412TH Test Wing
Edwards Air Force Base, California

Environmental Restoration Program

South AFRL First Five-Year Review Report
(Sites 37, 133, 120, and 321)

Air Force Research Laboratory
Detachment 7
Operable Units 4 and 9
Edwards AFB, California

Final

September 2012

AECOM

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August 24, 2012
ERS-0005-12-0408

U.S. Air Force 412th Test Wing
Environmental Restoration
412 TW/CEVR - Building 2650A
5 East Popson Avenue, Cube 513
Edwards AFB, California 93524-8060

Attention: Ms. Patrice Hallman

Contract No.: W91238-07-D-0005
Task Order: 0011

Subject: **SOUTH AFRL FIRST FIVE YEAR REVIEW REPORT (SITES 37, 133, 120, AND 321), AIR FORCE RESEARCH LABORATORY, OPERABLE UNITS 4 AND 9, EDWARDS AIR FORCE BASE, CALIFORNIA – FINAL**

Dear Ms. Hallman:

Transmitted herein are six hard copies and three CDs (including one for Mr. Warren Seidel) of the document referenced above, which has been revised from the July 2012 draft final to incorporate review comments from the RPMs (see responses to comments in Appendix H) as approved by yourself and Mr. Eric Barefoot (AFCEE/ERC). Copies of this document were also to Mr. Krongard; and to the RPMs and AFCEE in accordance with the attached transmittal letters.

If you have any questions, please do not hesitate to contact me at (714) 689-7196.

Very truly yours,

AECOM Technical Services, Inc.

Sarah Grossi

Sarah Grossi
Project Manager

SG:rh

Enclosures

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August 24, 2012
ERS-0005-12-0407

U.S. Army Corps of Engineers, Sacramento District
1325 J Street, 8th floor
Sacramento, CA 95814-2922

Attention: Mr. Gary Krongard

Contract No.: W91238-07-D-0005
Task Order: 0011

Subject: **SOUTH AFRL FIRST FIVE YEAR REVIEW REPORT (SITES 37, 133, 120, AND 321), AIR FORCE RESEARCH LABORATORY, OPERABLE UNITS 4 AND 9, EDWARDS AIR FORCE BASE, CALIFORNIA – FINAL**

Dear Mr. Krongard:

Transmitted herein is a CD of the document referenced above, which has been revised from the July 2012 draft final to incorporate review comments from the RPMs (see responses to comments in Appendix H) as approved by Ms. Patrice Hallman (412 TW/CEVR) and Mr. Eric Barefoot (AFCEE/ERC). Copies of this document were also to Ms. Hallman; and to the RPMs and AFCEE in accordance with the attached transmittal letters.

If you have any questions, please do not hesitate to contact me at (714) 689-7196.

Very truly yours,

AECOM Technical Services, Inc.

Sarah Grossi

Sarah Grossi
Project Manager

SG:rh

Enclosure

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 412TH TEST WING (AFMC)
EDWARDS AIR FORCE BASE CALIFORNIA

24 August 2012

MEMORANDUM FOR DISTRIBUTION

FROM: 412 Test Wing/CEVR
5 E. Popson Avenue
Edwards AFB CA 93524

SUBJECT: First Five-Year Review Report (Sites 37, 133, 120, and 321), Air Force Research Laboratory, Operable Units 4 and 9, Edwards AFB, CA – Final

1. Transmitted herein is the final version of the Five-Year Review (FYR) report cited above. Appendix H in this version of the document includes responses to regulator comments received on the draft and draft final versions of this document dated May and July 2012.
2. Edwards AFB will provide a signed, final copy of this report to USEPA and State RPMs on or before 24 September 2012.
3. If you have any questions or comments, please call me at (661) 277-1474 or Patrice Hallman at (661) 277-1419.

AI DUONG, NH-IV
Remedial Project Manager
Chief, Environmental Restoration

Attachment:
First Five-Year Review Report (Sites 37, 133, 120, and 321), Air Force Research Laboratory, Operable Units 4 and 9, Edwards AFB, CA – Final

DISTRIBUTION:
Mr. Eric Barefoot, AFCEE/ERC (1 CD)
Dr. Shanna Clark, AFCEE/TDV (1 CD)
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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 412TH TEST WING (AFMC)
EDWARDS AIR FORCE BASE, CALIFORNIA

24 August 2012

MEMORANDUM FOR: SEE DISTRIBUTION

FROM: 412 TW/CEVR
5 E. Popson Avenue, Bldg 2650A
Edwards AFB CA 93524-8060

SUBJECT: First Five-Year Review Report (Sites 37, 133, 120, and 321), Air Force Research Laboratory, Operable Units 4 and 9, Edwards AFB, CA –Final

1. Transmitted herein (per the distribution listed on the 2nd page) is the *unsigned* final version of the Five-Year Review (FYR) report cited above. Note that copies are sent to Mr. Ball at USEPA Region 9, and to Ms. Young and Ms. McEaddy at USEPA Headquarters, per request of Mr. James Ricks (USEPA Region 9).
2. This review is required because the remedies selected for groundwater and the vapor intrusion pathway (VIP) in the 2007 Record of Decision (ROD) for the South AFRL result in hazardous substances, pollutants, or contaminants on site above levels that allow for unlimited use and unrestricted exposure (UU/UE).
3. As lead agency, the United States Air Force is required to review remedial actions that do not attain UU/UE at a frequency no less than every 5 years to assure that human health and the environment are protected by the remedy. This is the first FYR since the South AFRL ROD was signed in September 2007.
4. Appendix H in this version of the document includes responses to regulator comments received on the draft and draft final versions of the document dated May 2012 and July 2012, respectively.
5. The Air Force will provide a signed, final copy of this report on or before 24 September 2012.
6. If you have any questions or comments, please call me at (661) 277-1474 or Patrice Hallman at (661) 277-1419.

AI DUONG
Chief, Environmental Restoration

Attachment: First Five-Year Review Report (Sites 37, 133, 120, and 321), Air Force Research Laboratory, Operable Units 4 and 9, Edwards AFB, CA –Final

DISTRIBUTION:

- Mr. James Ricks (one CD)
  U.S. EPA, Region 9
- Mr. Joe Healy (two CDs, one hard copy)
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- Mr. Harold Ball (one CD, sent by request of Mr. James Ricks)
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- Ms. Dianna Young (one CD, sent by request of Mr. James Ricks)
  U.S. EPA, Headquarters
- Ms. Monica McEaddy (one CD, sent by request of Mr. James Ricks)
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ENVIRONMENTAL RESTORATION PROGRAM

SOUTH AFRL FIRST FIVE-YEAR REVIEW REPORT
(SITES 37, 133, 120, AND 321)

AIR FORCE RESEARCH LABORATORY DETACHMENT 7
OPERABLE UNITS 4 AND 9
EDWARDS AIR FORCE BASE
CALIFORNIA

FINAL

SEPTEMBER 2012

Prepared for:

U.S. AIR FORCE 412TH TEST WING
ENVIRONMENTAL RESTORATION (412 TW/CEVR)
EDWARDS AIR FORCE BASE, CA 93524-8060

and the

DEPARTMENT OF THE ARMY
UNITED STATES ARMY CORPS OF ENGINEERS (USACE)
SACRAMENTO DISTRICT
SACRAMENTO, CA 95814-2922

South AFRL First Five-Year Review Report

(Sites 37, 133, 120, and 321)
Air Force Research Laboratory Detachment 7
Operable Units 4 and 9
Edwards Air Force Base
California

September 2012

United States Air Force
Edwards Air Force Base, CA

Approved by:

Date:

3 Oct 2012

MICHAEL T. BREWER, Brigadier General, USAF
Commander, 412th Test Wing
Edwards Air Force Base, California

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Edwards Air Force Base		
EPA ID: CA1570024504		
Region: 9	**State:** CA	**City/County:** Kern/Los Angeles/San Bernardino

SITE STATUS	
NPL Status: Final	
Remediation Status: ☐ Under Construction ☒ Operating ☐ Complete	
Multiple OUs ? Yes	**Has the site achieved construction completion?** No

REVIEW STATUS
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** United States Air Force
Author name (Federal or State Project Manager): USAF at Edwards AFB (Ai Duong, RPM)
Author affiliation: N/A
Review period: September 2007 – mid-April 2012
Date of site inspection: April 2012
Type of review: Statutory
Review number: 1
Triggering action date: 24 September 2007
Due date *(five years after triggering action date)*: September 2012

Five-Year Review Summary Form (continued)

The table below is for the purpose of the summary form and associated data entry and does not replace the two tables required in Section VIII and IX by the FYR guidance. Instead, data entry in this section should match information in Section VII and IX of the FYR report.

