in the waters of the state. All remedial activities that have the potential to cause a discharge to any stream lake or other body of water must comply with the requirements of the CFGC. U.S. EPA does not acknowledge that all CFGC requirements are more stringent than federal requirements but concurs with the Air force decision to comply with both federal and state requirements as ARARs in this IROD. CFGC ARARs are found in Table 6-5.

- **Historically or Culturally Significant Properties**—Some buildings on Travis AFB have recently been identified as Cold War Era buildings and historically significant. However, none of these buildings are affected by WABOU remedial activities.

- **Wilderness Areas, Wild and Scenic Rivers, and Coastal Zones**—No wilderness areas, wild and scenic rivers, or coastal zones exist within the boundaries of Travis AFB. Therefore, requirements related to these areas are not applicable or relevant to WABOU sites and actions.

- **Earthquake Faults**—Although the Vaca-Winters and the Vaca-Kirby faults are located in the Travis AFB area, WABOU sites are not located on these faults.

6.4.3 Chemical-Specific ARARs

Discharges of Effluent to Surface Water—Surface water at Travis AFB includes Union Creek which is a minor tributary to the Suisun Marsh. However, design, construction, and operation of remedial actions will have a negligible impact upon surface water. One of the options at all sites for which groundwater treatment has been selected is the discharge of treated groundwater to Union Creek. Provisions of 40 CFR Part 122 regulate discharge to surface waters. NPDES requirements establish standards for discharges to surface waters of the United States, and are provided in Table 6-6. The substantive CRWQCB requirements of federal or more stringent state ARARs for discharge of treated effluent to surface waters are included in Table 6-7.

Discharges of Effluent to Groundwater—The reinjection of treated groundwater is not a representative process option and has not been incorporated into any of the selected remedial alternatives identified in the WABOU Groundwater IROD.

Discharge of Effluent to Land—Irrigation is the designated beneficial use of treated groundwater at Travis AFB. The use of reclaimed and treated groundwater for irrigation activities shall meet the substantive standards set forth by the regional water quality control board order which establishes the general discharge requirements for treated groundwater. These standards ensure that reclaimed water is segregated from potable water sources and does not migrate or escape from the area of irrigation. Table 6-8 provides a list of the effluent treatment levels for beneficial use.

Aquifer Remediation Objectives—The State Water Resources Control Board (SWRCB) Resolution 92-49, Section III.G is a requirement for the establishment of final aquifer cleanup levels. However, the Air Force does not agree with the state on the full applicability of all the substantive requirements of this resolution and its impacts on the remedial actions and activities. Because final aquifer cleanup levels are not established in this IROD, this requirement is not an ARAR. The purpose of using an IROD in lieu of a ROD is to prevent the delay of remedial actions that would have resulted from this disagreement and to obtain the data needed to resolve this disagreement.

SWRCB Resolution 68-16 has been identified by the State as an ARAR for the protection of both surface water and groundwater of the state. All parties agree that this resolution is an ARAR with respect to active discharges of treated effluent to surface waters. However, the Air Force and U.S. EPA do not agree with the state on the full applicability of all the substantive requirements of this resolution and its impacts on the remedial action activities.

Table 6-1
Travis AFB - WABOU Groundwater Sites
Federal ARARs*
Waste Transfer, Treatment, and Storage and Disposal Requirements
*** (California Statutes and Regulations Comprising Federal Authorized RCRA Program)**

Source	Requirement, Standard, or Criterion	Type	Description	Remarks	Sites and Alternatives	
Title 22 CCR Chap 12, Art 1	66262.11	Applicable	Requires a facility to determine as to whether waste is hazardous.	Applicable to wastes excavated or resulting from treatment processes.	08, 39, 41, 43	G3, G4, G5, G6
Title 22 CCR Chap 14 Art 6	66264.94	Applicable	Establishes general groundwater monitoring requirements and concentration limits.	Applicable at groundwater sites for development of a comprehensive monitoring program for the site	08, 39, 41, 43	G3, G4, G5, G6
	66264.96(c)	Applicable	Establishes monitoring requirements upon removal of waste/contaminated material from a management unit. Requires monitoring showing compliance with water quality standards for 3 consecutive years.			
	66264.97	Applicable	Establishes groundwater monitoring requirements during closure and post-closure periods.			
Title 22 CCR Chap 14, Art 9 (Standards for Owners and Operators of Hazardous Waste Transfer, Storage, and Treatment, Disposal Facilities - Management of Containers)	66264.171	Relevant and Appropriate	Sets standards for containers holding hazardous waste or chemicals recovered from sediments, surface soils, or groundwater.	Sections in this article are relevant and appropriate to sites or actions where waste containers are used. Containers will be used to transfer and store wastes generated from construction activities or the operation of remedial actions. Examples would include spent carbon from treatment plants, drill cuttings from well installation, free product removed from a plume, etc.	08, 39, 41, 43	G3, G4, G5, G6
	66264.172	Relevant and Appropriate	Requires use of containers that are compatible with the recovered material for the storage of that material.			
	66264.173	Relevant and Appropriate	Requires containers used to transport material to be closed during transport and that waste be handled to minimize damage to containers.			
	66264.174	Relevant and Appropriate	Establishes requirements for inspecting containers weekly.			
	66264.175	Relevant and Appropriate	Establishes requirement for adequate secondary containment of stored waste.			
	66264.176	Relevant and Appropriate	Requires isolating waste from sources of ignition if waste is ignitable.			
	66264.177	Relevant and Appropriate	Requires segregation of waste from incompatible waste.			
	66264.178	Relevant and Appropriate	Establishes the requirement to remove all hazardous waste and waste residue at closure.	Sect 66264.178 is relevant and appropriate when sites are closed and wastes or residue, as described above, are on-site at closure.		

Table 6-1
Travis AFB - WABOU Groundwater Sites
Federal ARARs[a]
Waste Transfer, Treatment, and Storage and Disposal Requirements
(continued)

Source	Requirement, Standard, or Criterion	Type	Description	Remarks	Sites and Alternatives	
Title 22 CCR Chap 14, Art 10 (Standards for Owners and Operators of Hazardous Waste Transfer, Treatment, Storage, and Disposal Facilities - Use and Management of Tank Systems)	66264.192	Relevant and Appropriate	Establishes design/installation requirements for new tank systems/components.	Sections in this article are relevant and appropriate to alternatives incorporating the use of tanks or tank systems as part of the remedial equipment. Tanks will be used at treatment plants to store contaminated water prior to treatment. Tanks will also be used for temporary storage of free product, if necessary. Section 66264.197(a), (c)(3), and (c)(4) (cost estimates and financial responsibility requirements) are not ARARs. Section 66264.198 is relevant and appropriate to sites with ignitable waste [i.e., free product] or reactive waste. Remedies utilizing reactive oxidizers, such as ultraviolet oxidation or catalytic oxidation, trigger this requirement.	08, 39, 41, 43	G3, G4, G5, G6
	66264.193	Relevant and Appropriate	Tank system requirements including containment and detection of releases.			
	66264.194	Relevant and Appropriate	Delineates tank system requirements including operating requirements.			
	66264.195	Relevant and Appropriate	Delineates requirements tank systems including inspections.			
	66264.196	Relevant and Appropriate	Delineates tank system requirements including response to leaks or spills.			
	66264.197	Relevant and Appropriate	Delineates tank system requirements including closure and post-closure care.			
	66264.198	Relevant and Appropriate	Delineates requirements for tank systems including special care requirements for reactive wastes.			
	66264.199	Relevant and Appropriate	Delineates special tank system requirements for incompatible wastes.			
Title 22 CCR Chap 14, Art 15 (Standards for Incinerators)	66264.341	Applicable	Requires owner or operator of thermal treatment units to conduct sufficient waste analysis to verify that waste feed to the incinerator is within physical and chemical composition limits	Applicable to remedial actions that utilize thermal treatment units. Only the substantive requirements set forth in these sections are ARARs. Permitting requirements set forth in these sections are procedural and not ARARs	08, 39, 41, 43	G4, G5, G6
	66264.342	Applicable	Establishes treatment requirements for Principal Organic Hazardous Constituents (POHCs) in the waste feed.			
	66264.343	Applicable	Establishes construction, maintenance and performance standards for incinerators that burn hazardous waste.			
	66264.344 (a)	Applicable	Establishes operating conditions under which hazardous wastes may be burned.			
	66264.345	Applicable	Establishes operating requirements under which hazardous wastes may be burned.			
	66264.347	Applicable	Establishes inspection and monitoring requirements for incinerators.			

Table 6-1
Travis AFB - WABOU Groundwater Sites
Federal ARARs*
Waste Transfer, Treatment, and Storage and Disposal Requirements
(continued)

Source	Requirement, Standard, or Criterion	Type	Description	Remarks	Sites and Alternatives	
Title 22 CCR Chap 14, Art 16	66264.601	Applicable	Specifies performance standards for miscellaneous units that transfer, treat, store or dispose of hazardous waste.	Applicable at Travis AFB sites where air strippers or dual-phase extraction are used as part of the remedial action. Section 66264.602 requirements related to response and reporting procedures are not ARARs.	08, 39, 41, 43	G4, G5, G6
	66264.602	Applicable	Establishes analysis, inspection, response, reporting, monitoring and corrective action standards for miscellaneous units.			
	66264.603	Applicable	Establishes maintenance standards for miscellaneous units.			
Title 22 CCR Chap 14, Art 27 (Air Emission Standards for Process Vents)	66264.1032	Relevant and Appropriate	Establishes emission limits when process vents are used.	Relevant and appropriate to alternatives where closed vent systems are used. This includes sites with remediation systems that have system vents, to include air strippers, UV oxidation, carbon treatment vessels and catalytic oxidation equipment.	08, 39, 41, 43	G3, G4, G5, G6
	66264.1033	Relevant and Appropriate	Establishes standards for closed vent systems and control devices.			
	66264.1034	Relevant and Appropriate	Establishes test methods and procedures for closed vent systems.			
	66264.1035	Relevant and Appropriate	Establishes record keeping requirements; performance & design analysis/ parameters for closed vent systems;			
Title 22 CCR Chap 14, Art 28 (Air Emission Standards for Equipment Leaks)	66264.1054	Relevant and Appropriate	Establishes that pressure relief devices in gas/vapor service shall be operated with no detectable emissions.	Relevant and appropriate for actions where gas/vapor extraction systems are used.	39	G5, G6
	66264.1063	Relevant and Appropriate	Establishes leak detection monitoring requirements.			
	66264.1064	Relevant and Appropriate	Establishes record keeping requirements for gas/vapors extraction systems.			
Title 22 CCR Chap 18, Art 1 (Land Disposal Restrictions - General)	66268.3	Applicable	Establishes land disposal restrictions, including a prohibition of using dilution as a substitute for treatment.	Applies to hazardous waste generation from site excavation or from site construction activities. Restricts on-site disposal activities in unauthorized areas. Section 66268.7, para (a)(1), (b)(1), (2) and (3), and (c)(2) are substantive requirements. The remainder of the section is procedural and not ARARs.	08, 39, 41, 43,	G3, G4, G5, G6
	66268.7	Applicable	Establishes land disposal restrictions, including requirements for waste analysis and record keeping.			
	66268.9	Applicable	Establishes land disposal restrictions including special rules for wastes that exhibit a characteristic.			

Table 6-1
Travis AFB - WABOU Groundwater Sites
Federal ARARs*
Waste Transfer, Treatment, and Storage and Disposal Requirements
(continued)

Source	Requirement, Standard, or Criterion	Type	Description	Remarks	Sites and Alternatives	
Title 22 CCR Chap 18, Art 2	All Sections	Applicable	Establishes treatment technology for disposal of waste to land for RCRA and non-RCRA wastes identified in section 66268.106.	Applicable to sites where material, state regulated waste, or secondary hazardous waste is generated during construction activities (to include excavation for well installation, pipeline installation, and foundations for treatment facilities). Wastes identified will be managed in accordance with these standards.	08, 39, 41, 43,	G3, G4, G5, G6
Title 22 CCR, Chap 18 Art 3	66268.30	Applicable	Establishes waste-specific LDRs	Applicable to groundwater sites where media excavated for equipment installation is classified as hazardous waste and disposed/ treated on-site. Applicable to wastes excavated or removed from soil sites. Requires identification of waste through the proper characterization process.	08, 39, 41, 43	G2, G3, G4, G5, G6
	66268.31	Applicable	Establishes LDRs for wastes containing dioxin.			
	66268.32	Applicable	Establishes LDRs for certain hazardous wastes.			
	66268.33	Applicable	Establishes LDRs - First Third Wastes.			
	66268.34	Applicable	Establishes LDRs - Second Third Wastes.			
	66268.35	Applicable	Establishes LDRs - Third Third Wastes.			
	66268.36	Applicable	Prohibits land disposal of newly listed wastes.			
Title 22 CCR, Chap 18 Art 3	66268.37	Applicable	Prohibits land disposal of corrosive and characteristic wastes with vacated treatment standards.			
	66268.38	Applicable	Identifies waste specific prohibitions on newly identified organic toxicity characteristic wastes & newly listed coke by-product and chlorotoluene waste.			
Title 22 CCR Chap 18 Art 4	All Sections	Applicable	Identifies treatment standards for halogenated organic compounds regulated by section 66268.32	Applicable to sites where excavated material is classified as hazardous waste. Identified waste will be managed in accordance with these standards, if disposed of on land and not in a CAMU or AOC. Applicable at sites where wastes or contaminated soils are excavated or removed.	08, 39, 41, 43	G2, G3, G4, G5, G6
Title 22 CCR Chap 18 Art 5	All Sections	Applicable	Establishes prohibitions on storage of hazardous wastes restricted under Article 3 of this chapter or RCRA Section 3004 (42 USC 6924).			
Title 22 CCR Chap 18 Art 10	66268.100	Applicable	Establishes land disposal prohibitions for non-RCRA hazardous wastes.			
Title 22 CCR Chap 18 Art 11	All Sections	Applicable	Establishes disposal restrictions, treatment standards, & prohibitions, for certain identified hazardous wastes.			
Title 22 CCR Chapter 43 (Extremely Hazardous Wastes)	67430.3	Applicable	Establishes requirements for the removal of spilled or improperly deposited extremely hazardous wastes.	Applicable to sites where unintentional spills may occur.	08, 39, 41, 43	G2, G3, G4, G5, G6

Table 6-2
Travis AFB - WABOU Groundwater Sites
State ARARs
Air Remediation Requirements

Source	Requirement, Standard, or Criterion	Type	Description	Remarks	Sites and Alternatives	
Regulation 2, Rule 1 (Bay Area Air Quality Management District Regulations)	308	Applicable	Establishes that fugitive emissions from equipment or facilities must comply with all applicable requirements.	Applicable to actions where air strippers or other systems using pressurized components (UV oxidation, carbon adsorption, catalytic oxidation and ion exchange) may result in fugitive VOC emissions.	08, 39, 41, 43	G3, G4, G5, G6
	316	Applicable	Establishes maximum levels for toxic air contaminants, which, if exceeded, require a risk screening analysis.	Applicable to actions that have the potential to emit toxic air contaminants (e.g. TCE). Applicable to air stripping, UV oxidation, carbon adsorption, catalytic oxidation and ion exchange.		
	501	Applicable	Establishes that continuous emission monitors meet certain requirements.	Applicable to all sites or actions where air stripping, UV oxidation, carbon adsorption, catalytic oxidation and ion exchange technologies are used in the remedial action.		
Regulation 2, Rule 2	112	Applicable	Establishes exemptions for secondary pollutant emissions from abatement control equipment that complies with BACT or BARCT requirements.	Applicable to actions where BARCT or BACT abatement devices are used (i.e. carbon adsorption is used together with catalytic oxidation or UV oxidation or ion exchange) but where secondary emissions from the abatement equipment still exist.	08, 39	G4, G5, G6
	301	Applicable	Establishes BACT requirement for new sources emitted in excess of 10 lbs/day of non-precursor organic compounds, precursor organic, compounds, NOx, SOx, PM-10, CO_2.	Applicable to actions with potential to discharge to air. Not applicable for permitting requirements or authority to construct. Applicable for determining the applicability of BACT to a new source. Remedial alternatives using air strippers must ensure BACT is used (i.e. catalytic oxidation with carbon adsorption) to control emissions in excess of levels specified in the rule.		
Regulation 6	301	Applicable	Establishes limitations on visible emissions and opacity.	Applicable to sites where excavation or construction activities have the potential to release particulate matter into the air (i.e. dirt and dust), or at sites where portable soldering, brazing, welding equipment is used. Also applicable at sites where portable combustion engines of < 25 liters of displacement are used. Applicable to all actions subject to Regulation 6.	08, 39, 41, 43	G3, G4, G5, G6
	302	Applicable	Establishes limitations on opacity.			
	303	Applicable	Establishes limitations on emission rates, concentration, visible emissions and opacity.			
	501	Applicable	Establishes requirements for sampling facilities and instruments.			