Issues/Recommendations

OU(s) without Issues/Recommendations Identified in the Five-Year Review:
Sites without issues/recommendations are not identified in the Five-Year Review.
Issues and Recommendations Identified in the Five-Year Review:

OU(s): South AFRL OU4 and OU9 (Sites 37, 133, 120, and Site 321)	**Issue Category: Monitoring**			
	Issue: California primary Maximum Contaminant Level (pMCL) for perchlorate adopted in October 2007; 4 times lower than the containment level selected in Record of Decision (ROD).			
	Recommendation: Prepare an Explanation of Significant Differences (ESD) to adopt the CA pMCL as the perchlorate level to be contained inside the South AFRL Containment Zone (CZ).			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA	Prior to 2017

OU(s): South AFRL OU4 and OU9 (Sites 37, 133, 120, and 321)	**Issue Category: Monitoring**			
	Issue: Based on recent updates to the Integrated Risk Information System (IRIS) database, trichloroethene (TCE) is more toxic and tetrachloroethene (PCE) is less toxic than considered in CA Office of Environmental Human and Ecological Assessment (OEHHA) database used to develop indoor air vapor mitigation levels (IAVMLs) selected in ROD.			
	Recommendation: In ESD, update IAVMLs for PCE and TCE to incorporate use of the updated toxicity criteria.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA	Prior to 2017

Protectiveness Statement(s)
Include each individual OU protectiveness determination and statement. If you need to add more protectiveness determinations and statements for additional OUs, copy and paste the table below as many times as necessary to complete for each OU evaluated in the FYR report.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
South AFRL OU4 and OU9 (Sites 37, 133, 120, and 321)	Protective	N/A
Protectiveness Statement: Because land use controls (LUCs) selected in the 2007 ROD have been implemented, are effective, and no exposures are occurring, the LUCs component of the remedial action for the South AFRL is protective.		
Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
South AFRL OU4 and OU9 (Sites 37, 133, 120, and 321)	Protective	N/A
Protectiveness Statement: Based on the technical assessment presented in Section 7, the groundwater remedy at the South AFRL currently protects human health and the environment because LUCs and long-term monitoring (LTM) are in place and effective to prevent exposures and verify containment.		
Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
South AFRL OU4 and OU9 (Sites 37, 133, 120, and 321)	Protective	N/A
Protectiveness Statement: Based on the technical assessment presented in Section 7, the vapor intrusion (VI) remedy at the South AFRL currently protects human health and the environment because LUCs and monitoring are in place and effective to prevent exposures and verify containment.		

Sitewide Protectiveness Statement (if applicable)	
For sites that have achieved construction completion, enter a sitewide protectiveness determination and statement.	
Protectiveness Determination: Protective	*Addendum Due Date (if applicable):* *N/A*
Protectiveness Statement: The remedy continues to operate successfully as designed and is protective of human health and the environment.	

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LIST OF ACRONYMS AND ABBREVIATIONS

§	section
&	and
≥	equal to or greater than
>	greater than
<	less than
%	percent
α	building attenuation factor
α_x	dispersivity
μg/L	microgram per liter
μg/m^3	micrograms per cubic meter
3D	three-dimension
412 RANS	412th Range Squadron
412 TW/CEVR	412th Test Wing, Environmental Restoration
95 ABW/CEAO	95th Air Base Wing/Civil Engineering Division Asset Management Branch Community Planning
95 ABW/CEOFR	95th Air Base Wing/Civil Engineering Operations Facilities Research
95 ABW/CEPT	95th Air Base Wing/Civil Engineer Division, Technical Support Section
95 ABW/CEV	95th Air Base Wing/Environmental Restoration Branch, Environmental Management
95 ABW/CEVN	95th Air Base Wing/Environmental Restoration Branch, Conservation Section
95 ABW/CEVR	95th Air Base Wing/Civil Engineering Division, Environmental Restoration
95 ABW/EMR	95th Air Base Wing/Environmental Restoration Division
ABC+	Anaerobic BioChem
AECOM	AECOM Technical Services, Inc.
AF	Air Force
AF/A7CAN	Air Force (USAF), Office of the Civil Engineer, Asset Management and Operations Division, Environmental Branch
AFB	Air Force Base
AFCEE	Air Force Center for Engineering and the Environment
AFCEE/ER	Air Force Center for Engineering and the Environment/Environmental Restoration Directorate
AFCEE/ERC or AFCEE/ERD	Air Force Center for Environmental Excellence, Environmental Division
AFCEE/ESC	Air Force Center for Engineering and the Environment/Base Conversion Branch
AFCEE/EXEW or AFCEE/EXW	U.S. Air Force Center for Engineering and the Environment/Environmental Programs Execution - West
AFCEE/ICE	Air Force Center for Engineering and the Environment/MAJCOM and Installation Support-CONUS (AFMC)
AFCEE/ISM	Air Force Center for Environmental Excellence, Installation Support Materiel
AFCEE/TDV	Air Force Center for Engineering and the Environment, Technical Support Division, Environmental Restoration Branch
AFFTC	Air Force Flight Test Center
AFFTC/EMC	Air Force Flight Test Center, Environmental Compliance Division
AFFTC/EMR	Air Force Flight Test Center, Environmental Restoration Division

AFI	Air Force Instruction
AFLOA/JACE	Air Force Legal Operations Agency/Environmental Law and Litigation Division
AFRL	Air Force Research Laboratory
AFRL DET7/SE	Air Force Research Laboratory Detachment 7/Safety
AFRL/RZS	Air Force Research Laboratory/Space and Missile Propulsion Division
AFRL/RZSP	Air Force Research Laboratory/Space and Missile Propulsion Division, Propellants
AFRPA/BPM	Air Force Real Property Agency, Business Process Modeling
AGMR	annual groundwater monitoring report
aMSL	above mean sea level
AOC	area of concern
AOR	annual operations report
ARAR	applicable or relevant and appropriate requirement
ARD	anaerobic reductive dechlorination
AST	aboveground storage tank
AT&SF	Atchinson, Topeka & Santa Fe Railroad
AVEK	Antelope Valley-East Kern
BAA	Board Agency Announcement, AFCEE
BCS	Boron Community Services
BGP	Base General Plan
bgs	below ground surface
Blvd	boulevard
BW	basewide
CA	California
Cal EPA	California Environmental Protection Agency
CBr	competent bedrock
CCR	California Code of Regulation
CE	civil engineering
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation and Liability Information System
CF	chloroform
CFC	chlorofluorocarbon
CFR	Code of Federal Regulations
CIP	Community Involvement Plan
CLU-IN	Clean-Up Information
cm	centimeter
cm/s	centimeter per second
cm^2/s	square centimeters per second
Co.	County
COC	chemical of concern
COPC	chemical of potential concern
CPME	comprehensive plume monitoring event
CRWQCB-LR	California Regional Water Quality Control Board, Lahontan Region
CSM	conceptual site model
CWM	chemical warfare materiel
CZ	containment zone

D	downthrown side or decreasing
d	deep
DCA	dichloroethane
DCDFM	dichlorodifluoromethane
DCE	dichloroethene
DHC	*Dehalococcoides* sp.
DLCS	Desert Lake Community Services
DNAPL	dense non-aqueous phase liquid
DOD	Department of Defense
DODI	Department of Defense Instruction
DQO	data quality objective
DTSC	Department of Toxic Substances Control
DWEL	drinking water equivalent level
DWR	Department of Water Resources
E	east
EAFB	Edwards Air Force Base
e.g.	for example (exempli gratia)
EIAP	Environmental Impact Analysis Process
EM	Environmental Management
ERA	ecological risk assessment
ERP	Environmental Restoration Program
ESD	Explanation of Significant Differences
ESI/RFA	Expanded Source Investigation/RCRA Facility Assessment
ESOH	Environment, Safety, and Occupation Health
EST	Environmental Support Technologies, Inc.
ESTCP	Environmental Security Technology Certification Program
etc.	and so forth (et cetera)
EVO	emulsified vegetable oil
eZVI	emulsified ZVI
FBZ	fractured bedrock zone
FCPMP	Final Closure and Post-closure Monitoring Plan
FD or fd	field duplicate
FFA	Federal Facility Agreement
FI	further investigation
FS	feasibility study
FSP	Field Sampling Plan
ft	feet
ft^2	square feet
ft/day	feet per day
ft^2/day	square feet per day
ft/ft	feet per foot
FY	fiscal year
FYR	Five-Year Review
GETS	groundwater extraction and treatment system
GIS	geographic information system
GP	general plan

gpd	gallons per day
gpm	gallons per minute
GPS	global positioning system
GRA	Groundwater Resources Association
GSI	Groundwater Services, Inc.
GWVCL-ind	groundwater vapor compliance level for industrial exposure
GWVCL-res	groundwater vapor compliance level for residential exposure
HEAST	Health Effects Assessment Summary Table
HERO	Office of Human and Ecological Risk
HI	hazard index
HHRA	human health risk assessment
HQ	hazard quotient
HVAC	heating, ventilation and air conditioning
Hwy	highway
I	increasing
IA	indoor air sample
IASL-ind	indoor air screening level for industrial exposure
IAVML	indoor air vapor mitigation level
IAVML-ind	indoor air vapor mitigation level for industrial exposure
IAVML-res	indoor air vapor mitigation level for residential exposure
IC	institutional control
ID	identification
i.e.	that is (id est)
IPA	isopropyl alcohol
IRA	interim removal action
I-RAR	Interim - Removal Action Report
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
IS	interim sentinel
ISB	in situ bioremediation
ISCO	in situ chemical oxidation
ISCR	in situ chemical reduction
ITIR	Informal Technical Information Report
ITRC	Interstate Technology and Regulatory Council
IUR	Inhalation unit risk factor
J&E	Johnson and Ettinger
JACE/ER/CR/WR	Environmental Law and Litigation Division, Eastern Regional Office/Central Regional Office/Western Regional Office
Jan	January
Jct.	junction
JP-4	jet propellant 4
JPL	Jet Propulsion Laboratory
K	hydraulic conductivity
K-12	kindergarten through twelfth grade
KCEHSD	Kern County Environmental Health Services Department
LNAPL	light non-aqueous phase liquid