Table 6-3
Travis AFB - WABOU Groundwater Sites
State ARARs
Water Board Requirements

Source	Requirement Standard, or Criterion	Type	Description	Remarks	Sites and Alternatives	
Federal Water Pollution Control Act Section 402, Porter Cologne Water Act; California Water Code, Division 7, Sections 13000, 13140, 13240, Water Quality Control Plan for the San Francisco Bay Basin	SWB Resolution 68-16	Applicable	Establishes policy that whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated that any change will be consistent with maximum benefit to the people of the State, won't unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than prescribed in the policies. Discharges or proposed discharges to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that a pollution or nuisance will not occur and the highest water quality consistent with maximum benefit to the people of the State will be maintained.	Applicable to sites where groundwater actions will cause active discharges to surface water (i.e., Union Creek). The Air Force and the U.S. EPA agree to disagree with the RWQCB as to the applicability of this section with respect to passive discharge and plume migration. San Francisco Bay Region Order Number 94-087 establishes requirements for discharge or reuse of extracted and treated groundwater that was contaminated by VOCs. Contaminants in treated groundwater shall not exceed the more stringent of the substantive standards set forth in Order 94-087, MCLs, or such levels necessary to preclude degradation of the receiving water quality. The numeric effluent limitations for discharges of treated water that comply with Resolution 68-16 are specified in Table 6-6. The discharge must also comply with paragraphs A.1, A.2, and A.3 (prohibitions) of General Waste Discharge Order 94-087.	08, 39, 41, 43	G3, G4, G5, G6
Porter Cologne Water Act; CWC Sections 13000, 13140, 13240,	SWB Resolution 88-63	Applicable	Designates all ground and surface water of the state as potential drinking water with certain exceptions (TDS>3,000 ppm and it is not reasonably expected by Regional Boards to supply a public water system, well yield<200 gpd, geothermic resources, waste water conveyance facility, or can't be reasonably treated for domestic use).	Applicable to actions that will result in the discharge of treated groundwater to surface waters (i.e. Union Creek). The existing beneficial uses of Union Creek include navigation, contact and non-contact recreation, fish spawning, warm freshwater habitat, and wildlife habitat.	08, 39, 41, 43	G3, G4, G5, G6

Table 6-3
Travis AFB - WABOU Groundwater Sites
State ARARs
Water Board Requirement
(continued)

Source	Requirement Standard, or Criterion	Type	Description	Remarks	Sites and Alternatives	
Title 27 CCR (CWC Section 13140 - 13147, 13260, 13263, 13267, 13304)	20090 (d)	Relevant and Appropriate	Establishes exemption from provisions of this subchapter for actions taken by or at the direction of public agencies to clean up or abate conditions of pollution or nuisances resulting from unintentional or unauthorized releases of waste or pollutants to the environment. Requires that wastes, pollutants, or contaminated materials removed from the immediate place of release are discharged according to Art 2. Remedial actions intended to contain such wastes at the place of release shall implement applicable provisions of this subchapter to the extent feasible.	Relevant and appropriate to monitoring requirements and other specific actions that are not related to final cleanup levels or goals at sites where active remediation will occur. The Air Force does not concur with the RWQCB's interpretation that this requirement is applicable to unauthorized or unintentional releases.	08, 39, 41, 43	G3, G4, G5, G6
U.S. Office of Solid Waste	RCRA Groundwater Monitoring, Draft Tech. Guidance, Nov. 1992 (EPA /530-R-93-001)	Performance Standard	Sets forth requirements for the development of a groundwater monitoring program.	Applies to the development of a comprehensive monitoring program for the site (also reference Table 6-1, 22 CCR Section 66264.94, 66264.96, and 66264.97).	08, 39, 41, 43	G3, G4, G5, G6
Regional Water Quality Control Board	S.F. Bay Basin Water Quality Control Plan, Chapter 2, Beneficial Uses.	Applicable	Establishes beneficial uses of surface waters.	Applicable to define beneficial uses of surface waters to which treated effluent is discharged. Beneficial uses of Union Creek and downstream receiving waters include navigation, contact and non-contact recreation, fish spawning, warm freshwater habitat, and wildlife habitat.	08, 39, 41, 43	G3, G4, G5, G6
	S.F. Bay Basin Water Quality Control Plan, Chapter 3, Water Quality Objectives.	Applicable	Establishes discharge to surface requirements, including receiving water quality objectives and receiving water limits.	Applicable where effluent is discharged to the surface. Surface waters shall not contain concentrations of chemical constituents in amounts that affect any beneficial use or the objectives for selected toxic pollutants identified in Tables 3-3 and 3-4.		

Table 6-4
Travis AFB - WABOU Groundwater Sites
Federal ARARs
Requirements under the US Code and Related Regulations

Source	Requirements Standard, or Criterion	Type	Description	Remarks	Sites and Alternatives	
Title 16 USC (Endangered Species Act)	1531(c)	Applicable	Requires action to conserve endangered species and critical habitats upon which endangered species depend. Includes consultation with the Dept of Interior.	Activities at remedial sites must be performed in such a manner as to identify the presence of and protect endangered or threatened plants and animals at the site. Species at Travis AFB include the Black-Shouldered Kite, Boggs Lake Dodder, Burrowing Owl, Coopers Hawk, California Gull, Golden Eagle, Loggerhead Shrike, Northern Harrier, Red Fox, Tri-colored Blackbird, Vernal Pool Fairy Shrimp, Contra Costa Goldfields, Northwestern Pond Turtle, San Francisco Forktail Damselfly, Vernal Pool Tadpole Shrimp.	08, 39, 41, 43,	G2, G3, G4, G5, G6
	1536(a)	Applicable				
Title 16 USC (Fish and Wildlife Coordination Act)	662	Applicable	Regulates site actions affecting fish or wildlife in lakes, stream, or other water bodies by requiring coordination between lead agency and the US Fish and Wildlife Service, Dept. of the Interior, and applicable state agencies.	Applicable to active remediation actions and effluent discharges at sites that are located at or near, or which may impact., Union Creek and pond.	08, 39, 41, 43	G3, G4, G5, G6
Title 16 USC (Migratory Bird Treaty Act)	703	Applicable	Prohibits unlawful taking, possession, and sale of almost all species of native birds in the U.S.	Species at Travis AFB include Black-Shouldered Kite, Burrowing Owl, Coopers Hawk, California Gull, Golden Eagle, Loggerhead Shrike, Northern Harrier, Tri-colored Blackbird.	08, 39, 41, 43	G2, G3, G4, G5, G6
Federal Clean Water Act, Sect. 404, Title 33 CFR Part 330,Appx A, Subpart B - Army Corps of Engineers Nationwide Permit Program	Paragraph 12	Applicable	Establishes Nationwide Permit for discharges of material for backfill or bedding of utility lines, including outfall and intake structures affecting the waters of the U.S.	The substantive portions of these paragraphs are applicable. The notification requirements are not ARARs. Site activities related to construction and installation of remedial equipment give rise to these requirements.	08, 39, 41, 43	G3, G4, G5, G6
	Paragraph 13	Applicable	Establishes Nationwide Permit for bank stabilization activities required for erosion prevention.			
	Paragraph 27	Applicable	Establishes requirements for activities in waters of the United States associated with restoration of altered and degraded non-tidal wetlands and creation of wetlands on private lands.			

Table 6-4
Travis AFB - WABOU Groundwater Sites
Federal ARARs
Requirements under the US Code and Related Regulations
(continued)

Source	Requirement Standard, or Criterion	Type	Description	Remarks	Sites and Alternatives	
Clean Water Act, Section 404, Title 33 CFR Part 330, Appx A, Sub C Army Corps of Engineers Nationwide Permit Conditions (NWP)	Paragraph 2	Applicable	Requires structures or fill authorized be maintained, including maintenance to ensure public safety.	The substantive portions of these paragraphs are applicable. The notification requirements are not ARARs.	08, 39, 41, 43	G3, G4, G5, G6
	Paragraph 4	Applicable	Requires that no activity may substantially disrupt the movement of those species of aquatic life indigenous to the water body.			
	Paragraph 5	Applicable	Requires heavy equipment working in wetlands must be placed on mats or other measures be taken to minimize soil disturbance			
	Paragraph 11	Applicable	No activity is authorized under any NWP if likely to jeopardize the continued existence of a threatened or endangered species, or species proposed for such designation, as identified under the Endangered Species Act, or if likely to destroy or adversely modify the critical habitat of such species.			
Title 40 CFR Part 122 – EPA Administered Permit Programs: The National Pollutant Discharge Elimination System (NPDES)	122.26	Applicable	Requirements to ensure storm water discharges from remedial activities do not contribute to a violation of surface water quality standards.	Applicable at all sites where there will be discharge to the stormwater system and discharges to Union Creek. These sections relate to effluent limitations and monitoring requirements to be applied during the development of a monitoring plan. The SRWQCB is authorized to implement the NPDES program in the State of California. California Regional Water Quality Control Board, San Francisco Bay Region Order 94-087 establishes substantive discharge standards. Only substantive portions of Part 122 are ARARs; reporting requirements are procedural.	08, 39, 41, 43	G3, G4, G5, G6
	122.41(d)	Applicable	Requires all reasonable steps be taken to minimize or prevent discharges that have a reasonable likelihood of causing adverse impacts on surface water quality.			
	122.41(e)	Applicable	Requires proper operation and maintenance of treatment and control systems/ equipment.			
	122.41(j)(1)(3)&(4)	Applicable	Establishes requirements for monitoring and recordation of monitoring results.			
	122.41(l)(6)	Applicable	Establishes informational requirements for any noncompliance which may endanger health or the environment			
	122.41(m)	Applicable	Establishes prohibitions, limitations and restriction on treatment plant bypass.			
	122.41(n)	Applicable	Defines and establishes parameter for upset conditions in a treatment plant.			

Table 6-4
Travis AFB - WABOU Groundwater Sites
Federal ARARs
Requirements under the US Code and Related Regulations
(continued)

Source	Requirement Standard, or Criterion	Type	Description	Remarks	Sites and Alternatives	
Title 40 CFR Part 122 (Continued)	122.44(d)	Applicable	Requires that discharges to surface water must achieve federal and state water quality standards.	(Continued)	08, 39, 41, 43	G3, G4, G5, G6
	122.44(g)	Applicable	Identifies certain toxic pollutants as hazardous substances.			
	122.44(i)	Applicable	Establishes monitoring requirements to assure compliance with permit limitations and requirements to monitor.			
	122.45(c)	Applicable	Establishes techniques and methodologies for monitoring effluent levels of metals.			
	122.45(d)	Applicable	Establishes format for reporting effluent limitation standards and prohibitions.			
	122.45(e)	Applicable	Establishes format and limit criteria for non-continuous discharge.			
	122.45(f)	Applicable	Establishes requirements and exceptions for pollutants expressed in terms of mass.			
	122.45(g)	Applicable	Establishes credits for pollutants in the discharger's intake water.			
	122.48(a)	Applicable	Establishes requirements for proper use, maintenance, and installation of monitoring equipment or methods.			
	122.48(b)	Applicable	Establishes requirements for monitoring including type, intervals, and frequency sufficient to yield data which are representative of the monitored activity including, when appropriate, continuous monitoring.			
Title 40 CFR Part 141 40 USC Sec. 300 (National Primary Drinking Water Standards)	141.11	Relevant and Appropriate	Establishes the federal allowable maximum contaminant levels (MCLs) for arsenic in community water systems and nitrates in non-community water systems.	Relevant and appropriate to sites where discharge of treated groundwater to potential sources of drinking water will occur. Establishes effluent treatment standards for certain constituents which are not addressed by the substantive requirements of California Regional Water Quality Control Board, SF Bay Region, Order Number 94-087.	08, 39, 41, 43	G3, G4, G5, G6
	141.12	Relevant and Appropriate	Establishes federal maximum contaminant levels (MCLs) for trihalomethanes.			
	141.61	Relevant and Appropriate	Establishes MCLs for organic contaminants. Requires the best technology, treatment technique, or other means available for achieving compliance of MCLs contaminants.			
	141.62	Relevant and Appropriate	Establishes MCLs for inorganic contaminants. Requires the best technology, treatment technique, or other means available for achieving compliance of MCLs for identified contaminants, except fluoride.			

Table 6-4
Travis AFB - WABOU Groundwater Sites
Federal ARARs
Requirements under the US Code and Related Regulations
(continued)

Source	Requirement Standard, or Criterion	Type	Description	Remarks	Sites and Alternatives	
40 CFR Part 230 (Clean Water Act - Disposal of Dredged or Fill Material)	230.10	Applicable	Prohibits discharge of dredged or fill material into waters or wetlands without a permit. Establishes limitations on such discharges.	Applicable to sites where wetlands and vernal pools are located. Permitting requirements are procedural and are not ARARs.	08, 39, 43	G3, G4, G5, G6
	230.71	Applicable	Places limitations/requirements on the disposal and treatment of the dredged or fill material discharged.			
	230.72	Applicable	Establishes requirements and methods for the control of the effects of dredged or fill material after discharge, through use of levees, caps, lined containment areas, timing and placement.			
	230.73	Applicable	Establishes requirements for minimizing discharge effects by use of specific disbursement methods.			
	230.74	Applicable	Requires use of available technology, adapted to the particular site, to minimize the adverse effects of dredge and fill discharges.			
	230.75	Applicable	Requires minimization of adverse effects on populations of plants and animals caused by the discharge of dredge or fill materials.			
	230.76	Applicable	Requires use of fill or dredge material discharge methods that minimize the adverse effects on human use potential.			

Table 6-5
Travis AFB - WABOU Groundwater Sites
State ARARs
Fish and Game Requirements

Source	Requirement, Standard, or Criterion	Type	Description	Remarks	Sites and Alternatives	
California Fish and Game Code	1908	Applicable	Prohibits the possession, import, or taking or of rare or endangered native plants.	Applies to active remediation sites where rare or endangered native plants exist. Requires site surveys prior to action to determine presence of endangered/threatened plants at the site and consideration of potential impact.	08, 39, 41, 43	G2, G3, G4, G5, G6
	2080	Applicable	Prohibits the import, taking or sale of threatened or endangered native plants			
	2090	Relevant and Appropriate	Requires state lead agencies to consult with DF&G to ensure authorized actions will not jeopardized endangered or threatened species.	Relevant and appropriate for federal agencies at all sites where endangered or threatened species are located. Requires coordination and, if appropriate, consideration of alternative actions at sites where impact to endangered or threatened species may occur. Will be considered at all sites where active remediation occurs.		
	2091	Relevant and Appropriate	Requires state agencies to use alternative actions where impact to threatened or endangered species or habitat is found.			
	2092	Relevant and Appropriate	Requires state agencies to adopt reasonable alternative actions where project would result in the extinction of a species.			
	3005	Applicable	Prohibits taking of birds or animals with net, pound, cage, trap, set line, wire, or poison.	Applicable at all remediation sites where birds, animals, or other wildlife identified by the applicable statutory provision exist. Applicable to the extent that these laws are more stringent than the Federal Endangered Species Act or Migratory Bird Treat Act.		
	3511	Applicable	Prohibits taking of birds identified as "fully protected."			
	3513	Applicable	Prohibits taking of protected migratory non-game birds.			
	4700	Applicable	Prohibits taking or possession of mammals identified as "fully protected."			
	5050	Applicable	Prohibits taking or possession of reptiles/ amphibians identified as "fully protected."			
	5515	Applicable	Prohibits taking or possession of fish identified as "fully protected."			
	5650	Applicable	Prohibits deposit or placement of specified materials and substances into places where is can pass into the waters of the state.	Applicable to all remediation actions or sites where substances have a pathway to state waters.		

Table 6-5
Travis AFB - WABOU Groundwater Sites
State ARARs
Fish and Game Requirement
(continued)

Source	Requirement, Standard, or Criterion	Type	Description	Remarks	Sites and Alternatives	
Title 14 CCR	40.00	Applicable	Prohibits the taking or possession of native reptiles and amphibians.	Applicable to all site and action alternatives where identified mammals, fish, reptiles or amphibians or plants exist. Will be considered at all sites where active remediation occurs Requires site surveys prior to action to determine presence of endangered/threatened plants at the site. Section 640 will be considered to the extent feasible and consistent with CERCLA planning documents. Species found at Travis AFB which are covered by these sections include the Black-Shouldered Kite, Boggs Lake Dodder, Burrowing Owl, Coopers Hawk, California Gull, Golden Eagle, Loggerhead Shrike, Northern Harrier, Red Fox, Tri-colored Blackbird, Vernal Pool Fairy Shrimp, Contra Costa Goldfields, Northwestern Pond Turtle, San Francisco Forktail Damselfly, Vernal Pool Tadpole Shrimp.	08, 39, 41, 43	G2, G3, G4, G5, G6
	40.10	Applicable	Prohibits the possession or taking of native reptiles and amphibians.			
	460	Applicable	Prohibits the taking of certain fur bearing mammals at any time.			
	640	Applicable	Establishes requirement for fish and wildlife planning to optimize fish and wildlife resources.			
	670.2	Applicable	Establishes species, subspecies, and varieties of native California plants as endangered, threatened, or rare.			
	670.5	Applicable	Establishes species, subspecies, and varieties of native California plants as endangered, threatened, or rare.			

TABLE 6-6
NPDES Effluent Limitations for Treated Groundwater

Constituent	Instantaneous Maximum (µg/L)	30-Day Median (µg/L)
Halogenated Volatile Organics[a]		
Bromodichloromethane	100.0[b]	0.5
Carbon Tetrachloride	0.5[b]	0.5
Chlorobenzene	70.0[b]	0.5
Chloroform	100.0[b]	0.5
Chloromethane		0.5
Dibromochloromethane	100.0[b]	0.5
1,4-Dichlorobenzene	5.0[b]	0.5
1,2-Dichloroethane	0.5[b]	0.5
1,1-Dichloroethylene	6.0[b]	0.5
cis-1,2-Dichloroethylene	6.0[b]	0.5
trans-1,2-Dichloroethylene	10.0[b]	0.5
1,2-Dichloropropane	5.0[b]	0.5
Ethylene Dibromide	0.05[b]	0.5
Tetrachloroethylene (PCE)	5.0[b]	0.5
Trichloroethylene (TCE)	5.0[b]	0.5
Vinyl Chloride	0.5[b]	0.5
Total Halogenated Volatile Organics		1.0
Non-Halogenated Volatile Organics		
Benzene	1.0[b]	0.5
Ethylbenzene	29.0[c]	0.5
Toluene	42.0[c]	0.5
Xylenes	17.0[c]	0.5
TPH - Gasoline	50.0[d]	50.0[d]
Semi-Volatile Organics[e,f]		
Aldrin	1.4×10^{-4}	1.4×10^{-4}
Alpha-BHC	0.013	0.013
Beta-BHC	0.046	0.046
Gamma-BHC (Lindane)	0.063	0.063
Chlordane	5.9×10^{-4}	5.9×10^{-4}
4,4'DDT	6.0×10^{-4}	6.0×10^{-4}
4,4'DDD	8.4×10^{-4}	8.4×10^{-4}
Dieldrin	1.4×10^{-4}	1.4×10^{-4}
2,3,7,8-TCDD (Dioxins)	1.4×10^{-8}	1.4×10^{-8}