LPSC	Liquid Propellant Storage Complex
LTM	long-term monitoring
LUC	land use control
MAJCOM	Major Command
MAROS	Monitoring and Remediation Optimization System
MBFL	Main Base Flightline
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mg/kg	milligrams per kilogram
mg/kg/day	milligrams per kilogram per day
mg/L	milligrams per liter
Misc.	miscellaneous
MK	Mann-Kendall
MLS	multilevel monitoring system
MMH	monomethyl hydrazine
MS/MDL	matrix spike/matrix spike duplicate
msl	mean sea level
MTBE	methyl tert-butyl ether
N_2O_4	nitrogen tetroxide
N	nitrogen or north
NA	not applicable or not available
NAD 83	North American Datum 1983
NAPL	non-aqueous phase liquid
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	not detected
NDMA	N-nitrosodimethylamine
NE	northeast or not encountered
NFA	no further action
NFI	no further investigation
NL	notification level
No.	number
NPL	National Priorities List
NS	not sampled
NT	no trend
NW	northwest
O&M	operations and maintenance
OEHHA	Office of Environmental Health Hazard Assessment
OPS	Operations
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
p.	page
Pa	pascals
PAT	pump and treat
PBR	Performance Based Restoration
PCE	tetrachloroethene

PD	probably decreasing
pdf	portable document format
PERA	Predictive Ecological Risk Assessment
PG	professional geologist
PHG	public health goal
PI	probably increasing
PIRA	Precision Impact Range Area
pMCL	primary Maximum Contaminant Level
PMP	Project Management Professional
POC	point of contact
PP	Proposed Plan
ppb(v)	parts per billion by volume
ppb v/v	parts per billion volume per volume
ppmv	parts per million by volume
PRB	permeable reactive barrier
PPRTV	Provisional Peer-Reviewed Toxicity Value
PRG	preliminary remediation goal
PRL	potential release location
QC	quality control
R&D	Research and Development
RA	remedial action
RAB	Restoration Advisory Board
RAO	remedial action objective
RAWP	remedial action work plan
RBCG	risk-based cleanup goal
RBCL	risk-based cleanup level
RCRA	Resource Conservation and Recovery Act
Rd	road
RF	radio-frequency
RfC	reference concentration
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RISR	Remedial Investigation Summary Report
RL	reporting limit
ROD	Record of Decision
ROI	radius of influence
RPM	remedial project manager
RSL	Regional Screening Level
RTS	Report to Stakeholders
S	South, storativity, stable, or sand
s	shallow
S-ISCO	surfactant-enhanced ISCO
SARA	Superfund Amendments and Reauthorization Act
SCL	sandy clay loam
SE	southeast
SERA	Scoping Ecological Risk Assessment

SERDP	Strategic Environmental Research and Development Program
SI	site investigation or site inspection
SIL	silt loam
SN	screening number (for soil gas)
sp.	species
SP	Southern Pacific Railroad
SS	sub-slab sample
SSD	sub-slab depressurization
St	street
STP	Sewage Treatment Plant
SWAT	Solid Waste Assessment Test
SVE	soil vapor extraction
SVOC	semivolatile organic compound
SVSL-ind	soil vapor screening level for industrial exposure
SWMU	Solid Waste Management Unit
T	transmissivity
t-GAC	tailored liquid phase granular activated carbon
TCA	trichloroethane
TCE	trichloroethene
TCFM	trichlorofluoromethane
TEFA	technical and economic feasibility analysis
TI	technical impracticability
TIP	Technology Innovation Program
TSER	Treatability Study Evaluation Report
TSWP	Treatability Study Work Plan
U	upthrown side
UCL	upper confidence limit
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
URF	unit risk factor
U.S. or US	United States
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USC	United States Code
USEPA or U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	underground storage tank
USTI	Underground Storage Tank Investigation
UTM	Universal Transverse Mercator
UU/UE	unlimited use and unrestricted exposure
UXO	unexploded ordnance
VI	vapor intrusion
VICB	vapor intrusion compliance boundary
VIP	vapor intrusion pathway
VOC	volatile organic compound
VPGAC	vapor-phase granular activated carbon

vs.	versus
W	west
WBr	weathered bedrock
WGS 84	World Geodetic System 1984
WIR	Well Installation Report
WIWP	Well Installation Work Plan
WP/SAP	work plan/sampling and analysis plan
WWTP	wastewater treatment plant
ZVI	zero-valent iron

EXECUTIVE SUMMARY

This report presents the results of the first five-year review (FYR) for Environmental Restoration Program (ERP) Sites 37, 120, 133, and 321 in the South Air Force Research Laboratory (AFRL), Operable Units (OUs) 4 and 9 at Edwards Air Force Base (AFB), California (CA). The purpose of the FYR is to evaluate whether the remedies for groundwater and subsurface vapor implemented at ERP Sites 37, 120, 133, and 321 are functioning as intended by the 2007 Record of Decision (ROD) and remain protective of human health and the environment. The ROD also documented a decision of No Action for soil at ERP Sites 37, 120, 133, and 321. This review is required by statute because the selected remedies result in hazardous substances, pollutants, or contaminants on site above levels that allow for unlimited use and unrestricted exposure (UU/UE).

The United States Air Force (USAF) is the lead agency for conducting FYRs at Edwards AFB under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Pursuant to CERCLA (42 United States Code [USC] §9621[c]) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the triggering action for a FYR is remedy initiation. This first FYR was prepared to coincide with the 5-year anniversary of remedy initiation that occurred with signing of the South AFRL ROD by the United States Environmental Protection Agency (USEPA) on 24 September 2007. The review includes an evaluation of remedy performance data from Sites 37, 120, 133, and 321 from October 2007 through mid-April 2012; the end date was selected to allow time for data review and compilation before submittal of the draft FYR in May 2012.

The selected remedy for groundwater at ERP Sites 37, 120, 133, and 321 includes a technical impracticability (TI) waiver from attaining applicable or relevant and appropriate requirements (ARARs) within a 16.4-square mile area designated the South AFRL Containment Zone (CZ) to a depth of 500 feet (ft) below ground surface (bgs); land use controls (LUCs) to prevent exposure to groundwater within the CZ; and long-term monitoring (LTM) to confirm that groundwater impacted by contaminant concentrations above the ARARs does not migrate outside the South AFRL CZ (TI waiver zone). The selected remedy for the vapor intrusion pathway (VIP) includes LUCs to prevent exposure to volatile organic compounds (VOCs) in subsurface vapor intruded into the indoor air of buildings under an unrestricted (residential) use scenario; and LUCs with engineering controls to prevent exposure via the VIP to VOCs in indoor air at concentrations (of individual chemicals) that pose a

cancer risk exceeding 1 x 10^{-6} or a hazard index (HI) exceeding 1 under the current industrial use scenario.

In accordance with the *Comprehensive Five-Year Review Guidance* (USEPA 2001) and *Recommended Evaluation of Institutional Controls: Supplement to the "Comprehensive Five-Year Review Guidance"* (USEPA 2011), the FYR review process consisted of the following components:

- Administrative
- Community notification and involvement
- Document review
- Data review
- Site Inspection; and
- Interviews

Based on the document and data reviews, site inspection, and interviews, a technical assessment of the remedy and remedial action objectives (RAOs) was completed as summarized below.

1. Question A: Is the remedy functioning as intended? **Yes**.

    a. LUCs selected in the ROD have been implemented and are effective in preventing exposure to contaminated groundwater and soil vapor;

    b. Groundwater monitoring results demonstrate that the leading edges of the contaminant plumes are more than 1 mile (in the direction of groundwater flow) from the CZ boundary; and

    c. Results from the VIP evaluation indicate that indoor air concentrations of tetrachloroethene (PCE) and trichloroethene (TCE) are generally below ROD-selected levels; at Building 8595, performance monitoring continues to evaluate effectiveness of soil vapor extraction (SVE) to reduce VIP risks.

2. Question B: *Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid*? **No**. The exposure assumptions and RAOs are still valid; however, a State primary maximum contaminant level (pMCL) was established for perchlorate; and toxicity data were updated for the primary chemicals of concern (COCs), TCE and PCE. Based on these revisions and to ensure the continuing protectiveness of the remedy, an Explanation of Significant Differences (ESD) is recommended to update the:

a. Containment level for perchlorate in groundwater. The ESD should revise the concentration to be contained inside the CZ to the State pMCL of 0.006 milligrams per liter (mg/L) rather than the non-promulgated USEPA drinking water equivalent level (DWEL) of 0.024 mg/L.

b. Mitigation levels for TCE and PCE intruded into indoor air via the VIP. If an ESD is prepared, the indoor air vapor mitigation levels (IAVMLs) selected for PCE and TCE in the ROD should be revised to incorporate toxicity criteria updated in the Integrated Risk Information System (IRIS) database in September 2011 and February 2012, respectively.

3. Question C: Has any other information come to light that could call into question the protectiveness of the remedy? **No**; there is no information that impacts protectiveness of the remedy.

As an outcome of the FYR, issues and opportunities for remedy optimization were identified; and the following protectiveness statements can be made:

- **LUCs:** Because LUCs selected in the 2007 ROD have been implemented, are effective, and no exposures are occurring, the LUCs component of the remedial action for the South AFRL is protective.

- **Groundwater:** Based on the technical assessment presented in Section 7, the groundwater remedy at the South AFRL currently protects human health and the environment because LUCs and LTM are in place and effective to prevent exposures and verify containment.

- **Vapor:** Based on the technical assessment presented in Section 7, the vapor intrusion (VI) remedy at the South AFRL currently protects human health and the environment because LUCs and monitoring are in place and effective to prevent exposures and verify containment.

The next FYR for South AFRL is 5 years from the finalization date of this review.

1.0 INTRODUCTION

The United States Air Force (USAF) as lead agency, with approval by the United States Environmental Protection Agency (USEPA) and concurrence from the State of California, Department of Toxic Substances Control (DTSC) and the California Regional Water Quality Control Board, Lahontan Region (CRWQCB-LR), authorized on 24 September 2007 a Record of Decision (ROD) for groundwater and subsurface vapor (intruding into the indoor air of buildings) at Sites 37, 120, 133, and 321 in the South Air Force Research Laboratory (AFRL), Operable Units (OUs) 4 and 9 at Edwards Air Force Base (AFB), California (CA) (Figure 1.0-1). The ROD (USAF 2007), prepared in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), documented a decision of No Action for soil at Sites 37, 120, 133, and 321.

The selected remedy for groundwater at the South AFRL includes a technical impracticability (TI) waiver from attaining applicable or relevant and appropriate requirements (ARARs) – namely, the drinking water primary Maximum Contaminant Levels (pMCLs) – for chemicals of concern (COCs) inside a 16.4-square-mile Containment Zone (CZ) to a depth of 500 feet (ft) below ground surface (bgs); land use controls (LUCs) to prevent exposure to groundwater within the CZ; and long-term monitoring (LTM) to confirm that groundwater impacted by contaminant concentrations above these ARARs does not migrate outside the South AFRL CZ. The TI waiver was selected based on an evaluation (presented in Section 2.5.8 of the ROD) of the TI from an engineering perspective of restoring groundwater in fractured granitic bedrock and impacted by chlorinated solvents (among other COCs) to drinking water standards. The evaluation followed procedures in the USEPA *Guidance for Evaluating Technical Impracticability of Ground-Water Restoration* (USEPA 1993), hereinafter cited as the TI Waiver Guidance. Figure 1.0-2 includes coordinates for the South AFRL CZ boundary, which is further described in Section 3.1.1.1.

The selected remedy for subsurface vapor includes LUCs to prohibit residential land use (including child development centers, kindergarten through 12th grade schools [K-12], play areas and hospitals) inside the vapor intrusion compliance boundary (VICB) shown on Figure 1.0-3 (as further described in Section 3.1.1.2) and thus prevent exposure to volatile organic compounds (VOCs) in indoor air at concentrations that exceed indoor air vapor mitigation levels for residential exposure (IAVMLs-res); monitoring to assess whether the vapor intrusion pathway (VIP) is complete in existing, occupied

industrial buildings inside the VICB; implementation of mitigation measures inside buildings where indoor air concentrations exceed risk-based indoor air vapor mitigation levels for industrial exposure (IAVMLs-ind); and engineering controls to reduce risk via the VIP in all new construction inside the VICB.

This document is the first Five-Year Review (FYR) of the selected remedy for the South AFRL. This review is required by statute because the selected remedies result in hazardous substances, pollutants, or contaminants on site above levels that allow for unlimited use and unrestricted exposure (UU/UE). Specifically, the designated beneficial use of the groundwater as a drinking water source has not been restored; the concentrations of groundwater COCs inside the CZ remain at levels that exceed pMCLs or risk-based cleanup goals (RBCGs) established in the ROD. Further, LUCs are in place to reduce the risk of exposure to indoor air containing VOCs intruded into buildings from the subsurface via the VIP, and exposure to groundwater via dermal contact and as a drinking water source.

1.1 PURPOSE OF THE FIVE-YEAR REVIEW

The purpose of the FYR is to determine whether the remedy implemented for groundwater and subsurface vapor at Sites 37, 120, 133, and 321 in accordance with the 2007 *South AFRL ROD* is protective of human health and the environment.

This report documents the evaluation of whether:

1. The remedy is functioning as intended;
2. Exposure assumptions remain valid; and
3. There is any new information to consider.

The methods, review findings, and conclusions (i.e., protectiveness statements) for LUCs, the groundwater medium, and the VIP are documented in this first FYR report. This report also identifies potential issues and recommendations to address these issues.

1.2 AUTHORITY FOR CONDUCTING THE FIVE-YEAR REVIEW

The USAF as lead agency prepared this FYR pursuant to CERCLA Section (§) 121(c) (42 United States Code [USC] § 9621[c]) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This report was prepared in accordance with the *Comprehensive Five-Year Review Guidance* (USEPA 2001), *Recommended Evaluation of Institutional Controls: Supplement to the "Comprehensive Five-Year Review Guidance"* (USEPA 2011), and the Memorandum for AF/A7CAN, AFLOA/JACE, AFCEE/ER, AFCEE/EXC, AFCEE/TDV, AFRPA/BPM, MAJCOM Environmental Liaison Offices, JACE/ER/CR/WR (28 December 2011) (USAF 2011a).

CERCLA §121 states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

In addition, the NCP, Title 40 of the Code of Federal Regulations (CFR) §300.430(f)(4)(ii), states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

1.3 LEAD AGENCY WHO CONDUCTED THE FIVE-YEAR REVIEW IN 2012

The USAF conducted this first FYR of remedial actions implemented at Sites 37, 120, 133, and 321 in the South AFRL, Edwards AFB, CA, which was initiated in January 2012 in order to meet the statutory requirement to complete the FYR by 24 September 2012. This report documents the results of the review. As lead agency, the USAF is required to review remedial actions that do not attain UU/UE at a frequency no less than every 5 years to assure that human health and the environment are protected by the remedy. AECOM Technical Services Inc. (AECOM) under contract with the United

States Army Corps of Engineers (USACE) provided support for this FYR in accordance with Contract Number W91238-07-D-0005, Delivery Order Number ERS-0011.

The USEPA, DTSC and the CRWQCB-LR (Water Board) are the relevant support agencies that provided review comments on draft and draft-final versions of this FYR. Upon USAF incorporation/resolution of support agency comments, the FYR will become final.

1.4 REVIEW NUMBER

This is the first FYR of remedies selected for groundwater and subsurface vapor (intruded into the indoor air of buildings) at Sites 37, 120, 133, and 321 in the South AFRL.

1.5 TRIGGER ACTION AND DATE

Pursuant to CERCLA (42 USC §9621[c]) and the NCP, the triggering action for a FYR is remedy initiation. This first FYR was prepared to coincide with the 5-year anniversary of remedy initiation that occurred with the signing of the *South AFRL ROD* on 24 September 2007. The review includes an evaluation of remedy performance data from Sites 37, 120, 133, and 321 from October 2007 through mid-April 2012; the end date was selected to allow time for data review and compilation before submittal of the draft FYR in May 2012.

Pending the selection of final remedies for other sites and OUs at Edwards AFB, the USAF is conducting FYRs separately as described in Section 1.6 below.

1.6 NUMBER, DESCRIPTION, AND STATUS OF ALL OPERABLE UNITS AT THE SITE

Edwards AFB, located approximately 60 miles north-northeast of Los Angeles, California (Figure 1.0-1), occupies approximately 470 square miles of high desert, including all of Rogers, Buckhorn, and Rosamond lake beds. Originally activated as the Muroc Army Air Field during World War II, the Base was later renamed for Captain Glen W. Edwards, a test pilot killed in the crash of an experimental bomber, the YB-49 Flying Wing. The primary mission of the Base is aviation development through experimental and flight test activities.

The United States Congress passed the Resource Conservation and Recovery Act (RCRA) in 1976, CERCLA in 1980, and the Superfund Amendments and Reauthorization Act (SARA) in 1986. To ensure compliance with RCRA and later with CERCLA/SARA, the Department of Defense (DOD) developed the Installation Restoration Program (IRP) in 1980. The IRP, which was modified in 1986 to address SARA, was later designated as the Environmental Restoration Program (ERP); its purpose is to investigate and clean up wastes from past operations at military installations worldwide. The ERP at Edwards AFB is a localized version of the DOD program with active participation from USEPA and the State of California. The ERP is managed and implemented by Environmental Restoration under the 412th Test Wing, Civil Engineering Division (412 TW/CEVR).