TABLE 6-6
NPDES Effluent Limitations for Treated Groundwater

Constituent	Instantaneous Maximum (µg/L)	30-Day Median (µg/L)
Endosulfan	2.0	2.0
Heptachlor epoxide	1.1×10^{-4}	1.1×10^{-4}
PCBs (Arochlors)	4.5×10^{-5}	4.5×10^{-5}
Total Polynuclear Aromatics (PAHs)	0.031	0.031
TPH - Diesel	100.0[c]	50.0[d]
Inorganics[g,h]		
Arsenic[i]	10.0	10.0
Cadmium	1.1	1.1
Chromium VI[j]	11.0	11.0
Total Chromium	11.0	11.0
Copper	12.0	12.0
Lead	3.2	3.2
Mercury[k]	0.012	0.012
Nickel	160.0	160.0
Selenium	5.0	5.0
Silver	4.1	4.1
Zinc	110.0	110.0

a 30-day Median Limits for Volatile Organics are based on Best Available Technology.

b California Primary MCL

c Taste & odor threshold in water - USEPA

d Practical Quantitation Limit

e Both instantaneous maximum and monthly median limitations are based on USEPA Freshwater Ambient Water Quality Criteria.

f For certain semi-volatile parameters, the PQL exceeds the effluent limitation. In these cases, the discharger may use the PQL, as identified in the 1996 RD/RA Analytical Quality Assurance Project Plan (QAPP) to comply with its effluent limits. As laboratory technology improves, and as QAPPs are updated, it may be necessary to comply with more stringent PQLs in the future.

g With the exception of arsenic, both instantaneous maximum and monthly median limitations are based on USEQP Freshwater National Ambient Water Quality Criteria for Protection of Aquatic Life, expressed as total recoverable metal.

h Limits for Cadmium, Copper, Lead, Nickel, Silver, and Zinc are based on an annual hardness of 100 mg/L of $CaCO_3$.

i Arsenic limits are based on Best Available Technology.

j Compliance with the Chromium VI limitation may be met as Total Chromium.

k Compliance is achieved by meeting the Reporting Limit using EPA Method 7470/7471. The effluent shall not contain more than 1 gram/day of mercury.

TABLE 6-7
Discharge Limitations

1. The discharge of waste shall not cause the following conditions to exist in the waters of the State at any place:
   a) floating, suspended, or deposited macroscopic particulate matter or foam;
   b) bottom deposits or aquatic growths;
   c) alteration of temperature, turbidity, or apparent color beyond present natural background levels;
   d) visible, floating, suspended, or deposited oil or other products of petroleum origin;
   e) toxic or deleterious substances to be present in concentrations or quantities which will cause deleterious effects on aquatic biota, wildlife, or waterfowl, or which render any of these unfit for human consumption either at levels created in the receiving waters or as a result of biological concentration.
2. The discharge of waste shall not cause excursions of the following limits in waters of the State in any place within one foot of the water surface:
   a) Dissolved oxygen;

      For all tidal waters, upstream of Carquinez Bridge, 7.0 mg/L minimum; downstream of Carquinez Bridge, 5.0 mg/L minimum.

      For nontidal waters, waters designated as cold water habitat, 7.0 mg/L minimum; waters designated as warm water habitat, 5.0 mg/L minimum.

      The median dissolved oxygen concentration for any three consecutive months shall not be less than 80% of the dissolved oxygen content at saturation.

   b) pH: The pH shall not be depressed below 6.5 nor raised above 8.5, nor be caused to vary from normal ambient pH levels by more than 0.5 units.
3. The discharge shall not cause a violation of any applicable water quality standard for receiving waters adopted by the Board or the State Water Resources Control Board as required by the Federal Clean Water Act and regulations adopted thereunder.

Note: This table establishes narrative and numeric discharge limitation standards for treated groundwater discharged to waters of the State. These discharge standards are derived from California Regional Water Quality Control Board, San Francisco Bay Region, Order No. 94-087

TABLE 6-8
Effluent Treatment Levels for Beneficial Reuse
Discharges to Land for Irrigation Purposes

Water reclaimed for beneficial use shall meet the following limits:

Constituent	Instantaneous Maximum Limit (µg/L)
Volatile Organic Compounds	
Vinyl Chloride	0.5
Benzene	0.5
Dichloroethane	0.5
All Others, Per Constituent	5.0
Semi-Volatile Organic Compounds	
Per Constituent	5.0

The following limitations shall apply:

1. Water reclamation activities shall be limited to irrigation.
2. No reclaimed water shall be allowed to escape from the authorized use area by airborne, nor by surface flow except in minor amounts associated with good irrigation practice, nor from conveyance facilities.
3. Reclamation involving irrigation shall not occur when the ground is saturated.
4. The use of reclaimed water shall not impair the quality of waters of the State, nor shall it create a nuisance as defined by Section 13050(m) of the California Water Code.
5. Adequate measures shall be taken to minimize public contact with reclaimed water and to prevent the breeding of flies, mosquitoes, and other vectors of public health significance during the process of reuse.
6. Appropriate public warnings must be posted to advise the public that the water is not suitable for drinking. Signs must be posted in the area, and all reclaimed water valves and outlets labeled, as appropriate.
7. There shall be no cross-connection between the potable water supply and piping containing treated groundwater intended for reuse.

Note: This table establishes narrative and numeric discharge limitation standards for treated groundwater discharged to land. These discharge standards are derived from California Regional Water Quality Control Board, San Francisco Bay Region, Order No. 94-087

7.0 Works Cited

Association of Bay Area Governments. 1990. Provisional Series 3 projections, population, housing, employment and land uses. San Francisco Bay region. Hotel Claremont, Berkeley, California.

BioSystems Analysis, Inc. (Biosystems). 1993a. *Assessment of Special Status Plant and Animal Species at Travis Air Force Base, Solano County, California. Phase II Surveys* (Draft). August.

Biosystems. 1993b. *Assessment of Habitat for Special Status Species at Travis Air Force Base, California.* October.

Biosystems. 1994. *Vernal Pool Resources at Travis Air Force Base, Solano County.* Final Report. June.

California Department of Water Resources, Central District. 1994. Historical Ground Water Levels in Solano County. March.

California Regional Water Quality Control Board (RWQCB). 1995. *A Compilation of Water Quality Goals.* Prepared by Jon B. Marshack. July.

CH2M HILL. 1995. *West/Annexes/Basewide Operable Unit Data Gaps Summary.* Travis Air Force Base, California. October 31.

CH2M HILL. 1996. Final *Comprehensive Basewide Ecological Risk Assessment - Tier 2 Screening Assessment,* Travis Air Force Base, California. May 31.

CH2M HILL. 1997. *West/Annexes/Basewide Operable Unit Remedial Investigation Report.* (Volumes 1-4), 60th Air Mobility Wing, Travis Air Force Base, California. May.

CH2M HILL. 1998. *West/Annexes/Basewide Operable Unit Feasibility Study,* 60th Air Mobility Wing, Travis Air Force Base, California. April.

Freeze, R. Allen and John A. Cherry. 1979. *Groundwater.* Prentice-Hall, Inc., Englewood Cliffs, N.J.

Jacobs Engineering Group (JEG). 1994a. Final *Risk Assessment Protocol.* Travis Air Force Base, California. November.

Jacobs Engineering Group (JEG). 1994b. *West/Annexes/Basewide Operable Unit, Draft Preliminary Assessment,* Travis Air Force Base, California. March.

Mayer, K. E. and W. F. Laudenslayer, Jr. 1988. *A Guide to Wildlife Habitats of California.* California Department of Forestry and Fire Protection. Sacramento, California.

Olmsted, F.H. and G.H. Davis. 1961. Geologic Features and Ground-Water Storage Capacity of the Sacramento Valley, California. Geological Survey Water-Supply Paper 1497.

Page, R.W. 1986. *Geology of the Fresh Ground-Water Basin of the Central Valley, California, with Texture Maps and Sections.* U.S. Geological Survey Professional Paper 1401-C.

Radian. 1994. *Remedial Investigation/Feasibility Study Work Plan, North Operable Unit,* Travis Air Force Base, California. April.

Radian. 1996a. Final *Groundwater Sampling and Analysis Program.* Travis Air Force Base, California. July.

Radian. 1996b. Final *Remedial Investigation, West Industrial Operable Unit.* Travis AFB, California. February.

Radian. 1997. *Groundwater Interim Record of Decision for the NEWIOU,* Travis Air Force Base, California.

Sims, J.D., K.F. Fox, J.A. Bartow, and E.J. Helley. 1973. *Preliminary Geologic Map of Solano County and Parts of Napa, Contra Costa, Marin, and Yolo Counties, California.* U.S. Geologic Survey.

State of California, Department of Finance. 1994. Population Estimates for California Cities and Counties. Official State Estimates. Demographic Research Unit. Sacramento, California.

Thomasson, H.G., F.H. Olmsted and E.F. LeRoux. 1960. Geology, Water Resources and Usable Ground-Water Storage Capacity of Part of Solano County, California, Geological Survey Water-Supply Paper 1464.

Travis Air Force Base. 1998. *Proposed Plan for Groundwater Cleanup.* April.

U.S. Department of Commerce, U.S. Bureau of the Census. 1990. *Census data.*

U.S. Environmental Protection Agency (EPA). 1995. Region IX Preliminary Remediation Goals (PRGs) Second Half 1995. September 1.

Wagner, D.L. and E.J. Bortugno. 1982. *Geologic Map of the Santa Clara Quandrangle.* California Divisions of Mines and Geology.

Weston. 1993. Draft Final *Work Plan Addendum, East Industrial Operable Unit,* Travis AFB, California. September.

Weston. 1995a. Final *Basewide Ecological Habitat Assessment,* Travis AFB, California. June.

Weston. 1995b. Final *Remedial Investigation Report, East Industrial Operable Unit,* Travis AFB, California. October.

PART III

Responsiveness Summary

The Air Force has promoted public input through the WABOU Groundwater Proposed Plan and 8 April through 8 May 1998 public comment period. This Proposed Plan was issued to the public just prior to the start of the public comment period. To encourage public comment, the Air Force listed the phone numbers and E-mail addresses of Air Force and DTSC representatives in the Proposed Plan, distributed copies of the Proposed Plan to local libraries, and held a public meeting on 23 April 1998 at the Fairfield/Suisun Community Center.

Several community members attended the public meeting, and oral comments were received from one person: John Rundlett. No other comments were submitted to either the Air Force or DTSC during the public comment period. A written transcript of the public meeting contains the oral comments and is available for public review at the Travis AFB Information Repository, located at the Vacaville Public Library. The oral comments concerning the cleanup of contaminated groundwater in the WABOU at Travis AFB are presented below and have been paraphrased for greater clarity. The selection of groundwater remedial actions in the WABOU is based on the documents in the Administrative Record and comments received from the public.

Public Comment 1: There was concern that there may be alternative technologies available that could be used to clean up the contaminated groundwater in the WABOU in a more efficient or cost-effective manner.

Air Force Response: The Air Force is looking closely at the use of naturally occurring processes to clean up contaminated groundwater. Known as Monitored Natural Attenuation, this innovative technology relies on subsurface microorganisms that use the groundwater contaminants as a source of energy. They break the contaminant molecules down into harmless by-products.

Unfortunately, this technology has not been proven to be effective against all types of groundwater contaminants. In the WABOU the only groundwater contaminants against which Monitored Natural Attenuation may be effective are found at Building 755. This technology is not applicable to the groundwater contaminants at the other three sites, so the more established pump-and-treat technology is proposed for those sites. Also, the microorganisms have not been shown to be active and capable of preventing the future expansion of the solvent plume at Building 755. As a result, the proposed interim groundwater remedial alternative for this site includes the collection of groundwater data to demonstrate the effectiveness of this technology under the site-specific conditions at Building 755. These data will be used to select the final groundwater remedies for all of the contaminated groundwater sites on Travis AFB.

Other innovative technologies were ruled out in the WABOU Feasibility Study, because they were evaluated to be not effective under the site-specific conditions at Travis AFB.

Public Comment 2: There was concern that the extraction and treatment of the contaminated groundwater would result in the accumulation of large drums of concentrated contaminants that the Air Force would have to transport to an offbase dumpsite.

Air Force Response: The contaminants that are accumulated through the extraction and treatment of contaminated groundwater will not be stored in drums at Travis AFB. For example, one treatment method is to run the contaminated groundwater though an activated carbon canister to remove the contaminants from the groundwater. The contaminant molecules attach themselves to the carbon material, allowing the cleaned water to flow out of the canister. Afterward, the canister is sent to an appropriate offsite facility where the contaminant molecules are stripped from the carbon and destroyed, and the carbon canister is prepared for reuse. So, with this method, the contaminants are not in a concentrated form and are not stored onbase for a long period of time. Another treatment option is to use an oxidation system to physically destroy the contaminants in the groundwater. All of the treatment options that were evaluated for use in the WABOU will result in the safe removal of the contaminants. Drums will not be used to collect concentrated contaminants.

Public Comment 3: Will the contaminated groundwater have a negative impact on the repair of the runways at Travis AFB?

Air Force Response: The groundwater sites in the WABOU are located far from the runways, so the presence of this groundwater contamination and its treatment will not impact the repair of the runways.

APPENDIX A

Site Summary Figures

The figures in this appendix summarize the site-specific information for each West/Annexes/Basewide Operable Unit (WABOU) groundwater site. Each summary contains background and contaminant information from the WABOU Remedial Investigation report, a brief description and estimated costs of the remedial alternatives that were developed in the WABOU Feasibility Study (FS), and a description of the selected interim groundwater remedial action. It also includes a conceptual model of a cross section of the site and a conceptual design of the selected alternative.

These figures were created to give the reader a snapshot of the characteristics of each site and associated contamination that led to the selection of the remedial actions. For additional information, Section 3.0 of this interim Record of Decision provides a more detailed description of the nature and extent of contamination and the calculated potential risks at each site. Section 4.0 provides a more detailed description of the FS process and the detailed evaluation of the remedial alternatives based on seven of the nine Comprehensive Environmental Response Compensation and Liability Act (CERCLA) criteria. Tables 4-1 through 4-6 summarize the qualitative evaluation of the groundwater remedial alternatives against each criterion. Table 4-7 provides the estimated cost of each remedial alternative at each site. Section 5.0 provides a more detailed description of the selected remedial actions and the rationale for their selection.

Building 755 (DP039)

Problem: Battery acid solutions and solvents were discharged from Building 755 into a sump and leach line resulting in contamination of the subsurface soil and groundwater with VOCs. A groundwater TCE plume extends about 1,600 feet downgradient of the site. The undissolved TCE beneath the water table may represent a continuing source of groundwater contamination.

Site Description: Battery and Electric Shop
Groundwater Flow Direction: southeast

Depth to Groundwater: 23 feet bgs (July 1996)
Depth to Bedrock: about 49 feet bgs near Building 755

Primary Groundwater Contaminants and Associated Human Health Risks

Contaminants	Maximum Concentration	Total Potential Cancer Risk	Maximum Hazard Index	Primary Contributors	Maximum Concentration
1,1-DCE	7,600 µg/L	3×10^{-2}	436	TCE	210,000 µg/L
TCE	210,000 µg/L		10	1,1-DCE	7,600 µg/L

na - not applicable because risk is less than 10^{-6} or Hazard Index is less than 1.

Selected Interim Remedial Action and Conceptual Design Assumption

Alternative G3 and G5—Source Area Extraction/ Containment/Treatment/ Discharge

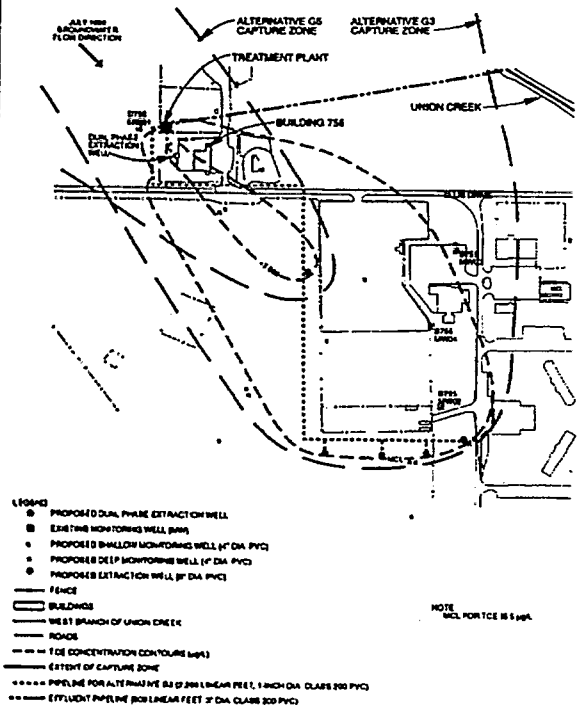
- One 6-inch diameter dual phase extraction well (5 gpm)
- Five 6-inch diameter PVC extraction wells (5 gpm each)
- Four 4-inch diameter PVC monitoring well pairs
- Six 4-inch diameter PVC shallow monitoring wells
- One 4-inch diameter PVC deep monitoring well
- Long-term monitoring of new wells plus 4 existing shallow wells and 1 existing shallow piezometer
- Six soil vapor piezometers
- Long-term annual monitoring of new piezometers
- Dual phase granular activated carbon treatment plant consisting of two 50-gpm disposable liquid phase carbon adsorbers and two 500-cfm disposable vapor phase carbon canisters
- Approximately 2,200 linear feet of subsurface influent pipeline, 1-inch diameter, Class 200 PVC
- Approximately 900 linear feet of subsurface effluent pipeline, 3-inch diameter, Class 200 PVC
- Discharge of treated groundwater to West Branch of Union Creek

Feasibility Study Alternatives and Associated Costs[a]