Edwards AFB was listed by the USEPA on the National Priorities List (NPL) on 30 August 1990, following which the USAF entered into a Federal Facility Agreement (FFA) with the USEPA, CA DTSC, and the Water Board. The FFA establishes the process for involving USEPA and the State and public in the Edwards AFB remedial response process. It provides a procedural framework for developing, implementing, and monitoring response actions at Edwards AFB in accordance with CERCLA, SARA, the NCP, pertinent provisions of RCRA, and applicable or relevant and appropriate state laws.

To facilitate the investigation of wastes and implementation of response actions under the ERP, Edwards AFB was divided into 10 OUs defined by lease boundaries (as applicable); geographic location; similarities in contaminant types and distribution; and/or hydrologic setting. The locations of these OUs are presented on Figure 1.6-1 and briefly described below:

OU1 – Main Base Flightline (MBFL) covers the flightline from the National Aeronautics and Space Administration (NASA) facility on the north to Main Base Runway 4/22 on the south; this runway separates the Main Base from South Base (OU2). In its northern portion, the MBFL OU1 also includes facilities east of Gregorius Avenue. The MBFL OU1 is primarily used for aircraft testing and maintenance by various aerospace contractors. Major contaminant sources include: a removed pipeline formerly used to transport jet propellant 4 (JP-4) fuel; former leaking underground storage tanks (USTs); engine test cells; aircraft testing and maintenance areas; and waste disposal areas.

OU1 is in the Proposed Plan (PP) phase of the CERCLA process.

OU2 – South Base is located south of Main Base, along the southwestern edge of Rogers Lake on the margin of the playa deposits. In the 1950s, most facilities at the Old South Base Cantonment Area were abandoned but others were moved to the present Main Base. The remaining facilities were demolished in the 1980s to make way for the Birk Flight Test Facility. The present South Base including the Birk Flight Test Facility was later built in the former locations of some earlier facilities.

- Final remedies for five OU2 sites (Sites 5, 14, 76, 86, and 29) were selected in a 2009 ROD (USAF 2009a); and remedies have been implemented at Sites 5, 14, 76, and 86. The first FYR for these OU2 sites is scheduled for completion in 2014. No further action was selected for Sites 69, 78, 79 and 96 in the 2009 ROD.
- A ROD Amendment for OU2 Site 29 (a former landfill) is in progress and anticipated to be completed in 2012.
- Data gap sampling was required for OU2 Sites 81 and 102, which are former skeet ranges. These sites are in the Remedial Investigation/Feasibility Study (RI/FS) phase of the CERCLA process.

OU3 – Base-Wide Water Wells includes all former homestead water wells, unused Base supply wells, playa research wells, and test wells located on Base property. A Base-wide Water Wells Closure Program (Earth Tech 2004a) was implemented to manage the destruction, sealing, and closure of former homestead water wells and playa research wells located on Base. Between July 1996 and October 2003, 401 abandoned and unused water wells were sealed as part of this program. Based on the results of the program, OU3 Base-wide Water Wells was closed under a No Action ROD dated September 2003.

OU4 and OU9 – AFRL and **East AFRL** are located in the eastern portion of Edwards AFB east of Rogers Lake. OU4 includes rocket test areas on Leuhman Ridge and the major support facilities in the administrative area along Mercury Boulevard (Blvd) while OU9 includes the more widely spaced rocket test areas past the north end of Mercury Blvd to the northeast; Mars Blvd to the southeast; and abandoned mineshafts formerly used for waste disposal located on the Precision Impact Range Area (PIRA). In addition to releases associated with the testing of liquid and solid rocket motors, sites in OU4 and OU9 include waste disposal (dry) wells associated with machine shops and missile assembly buildings; parts-cleaning operations; a solid propellant cutting facility; fuel transport and storage facilities; a former landfill; and a former beryllium-use area.

During the preparation of Remedial Investigation Summary Reports (RISRs) for OU4 (Earth Tech 2005a) and OU9 (Earth Tech 2006a), and as an aid to the development of feasibility study (FS) documents, the AFRL sites with groundwater contamination were assigned to one of four areas based on geographic location and the direction of regional groundwater flow (refer to Figure 1.6-2). The CERCLA status of AFRL groundwater areas and soil/debris sites (locations shown on Figure 1.6-3) is as follows:

1. **South AFRL** includes Sites 37, 120, 133, and 321. A TI waiver remedy for groundwater and LUCs to address VIP risk were selected in a 2007 ROD; this report constitutes the first FYR.

2. **AFRL Arroyos** includes Sites 162 (encompassing Site 36) and 461. ROD in progress.

3. **Northeast AFRL** includes Sites 115, 116, 177, 178 (A and B), 318, 325, and Area of Concern (AOC) 118. FS in progress.

4. **Mars Blvd** includes Sites 27, 125, 127, 167, and 333. FS to be completed within 5 years.

5. **AFRL Soil and Debris Sites**. A ROD was finalized in May 2008 (USAF 2008). No action was selected for Sites/AOCs 7, 26, 150, 153, 166, 170, 171, 172, 329, and 396; final remedies were selected for the soil medium at Sites 13, 36, 115, 167, 312, and 318; and final remedies were selected for soil and groundwater media at Sites 6 and 113. The first FYR for the eight action sites (shown in red on Figure 1.6-3) is scheduled in 2013. An Explanation of Significant Differences (ESD) is in preparation for Site 312.

OU5/10 – North Base consists of approximately 1,321 acres that include the North Base complex and former NASA Jet Propulsion Laboratory (JPL); and an unoccupied area (approximately 4,022 acres) north of Rogers Lake. These occupied and unoccupied portions of North Base were designated as OUs 5 and 10, respectively, until combined in 2005. Operations in OU5/10 that involved the use of hazardous materials and generation of hazardous waste included aircraft repair and cleaning, rocket testing, photographic laboratory operations, painting, and fluid replacement. Rocket testing activities included processing perchlorate for use in rocket motors.

OU5/10 is in the FS phase of the CERCLA process.

OU6 - NASA Dryden Flight Research Center is located on the northwestern edge of Rogers Lake, at the northern end of the Edwards AFB Main Base area (OU1). Originally established in 1946, NASA Dryden operates under a host tenant agreement with the USAF to conduct various aircraft research

projects (such as Space Shuttle flight testing from 1977 through 2011). NASA Dryden consists of 838 acres occupied by administrative, research, laboratory, service, hangar, and storage buildings that support various flight test and research operations that included Space Shuttle support. Operations that produced past releases of hazardous waste include aircraft repair and cleaning, photographic laboratory operations, painting, and fluid replacement.

Final remedies for OU6 sites N2, N3, and N7 were selected in a 2006 ROD (USAF 2006a); and remedies have been implemented at these sites. The first FYR for OU6 sites was conducted in 2011; a revised FYR is scheduled for completion in 2014.

OU7 – Base-Wide Miscellaneous includes all ERP sites and AOCs not included in other OUs. OU7 includes outlying regions in the western portion of Edwards AFB, the area east of Rogers Lake (excluding the AFRL), and the area south of the South Base. A variety of facilities are contained within this OU including landfills, burn sites, USTs, rifle ranges, drum storage areas, and evaporation ponds. A number of abandoned facilities (East Camp, Mojave Corporation, etc.) are also included in OU7. A large portion of the area east of Rogers Lake is occupied by the PIRA, where aircraft weapons and systems are tested.

- A ROD was signed for OU7 Chemical Warfare Materiel (CWM) sites in 2009 (USAF 2009b). All sites were closed to further action, except for Site 442, Areas 1, 2, and 3. The remedies for the three areas are in the Remedial Action – Construction phase of the CERCLA process; and a FYR will be completed in 2014.
- A final ROD for OU7 Site 3 (the Main Base Inactive Landfill) is in progress and anticipated to be completed in 2012.
- The remaining non-CWM OU7 sites, which address soil contamination, are in the FS phase of the CERCLA process.

OU8 - Northwest Main Base is located west of NASA Dryden and northwest of Main Base. The majority of facility operations are located in the southeast portion of the OU, along Rosamond Blvd and Forbes Avenue. Industrial facilities in OU8 include tank farms; a jet fuel pipeline; hazardous waste, paint and waste paint storage areas; photography laboratory; automotive hobby shop; unconventional fuel storage area and other miscellaneous facilities. Leaks, improper storage, and unintentional spillage of materials are the primary sources of contamination at OU8.

- OU8 sites are in the FS phase of the CERCLA process.
- Site 25. A separate FS is in preparation for this site (the unconventional fuel storage area), which includes a large groundwater plume in fractured granitic bedrock.

1.7 IF REVIEW COVERS ONLY PART OF A SITE, EXPLAIN APPROACH

This first FYR for the South AFRL evaluates the protectiveness of the selected remedy for groundwater and soil vapor (intruded into the indoor air of buildings) media at Sites 37, 120, 133, and 321; the ROD selected No Action for soil at these sites.