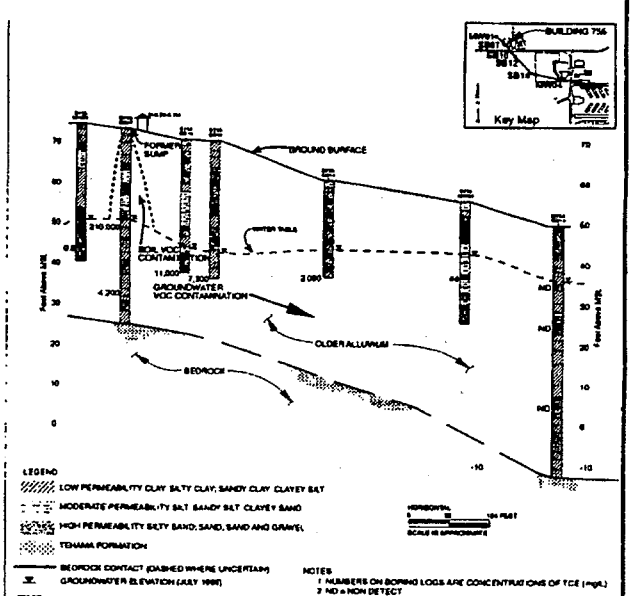
- Alternative G1—No Action: $0
- Alternative G2—Monitored Natural Attenuation: $510,300
- Alternative G3—Containment/Treatment/ Discharge: $929,700
- Alternative G4—Extraction/Treatment/ Discharge: $2,277,000
- Alternative G5—Source Area and Ground-water Extraction/Treatment/Monitored Natural Attenuation: $4,950,000
- Alternative G6—Source Area Extraction/ Treatment/Monitored Natural Attenuation: $7,406,000

[a]Present Worth Costs based on 30 years and 5 percent discount rate.

RCO-SFO/981279002E.DOC (LNDFILL3.DOC)



CONCEPTUAL DESIGN OF SELECTED ALTERNATIVES



CONCEPTUAL MODEL/CROSS SECTION

FIGURE A-1
BUILDING 755
SITE SUMMARY
WEST/ANNEXES/BASEWIDE OPERABLE UNIT (WABOU)
WABOU GOUNDWATER IROD
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

Landfill 3 (LF008)

Problem: Historically, pesticide containers were disposed of in trenches excavated at the site. As a result of this activity, elevated concentrations of organochlorine pesticides are found in the soil and groundwater at the site.

Site Description: Landfill (inactive)
Groundwater Flow Direction: southeast to northwest

Depth to Groundwater: 25 to 35 feet bgs (July 1996)
Depth to Bedrock: about 65 feet bgs

Primary Groundwater Contaminants and Associated Human Health Risks

Contaminants	Maximum Concentration	Total Potential Cancer Risk	Maximum Hazard Index	Primary Contributors	Maximum Concentration
aldrin heptachlor alpha-chlordane heptachlor epoxide	0.11 µg/L 0.084 µg/L 0.27 µg/L 0.033 µg/L	2×10^{-5}	1	na	na

na - not applicable because risk is less than 10^{-6} or Hazard Index is less than 1.

Selected Interim Remedial Action and Conceptual Design Assumptions

Alternative G4—Extraction/Treatment/ Discharge

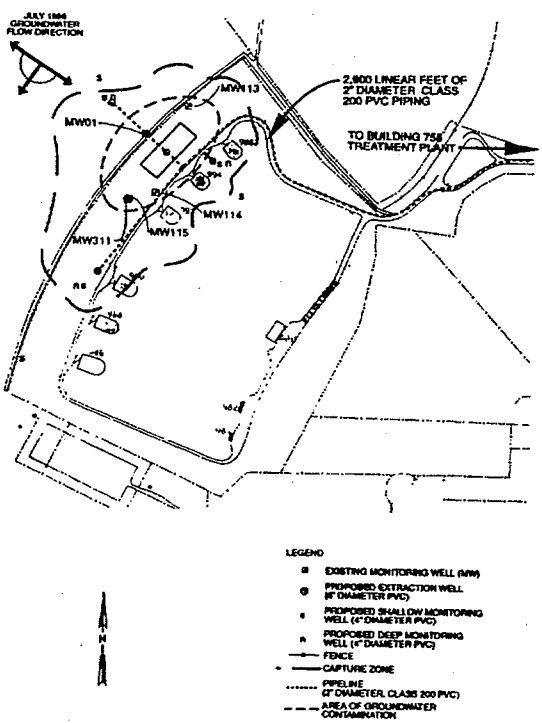
- Four 6-inch-diameter PVC extraction wells (5 gpm each)
- Three 4-inch-diameter PVC monitoring well pairs
- Three 4-inch-diameter PVC shallow monitoring wells
- Long-term monitoring of new wells plus 4 existing shallow and one existing deep well
- Liquid-phase granular activated carbon treatment at Building 755
- Approximately 2,800 linear feet of subsurface effluent pipeline, 2-inch-diameter PVC (to Building 755 for treatment)

ROD-SFO/981270002.DOC (LANDFILL3.DOC)

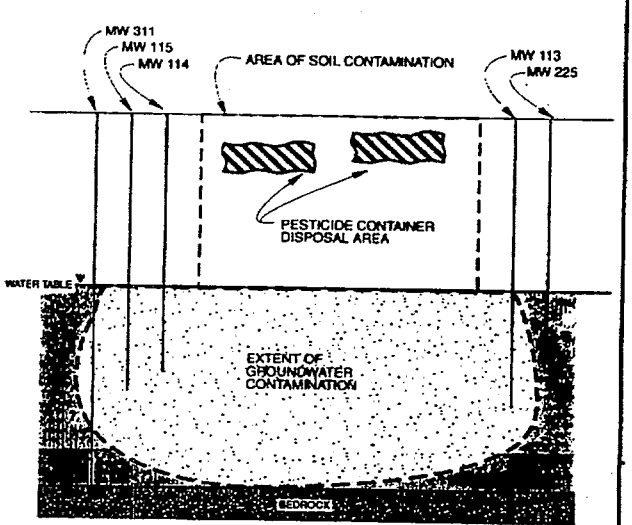
Feasibility Study Alternatives and Associated Costs[a]

- Alternative G1—No Action: $0
- Alternative G2—Monitored Natural Attenuation: $565,400
- Alternative G3—Containment/Treatment/ Discharge: $582,300
- Alternative G4—Extraction/Treatment/ Discharge: $819,800

[a]Present Worth Costs based on 30 years and 5 percent discount rate.



CONCEPTUAL DESIGN OF SELECTED ALTERNATIVE



CONCEPTUAL MODEL

FIGURE A-2
LANDFILL 3
SITE SUMMARY
WEST/ANNEXES/BASEWIDE OPERABLE UNIT (WABOU)
WABOU GROUNDWATER IROD
TRAVIS AIR FORCE BASE, CALIFORNIA

2443_706 (8/31/98)

CH2MHILL

Building 905 (SS041)/916 (SD043)

Building 905 Problem: Historical pesticides handling and equipment maintenance activities have resulted in contamination of the surface soil and groundwater at the site. Elevated concentrations of organochlorine pesticides were found in the surface soil within the fenced perimeter of the site and in the groundwater underlying the facility.

Building 916 Problem: A former electrical power transformer containing a PCB isomer leaked and contaminated the soil and groundwater at the site. The PCBs in the subsurface soil may represent a continuing source of groundwater contamination. In addition, TCE was detected in the groundwater.

Site Description: Entomology Shop (Bldg. 905)/ Emergency Power Generation Facility (Bldg. 916)
Groundwater Flow Direction: south/southeast

Depth to Groundwater: 9 feet bgs (July 1996)
Depth to Bedrock: about 50 feet bgs

Primary Groundwater Contaminants and Associated Human Health Risks

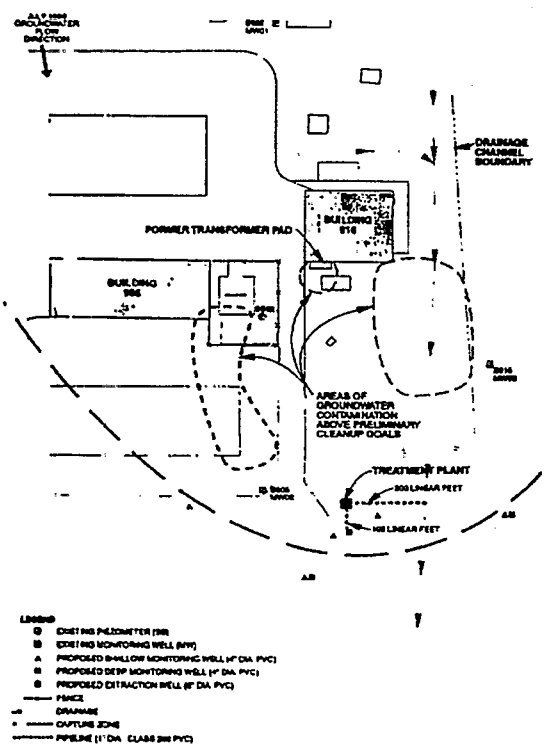
Building	Contaminants	Maximum Concentration	Total Potential Cancer Risk	Maximum Hazard Index	Primary Contributors	Maximum Concentration
Bldg. 905	heptachlor epoxide	0.023 µg/L	2×10^{-6}	< 1	na	na
Bldg. 916	PCB (Arochlor 1254)	22 µg/L	5×10^{-5}	22	PCB-1254	22 µg/L
	TCE	71 µg/L				

na - not applicable because risk is less than 10^{-6} or Hazard Index is less than 1.

Selected Interim Remedial Action and Conceptual Design Assumption

Alternative G3—Containment/Treatment/Discharge

- One 6-inch diameter extraction well (5 gpm)
- Two 4-inch diameter monitoring well pairs
- Three 4-inch diameters shallow monitoring wells
- Long-term monitoring of new wells plus 3 existing shallow wells and 1 existing shallow piezometer
- Liquid-phase granular activated carbon treatment plant consisting of two 15-gpm DOT 5B drum disposable carbon adsorbers
- Approximately 100 linear feet of subsurface influent pipeline, 1-inch diameter, Class 200 PVC
- Approximately 200 linear feet of subsurface effluent pipeline, 1-inch diameter, Class 200 PVC

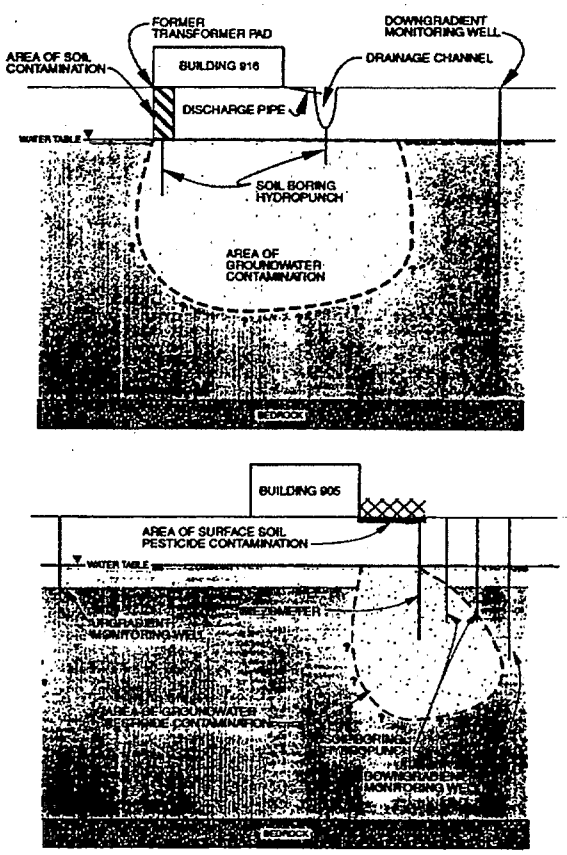


CONCEPTUAL DESIGN OF SELECTED ALTERNATIVE

Feasibility Study Alternatives and Associated Costs[a]

- Alternative G1—No Action: $0
- Alternative G2—Monitored Natural Attenuation: $532,800
- Alternative G3—Containment/Treatment/Discharge: $568,100

[a]Present Worth Costs based on 30 years and 5 percent discount rate.



CONCEPTUAL MODEL

FIGURE A-3
BUILDINGS 905/916
SITE SUMMARY
WEST/ANNEXES/BASEWIDE OPERABLE UNIT (WABOU)
WABOU GROUNDWATER IROD
TRAVIS AIR FORCE BASE, CALIFORNIA

CH2MHILL

Response to EPA Comments on the Draft Final WABOU Groundwater Interim ROD

The following revisions to the draft final WABOU Groundwater Interim ROD have been agreed upon by all parties. The revisions are in bold type. The change pages based on revisions 1 through 5 were sent out to all parties on February 19, 1998. The change pages based on revisions 6 and 7 are included with the final change pages distributed on June 24, 1998.

1. We revised the second paragraph from the bottom of page 3 of Part 1 (Declaration, Description of the Selected Interim Remedies) to read:

"In addition to the addendum to the NEWIOU Groundwater RD/RA Plan, the Air Force will **perform a pre-design investigation, as necessary, and then** prepare a site-specific RD/RA work plan for each WABOU groundwater site. **The purpose of the pre-design investigation is to fill existing data gaps so that the Air Force can successfully implement the remedial action at a site. Examples of data gaps may include the distribution of groundwater contamination in subsurface strata, hydrogeologic conditions that affect remedial action performance, and unusual groundwater analytical results that may indicate the presence of additional groundwater contamination sources.** The site-specific RD/RA work plan will present the **results of the site-specific pre-design investigation, the preliminary design information including the potential** placement of **extraction and** monitoring wells, groundwater monitoring protocols and frequency, and procedures to determine whether plume migration is occurring. **After regulatory approval of the site-specific RD/RA work plan, the Air Force will submit the RD design package that includes drawings, specifications, and a design report. The site-specific RD/RA work plan and the RD design package are primary documents and are described in the final NEWIOU Interim Groundwater RD/RA Plan.** If a contingency action is necessary to control migration, the Air Force will request funding and implement a contingency action as soon as funding becomes available."

We added the following sentences to the last paragraph in this section on page 4:

"Travis AFB will eventually replace this interim ROD with a final ROD as soon as sufficient data has been collected to support the selection of a final remedy. The sites described in the final NEWIOU Groundwater IROD and the WABOU groundwater sites may be addressed in one basewide groundwater ROD if the Travis AFB Cleanup Team decides that this approach is appropriate."

2. We revised the last paragraph in Section 3.3 (Chemicals of Concern) on page 36 to read:

"The approach to evaluating pesticide concentrations in the WABOU is based on comparisons with the concentrations found at other locations on Travis AFB. The WABOU RI used the Inorganic Constituent Evaluation Methodology (Radian, 1996b) to determine whether **compounds** detected in samples are naturally occurring or are contaminants from past industrial practices. **Statistical analysis of the pesticide detections from non-pesticide sites resulted in the establishment of WABOU reference concentrations for pesticides.** More detailed discussion of the WABOU pesticide evaluation is provided in Appendix I of the WABOU RI report (CH2M HILL, 1997).

3. We revised section 4.3.1 (Overall Protection of Human Health and the Environment) to read:

"Overall protection of human health and the environment serves as a threshold determination that must be met by any alternative for it to be selected as a remedy. Each of the groundwater

alternatives, except for Alternative G1 (No Action), are protective of human health and the environment."

Also we deleted Table 4-2.

4. We revised the first paragraph of section 5.6 (Land Use Restrictions) to read:

"The Air Force **has** land use restrictions **in place at the four** WABOU groundwater sites. These administrative actions **restrict** the use of onbase groundwater from **these** contaminated sites. Travis AFB does not currently use its onbase groundwater for drinking water. These **actions** also restrict soil excavation and other subsurface work where the excavation worker will encounter contaminated groundwater or vapors. These subsurface activities **are** only allowed after environmental and worker safety control measures are in place. Travis AFB **uses** its digging permit program to coordinate, and if necessary, restrict contractor and Base personnel access to contaminated areas. In addition, Travis AFB will amend its General Plan to document **additional** land use restrictions, once the final remedial actions are selected in the basewide groundwater ROD. **A detailed description of the existing land use restrictions at the four WABOU groundwater sites will be included in the addendum to the NEWIOU Groundwater RD/RA Plan.**"

5. We added the following sentence in front of the last sentence of the subsection titled "Habitats of Rare, Threatened, Endangered, and Special-Status Species" in section 6.4.2 (Location-Specific ARARs) on page 63:

"U.S. EPA does not acknowledge that all CFGC requirements are more stringent than federal requirements but concurs with the Air Force decision to comply with both federal and state requirements as ARARs in this IROD."

6. We deleted the reference to Title 22 CCR 66264.97 as a Relevant and Appropriate requirement in Table 6-3. This requirement was previously identified in Table 6-1 as Applicable, and therefore was deleted from Table 6-3 to avoid confusion.

7. We revised the Source description of the NPDES requirements on the second page of Table 6-4 to read:

"**Title 40 CFR Part 122 – EPA Administered Permit Programs:** The National Pollutant Discharge Elimination System **(NPDES)**"

NTIS does not permit return of items for credit or refund. A replacement will be provided if an error is made in filling your order, if the item was received in damaged condition, or if the item is defective.

Reproduced by NTIS

National Technical Information Service
Springfield, VA 22161

This report was printed specifically for your order from nearly 3 million titles available in our collection.

For economy and efficiency, NTIS does not maintain stock of its vast collection of technical reports. Rather, most documents are printed for each order. Documents that are not in electronic format are reproduced from master archival copies and are the best possible reproductions available. If you have any questions concerning this document or any order you have placed with NTIS, please call our Customer Service Department at (703) 605-6050.

About NTIS

NTIS collects scientific, technical, engineering, and business related information — then organizes, maintains, and disseminates that information in a variety of formats — from microfiche to online services. The NTIS collection of nearly 3 million titles includes reports describing research conducted or sponsored by federal agencies and their contractors; statistical and business information; U.S. military publications; multimedia/training products; computer software and electronic databases developed by federal agencies; training tools; and technical reports prepared by research organizations worldwide. Approximately 100,000 *new* titles are added and indexed into the NTIS collection annually.

For more information about NTIS products and services, call NTIS at 1-800-553-NTIS (6847) or (703) 605-6000 and request the free *NTIS Products Catalog,* PR-827LPG, or visit the NTIS Web site **http://www.ntis.gov.**

NTIS
Your indispensable resource for government-sponsored information—U.S. and worldwide