The Site 13 closed AFRL landfill is located inside the South AFRL CZ (refer to Figures 1.0-1 and 1.6-3); a final remedy for this site was selected in the 2008 *AFRL Soil and Debris Sites ROD*. From July 2002 through April 2011, semiannual groundwater monitoring was conducted at the landfill under a *Final Closure and Post-closure Monitoring Plan* (FCPMP) (Earth Tech 1999a rev 2000) prepared in compliance with landfill closure requirements in California Code of Regulations (CCR) Title 27 and Subtitle D of RCRA. As of October 2011, the USAF discontinued Site 13 specific groundwater monitoring; monitoring requirements under the FCPMP are superseded by the remedy selected for Site 13 in the 2008 *AFRL Soil and Debris Sites ROD* (USAF 2008): no separate groundwater monitoring for the landfill due to redundancy with LTM conducted under the *South AFRL ROD*. The Water Board (in an email dated 30 September 2011, which is included in Appendix A.4 of the *Annual Compliance Monitoring Report for 2011, AFRL Landfill Site 13* (AECOM 2012a) concurred with the USAF's rescission of the Site 13 specific groundwater monitoring.

2.0 SITE CHRONOLOGY

Table 2.0-1 lists relevant dates for the important site events and primary document submittals that led to selection of a remedial action for Sites 37, 120, 133, and 321 in the 2007 South AFRL ROD. Major events include the listing of Edwards AFB on the NPL on 30 August 1990, following which the USAF entered into an FFA with the USEPA, CA DTSC, and the Water Board; a preliminary assessment conducted between 1991 and 1993 as documented in the *Expanded Source Investigation/RCRA Facility Assessment* (ESI/RFA, The Earth Technology Corporation 1993); identification of sites to continue into remedial investigation (RI) based on results of site inspections (SIs) conducted from 1993 through 1996; RI activities (see Tables A.1-1 through A.1-4 in Appendix A.1 for a summary at each site); human health and ecological risk assessments (HHRA and ERA) completed between 2002 and 2005; operation of a groundwater extraction and treatment system (GETS) as treatability studies at each of Sites 37 and 133 (these systems were deactivated after remedy selection in the ROD); operation of a soil vapor extraction (SVE) and treatment system installed as an interim removal action (IRA) for Site 172 south of Building 8595 (in Site 37); and completion of FS, PP, and ROD documents for the South AFRL.

A brief chronology of remedial actions completed between September 2007, when the South AFRL ROD was signed, through mid April 2012 is also included in Table 2.0-1. Items 6, 20, 31, and 40 summarize public outreach and comment periods (further discussed in Section 6.2) that include respectively: formation of the Restoration Advisory Board (RAB) (1995); the public comment period on the PP for the South AFRL (2006); a Fact Sheet on vapor intrusion (VI) sampling at the South AFRL (2009); and notification of initiating this FYR (2012).

3.0 BACKGROUND

Edwards AFB is located in the southern California counties of Kern, Los Angeles, and San Bernardino; approximately 5 miles northeast of the city of Lancaster (refer to Figure 1.0-1). The area east of Rogers Lake that is currently known as the AFRL has been used as a rocket research and testing facility since the 1950s. During that time, workers involved in research, testing, evaluation, and maintenance activities used toxic and hazardous materials. Current use and disposal of these materials are strictly regulated under RCRA compliance regulations to prevent releases to the environment. However, in the past, materials were spilled or otherwise released to the ground surface or subsurface.

The South AFRL encompasses groundwater contaminant plumes identified as Sites 37, 133, and 120 in OU4 and Site 321 in OU9. Facilities at these sites are (or were) associated with rocket component maintenance (Building 8595 at Site 37); civil engineering (CE) shops and former missile assembly buildings (Site 133); the AFRL's former sewage treatment plant (STP) (Site 120); and rocket propellant storage (Site 321). Section 3.3 provides details regarding the history of release at each site.

The most widespread COCs in South AFRL groundwater include the chlorinated solvents tetrachloroethene (PCE) and trichloroethene (TCE), their daughter product cis-1,2-dichloroethene (DCE), and the inorganic salt perchlorate, a constituent of solid rocket propellant. The estimated distributions of these four primary COCs, based on groundwater sampling results through 2011 as interpreted by the USAF, are shown for Sites 37, 133, and 120 on Figures 3.0-1 through 3.0-4; and for Site 321 on Figure 3.0-5. Note that the USEPA has proposed a different interpretation of groundwater sampling results for TCE as presented on Figure 6.4-5 cited in Section 6.4.2.2, Objective 1, Item (a)(iii). Table 3.0-1 presents information regarding the vertical distribution of COCs based on groundwater sampling results from several well clusters installed to screen various depths within the fractured bedrock aquifer. As listed in Table 3.5-1, other COCs in groundwater at the South AFRL include the petroleum fuel additive methyl tert-butyl ether (MTBE) and other less widely distributed VOCs; two semivolatile organic compounds (SVOCs), 1,4-dioxane and N-nitrosodimethylamine (NDMA); and the inorganic anion nitrate.

3.1 PHYSICAL CHARACTERISTICS

The following sections provide a general description of the South AFRL including size of the groundwater TI waiver zone and VICB, topography, geology, hydrogeology, water supply, and ecological setting.

3.1.1 SIZE

The AFRL (area shown with blue hatch marks on Figure 1.0-1) occupies approximately 80,000 acres (125 square miles) on the eastern side of Rogers Lake. Under the ERP, OU4 and OU9 cover a portion of the AFRL plus a portion of the PIRA outside the AFRL. As shown on Figure 1.6-2, sites with groundwater contamination in OU4 and OU9 were further assigned to one of four areas (the South AFRL, AFRL Arroyos, Northeast AFRL, and Mars Blvd) based on geographic location and the direction of regional groundwater flow.

3.1.1.1 Spatial Area Over Which Groundwater TI Waiver Applies

The South AFRL CZ, as established in the 2007 *South AFRL ROD*, covers an area of approximately 10,500 acres (16.4 square miles) extending to a depth of 500 ft bgs. Figure 1.0-2 shows the CZ boundary established in the ROD, within which a TI waiver of groundwater cleanup to drinking water standards is applied. The TI waiver was granted based on an evaluation that demonstrated, in accordance with the *TI Waiver Guidance* (USEPA 1993), the technical impracticability from an engineering perspective of restoring groundwater (impacted by chlorinated solvents among other COCs) in fractured granitic bedrock to drinking water standards. The dark blue outline shows the 2007 estimated outer extent of groundwater impacted by PCE and TCE above the laboratory reporting limit (RL) of 1 microgram per liter (μg/L), while the red outline shows the simulated maximum extent of groundwater that may be impacted in approximately 800 years, based on predictive contaminant transport modeling conducted in 2005. By comparison, Figure 3.1-1 shows the estimated outer extent of groundwater impacted by PCE (in red), TCE (in blue), cis-1,2-DCE (in mustard) and perchlorate (in green) above 1 μg/L (0.001 milligrams per liter [mg/L] for perchlorate) based on groundwater sampling results from 2008 through 2011. Note that USEPA has questioned the depiction of these outer extents, especially with regard to TCE at the toe of the Site 133 plume (vicinity of Wells 13-MW37 and 13-MW39) and requested that the USAF develop an alternate depiction of plume

extent, which is shown on Figure 6.4-5 as discussed in Section 6.4.2.2, Objective 1, Item (a). In 2012, a five-layer groundwater flow and contaminant transport model (AECOM 2012b) was developed that supersedes the two-layer 2005 groundwater flow and transport model (Earth Tech 2005b) cited in the ROD. The significant differences in predictive simulations between the 2005 and 2012 groundwater models are discussed in Section 4.5.2.2, with reference to figures and text included in Appendix A.3.

As shown on Figure 1.0-2, the South AFRL CZ extends south from Building 8595 in Site 37 on Leuhman Ridge and CE facilities identified at Site 133 east of Mercury Blvd to encompass the AFRL closed landfill (Site 13) and former STP facilities in Site 120, as well as the current AFRL Wastewater Treatment Plant (WWTP); the WWTP (and former STP) facilities are located outside the AFRL on the PIRA. On the east, the CZ encompasses Site 321 facilities in the Liquid Propellant Storage facility on Mars Blvd. The western boundary of the South AFRL CZ was designed to: (1) prevent contaminants from impacting the alluvial aquifer to the west (Lancaster Subbasin); (2) exclude the inactive production wells at Mary's Well Field and active production wells in the Lower Well Field; and (3) encompass the maximum projected extent of PCE and TCE contaminant plumes as simulated by the 2005 flow and transport model. As shown on Figure 3.1-2, the perimeter of the South AFRL CZ is located 20,000 ft (nearly 3.8 miles) from the nearest on-Base active drinking water well (Well C in the Lower Well Field); 24,000 ft (4.5 miles) from the nearest off-Base active drinking water well (Well 1 operated by the Desert Lakes Community Services District, located north and up gradient from groundwater flow direction at the South AFRL); 47,000 ft (8.9 miles) from the nearest on-Base residential area (across Rogers Lake at Main Base); 23,000 ft (4.3 miles) from the nearest off-Base residential area (to the north in West Boron); and 18,000 ft (3.4 miles) from the northern Base Boundary.

Due to its size, neither fences nor markers at boundary corners were considered practical for delineating the South AFRL CZ boundary; rather, Figure 1.0-2 provides coordinates for the boundary corner points. These coordinates were used to identify zone boundaries in the Edwards AFB geographic information system (GIS) database; global positioning system (GPS) receivers can be used to locate zone boundaries in the field. Consistent with the coordinate system used for the Edwards AFB GIS, the boundary corner points on Figure 1.0-2 are provided in Universal Transverse Mercator (UTM) format (Zone 11 North, referenced to the World Geodetic System of 1984 [WGS 84]). Also, for maximum compatibility with most GPS receivers, the coordinates are provided in geodetic format

(latitude and longitude, referenced to WGS 84) and in California State Plane format (Zone 5, referenced to the North American Datum of 1983 ([NAD 83]).

The TI Waiver Guidance specifies that the limits of the TI waiver zone be fixed in space vertically as well as horizontally; a depth of 500 ft was selected as the vertical limit of the South AFRL CZ. This 500-foot vertical depth is approximately 175 ft below the maximum depth of contamination identified (in Well 133-MW04 screened over a depth from 317 ft to 327 ft bgs, refer to Table 3.0-1; Table A.2-1 in Appendix A.2 lists well specifications for all South AFRL wells). As cited from the ROD, "The 500 ft bgs vertical extent of the CZ was deemed reasonable because: (1) no water-bearing units exist below the competent, crystalline bedrock (i.e., there is no deeper aquifer); and (2) the size and density of fractures decrease with increasing depth. Because fractures become smaller and less frequent and do not effectively transport water at greater depth, installation of monitoring wells becomes increasingly difficult and expensive, especially if care is taken not to carry contamination further downward. In addition, it becomes highly unlikely that contaminants in groundwater below 500 ft bgs could be intercepted and effectively remediated or their migration could be controlled." Section 2.1.2.3 and Appendix D in the *2012 Groundwater Modeling Report for the South AFRL* (AECOM 2012b) provide support for the concept that the hydraulic conductivity (K) of AFRL groundwater decreases with depth.

3.1.1.2 Spatial Area Covered by the Vapor Intrusion Compliance Boundary

As described in Section 1.0, the remedy selected for subsurface vapor at the South AFRL includes LUCs to prohibit residential land use inside the VICBs shown outlined in blue on Figure 1.0-3. These initial VICBs, which cover an area of approximately 2,800 acres overlying the commingled Sites 37, 120 and 133 plumes and an area of approximately 175 acres overlying the Site 321 plume, were established in Section 2.13.2 of the ROD based on the 30-year projected extent of groundwater (as simulated by the 2005 flow and transport model [Earth Tech 2005b]) that will be impacted by PCE or TCE at concentrations that pose a VIP cancer risk of 1 in a million (10^{-6}) under the (hypothetical) residential exposure scenario. Section 6.4.3.4 in this FYR report evaluates whether the VICB requires revision per the additional ROD requirement to revise the VICB when "subsequent plume migration modeling during a future Five-Year Review predicts that the residential risk contours will exceed the current VICB in less than 10 years."

The groundwater vapor compliance levels for residential (GWVCLs-res) and for industrial (GWVCLs-ind) exposure were based on a simulated volatilization of chemical concentrations in groundwater samples using the Johnson and Ettinger (J&E) model, Version 3.1 (USEPA 2003a). Tables 3.1-1 and 3.1-2 (modified from ROD Tables 2.13-1 and 2.13-2) list the GWVCLs-res and GWVCLs-ind established in the ROD. Areas overlying 2005 groundwater concentrations that exceed the GWVCLs-ind are shown outlined in green on Figure 1.0-3; these are areas identified in the ROD (based on J&E model simulations) where groundwater contaminants could potentially pose a 10^{-6} cancer risk via the VIP to current building workers. Updates to the GWVCLs (listed in Table 6.4-10), and how the VICB is impacted by recent revisions to the toxicity criteria for PCE and TCE, are discussed in Section 6.4.3.4.

3.1.2 TOPOGRAPHY

The topography of the AFRL is greatly influenced by Leuhman Ridge, a prominent northeast-southwest trending topographic high, with a maximum elevation at 3,360 ft above mean sea level (aMSL). The South AFRL begins on, and extends down gradient from, the southeast facing flank of Leuhman Ridge (refer to Figure 1.0-2). Throughout the AFRL, and particularly along Leuhman Ridge and its southeastern flank, weathered and competent fractured granitic bedrock crops out at the ground surface.

Topographic relief in the South AFRL area varies from moderate (275 vertical ft over 1.2 miles) between Building 8595 in Site 37 and the intersection of Mercury Blvd and Range Road, to mild (approximately 425 vertical ft over a distance of 3.3 miles) between the former evaporation/ percolation ponds in Site 120 and Mary's Well Field (Figure 3.1-3). Elevations range from approximately 3,125 ft aMSL just north of Building 8595 to 2,425 ft aMSL near Mary's Well Field. Surface drainage is generally to the south and southwest, ultimately flowing into Rogers Lake.

3.1.3 GEOLOGY

The regional subsurface geology at the AFRL is characterized as a crystalline granitic bedrock complex overlain in areas by a thin veneer of unconsolidated material, which increases in thickness down slope from the crest of Leuhman Ridge. Approximately 3.5 miles down gradient of the Sites 37 and 133 source areas, the thickness of the alluvium gradually increases to hundreds of ft as alluvial material transitions to lacustrine deposits at depth.

Figure 3.1-4 presents the surface geology. The unconsolidated material originates from the erosion and weathering of exposed and shallow bedrock, and the reworking of older alluvium, windblown sand, and gravel deposits. It consists of fine-grained, quartzo-feldspathic, rock-fragment sand with varying percentages of low plasticity clay, silt, and gravel. These deposits are loose to very dense and typically dry to slightly moist. The unconsolidated material grades into fractured, weathered bedrock (WBr) below which fractured, competent bedrock (CBr) is encountered. Figure 3.1-4 presents generalized cross sections across Leuhman Ridge (A-A') and southeast of the ridge (B-B') in the area of Haystack Butte. Figures 3.1-5 through 3.1-8 show cross sections C-C'-C", D-D'-D"-D"', E-E'-E", and F-F' that illustrate the geology associated with groundwater contaminant plumes at Sites 37, 133, 120, and 321 respectively; locations of these lines are shown in green on Figure 3.1-3.

The bedrock underlying the AFRL consists of two types of crystalline rock: a quartz monzonite host rock that has been intruded by the granite that forms Leuhman Ridge. The intrusive granite that forms Leuhman Ridge is distinguished from quartz monzonite by an increase in the potassium feldspar constituent and a decrease in the plagioclase feldspar to near zero. Scattered mafic dikes and pegmatite-aplite dikes also occur in the AFRL.

Based on borehole logs, depth to CBr at the South AFRL varies from 2 ft to 65 ft bgs at Site 37; 3 ft to greater than 250 ft bgs at Site 133; 5 ft to 110 ft bgs at Site 120; and 13 ft to 52 ft bgs at Site 321 (refer to Table A.2-1 in Appendix A.2).

3.1.4 HYDROGEOLOGY

The Antelope Valley is underlain by a large groundwater basin that has been divided into several subbasins bounded laterally by consolidated rock, faults, and groundwater divides; or in some cases by arbitrary boundaries. Edwards AFB overlies portions of the North Muroc, Lancaster, and Gloster subbasins, and also encompasses two areas of shallow bedrock and low groundwater yield known as the Rosamond-Bissell Hills west of Rogers Lake, and the Hi Vista area where the AFRL is located (Figure 3.1-2). The two AFRL well fields (the inactive wells at Mary's Well Field and the active production wells in the Lower Well Field) as well as the South Base and South Track Well Fields on the west side of Rogers Lake are in the Lancaster subbasin; the Graham Ranch Well Field is located

west of the Lancaster subbasin; and the North Base Well Field (which is no longer active) is in the North Muroc subbasin.

Hydrogeology at the AFRL is typified by shallow crystalline bedrock with low groundwater yield. Bedrock at the AFRL is not an aquifer (i.e., it does not yield useable quantities of groundwater) and is not within a basin as delineated by the United States Geological Survey (USGS) based on geophysical evidence (Carlson et al. 1998) (refer to subbasin boundaries shown on Figure 3.1-2). However, the Water Board considers the AFRL to fall within the Antelope Valley hydrologic basin 6-44 (refer to blue-shaded areas on Figure 3.1-2 adapted from the California Department of Water Resources [DWR] Bulletin 118 [California DWR 2003]).

The orange line shown on Figures 3.1-1, 3.1-2, and various other figures in this report is the approximate location where groundwater discharges from fractured bedrock to an alluvial aquifer, based on review and interpretation (by AECOM registered Professional Geologists [PGs]) of ERP borehole logs for on-Base monitoring wells screened in granitic bedrock or alluvium and logs for off-Base wells (such as wells at the Boron Landfill), screened in alluvium (refer to Appendix C in AECOM 2012b). Except where updated based on additional and more detailed field data, this line generally follows the subbasin boundaries delineated by the USGS. Updates were made to the western portion of the orange line (down gradient of the South AFRL CZ boundary) based on surface geology and borehole log information as described in Appendix C of the *2012 South AFRL GW Modeling Report* (AECOM 2012b). Recent field data from well installations in late 2011 have provided information to update a small section of the northwestern portion of the orange line in the area of the AFRL Arroyos down slope of Test Areas 1-110, 1-40, and 1-120 (refer to Figure 1.6-2). Further details are provided in the *AFRL Arroyos, Northeast AFRL, and Mars Boulevard Well Installation Report for 2011/2012* (AECOM 2012g). Note that ongoing refinements to the orange line that depicts the location where groundwater in bedrock transitions to an alluvial aquifer do not impact the TI waiver CZ selected in the 2007 South AFRL ROD.

In the majority of monitoring wells installed as part of the ERP, groundwater occurs under hydrostatic pressure within fractures in both weathered and competent granitic bedrock. Depth to first groundwater contact varies from 24 ft to 266 ft bgs at Site 37; 20 ft to 150 ft bgs at Site 120; 12 ft to 420 ft bgs at Site 133; and 45 ft to 235 ft bgs (below ground surface) at Site 321 (refer to Table A.2-1).

Groundwater flow rates in monitoring wells screened across first water contact are generally low (less than 0.5 gallons per minute [gpm]). Table A.2-2 provides a summary of aquifer characteristics derived from pumping tests conducted at the South AFRL, AFRL Arroyos, and Northeast AFRL. The locations of pumping test wells are shown on Figure A.2-1.

In July 2007, the sustained yield for seven extraction wells operated as part of the Site 37 GETS ranged from 0.002 gpm (3 gallons per day [gpd]) to 0.40 gpm (576 gpd) for an average yield around 0.12 gpm (177 gpd). The sustained yield for three extraction wells operated as part of the Site 133 GETS ranged from 2 gpm (3,000 gpd) to 8 gpm (11,500 gpd). The locations of these wells are shown in orange and green respectively on Figure 3.1-9.

Regional groundwater flow directions generally mimic surface topography. In the South AFRL area, groundwater flows ultimately into the Lancaster Sub-basin, recharging the aquifer. Contoured potentiometric elevations in the South AFRL based on groundwater levels measured in October 2008 ranged from 2,188.79 ft aMSL (Well 13-MW33) to 3,028.62 ft aMSL (Well 171-MW05) (Figure A.2-2 in Appendix A.2). The 2008 groundwater elevation data set is referenced in this FYR because it represents the time frame coinciding with the most recent comprehensive contaminant analytical data set; for comparison, contoured potentiometric elevations based on groundwater levels measured in October 2010 and October 2011 are provided on Figure A.2-3 in Appendix A.2 and on Figure 3.1-10, respectively.

The average hydraulic gradient along the southern flank of Leuhman Ridge within the commingled Sites 37, 120, and 133 plumes is estimated at 0.03 vertical ft per horizontal foot (ft/ft), as measured from Well 171-MW05 (located near the source area for the Site 37 plume) to Well 13-MW29 (located southwest of the wastewater treatment plant at Site 120). Groundwater near the CE facilities at Site 133 flows to the south and ultimately to the southwest. The average horizontal hydraulic gradient at Site 133 ranges from 0.02 ft/ft to 0.03 ft/ft. Groundwater flow at Site 321 (depicted on Figure 3.0-5) is directed to the west-southwest at an average hydraulic gradient of 0.09 ft/ft as measured from Well 321-MW02 to Well 321-MW07.

3.1.5 WATER SUPPLY

Historically, potable water for the AFRL was supplied by the two production well fields previously mentioned: Mary's Well Field (including Wells 1, 2 and 3 that have been inactive since at least 1994) and the Lower Well Field (including active Wells A, B, and C and inactive Well D); as indicated in Section 3.1.1.1, the nearest active drinking water well (Well C in AFRL's Lower Well field) is nearly 3.8 miles southwest from the perimeter of the South AFRL CZ. Both well fields are located near the edge of Rogers Lake in the eastern portion of the Lancaster Subbasin, and draw groundwater from the middle aquifer in that subbasin. Beginning in late 1997, the AFRL purchased a portion of its potable water supply from the Antelope Valley-East Kern (AVEK) Water Agency via a pipeline that supplied both the AFRL and the town of Boron. On average, AVEK supplied approximately 80 percent of the AFRL water supply from 2001 to 2005. The CE Group at the AFRL discontinued the AVEK supply in mid-2008 (when off-Base water districts began blending to reduce arsenic concentrations, see next paragraph) and increased production from Wells A, B, and C at the Lower Well Field. The Lower Well Field production wells produced a combined total of approximately 46 million gallons of water (142 acre-feet) from June through December 2008.

The nearest off-Base groundwater production wells, that tap the unconfined aquifer of the North Muroc Subbasin, are located within 1-mile of the northern Base boundary (refer to Figure 3.1-2). These wells are operated by Desert Lakes Community Services (DLCS) and Boron Community Services (BCS) districts. Both water districts took their wells off line in 2006 due to naturally-occurring arsenic concentrations that exceed the Federal pMCL of 0.01 mg/L (reduced from 0.05 mg/L in January 2006). When active, the average pumping rates for DLCS district Wells 1 and 2 were 94.7 acre-feet per year and 265 acre-feet per year, respectively. The DLCS district resumed pumping from Well 1 in February 2008, blending the groundwater with water from AVEK to reduce arsenic levels. By comparison, the BCS district Wells 13 and 15 (prior to being taken off line in 2006) produced between 240 acre-feet to 260 acre-feet per year. BCS Well 15 was brought back online in late January/early February 2009 at a rate of 235 acre-feet per year. The extracted groundwater is blended with approximately 252 acre-feet per year of AVEK water.

Naturally-occurring arsenic concentrations also exceed the Federal pMCL in approximately 60 percent of groundwater monitoring wells at the South AFRL (USAF 2007) and in Well D at the Lower Well

Field. As of March 2012, however, the arsenic concentrations in Wells A, B, and C in the Lower Well Field (which are sampled monthly) meet the Federal pMCL.

3.1.6 ECOLOGICAL SETTING

The following description of the South AFRL ecological setting is derived primarily from the OU4 Predictive Ecological Risk Assessment (PERA) sections on Sites 37, 120, and 133 (Tetra Tech 2004) and the OU9 Scoping Ecological Risk Assessment (SERA) section on Site 321 (USGS 2004a). The source areas at Sites 37, 133, and 321 provide low to moderate quality ecological habitat due to proximity to industrial processes and related development; the Site 120 area provides a relatively high quality artificial aquatic habitat. The South AFRL CZ includes a large and relatively undisturbed area on PIRA down gradient from the AFRL sites that provides moderate to high quality Joshua tree habitat.

Vegetation at Sites 37, 120, 133, and 321 consists of a combination of Joshua Tree Woodland and Creosote Bush Scrub, typically composed of species including Mormon tea (*Ephedra nevadensis*), creosote bush (*Larrea tridentata*), allscale (*Atriplex polycarpa*), white bursage (*Ambrosia dumosa*), California buckwheat (*Eriogonum fasciculatum*), the native desert dandelion (*Malacothrix glabrata*), and desert cymopterus (*Cymopterus deserticola*). The evaporation/percolation ponds at the WWTP in the Site 120 area provide an Artificial Aquatic Habitat, supporting willow (*Salix* species [sp.]) and tamarisk (*Tamarix* sp.).

Potential ecological receptors include terrestrial plants, terrestrial invertebrates, reptiles, small herbivorous mammals, large carnivorous mammals, granivorous (seed and grain eating) and insectivorous birds, and raptorial avian species (Tetra Tech 2004). Small mammals such as desert cottontail (*Sylvilagus audubonii*) and kangaroo rats (*Dipodomys sp.*), small reptiles such as side-blotched lizards (*Uta stansburiana*), and common avian species such as red-tailed hawks (*Buteo jamaicensis*), mourning doves (*Zenaida macroura*), horned larks (*Eremophila alpestris*), and house finches (*Carpodacus mexicanus*) are expected to make up the majority of potential wildlife receptors present at these sites. Density of the desert tortoise (*Gopherus agassizii*), listed under the Federal Endangered Species Act as a threatened species, is estimated as medium at Sites 37 and 133, high at Site 120, and low at Site 321 (*General Plan for Edwards Air Force Base* [USAF 2011b]). The Mohave ground squirrel (*Xerospermophilus mohavensis*), a California state-listed threatened species,

may be found incidentally throughout Edwards AFB. During visits to Sites 37, 120, 133 and 321 in 2003, USGS biologists observed mallards (*Anas platyrhynchos*), loggerhead shrikes, killdeer (*Charadrius vociferous*), mourning doves, red-winged blackbirds (*Agelaius phoeniceus*), house finches, California quail (*Callipepla californica*), and prairie falcon (*Falco mexicanus*), a California Species of Concern. The observations of mallards and red-winged blackbirds were made at Site 120.

Figure 3.1-11 shows areas where sensitive natural resources (based on actual sightings) may be located inside the South AFRL CZ. These sensitive species include chuckwalla (*Sauromalus ater*), Barstow wooly sunflower (*Eriophyllum mohavense*), desert cymopterus (California Rare Plant Rank 1B [the California Native Plant Society List was changed in the spring of 2011]), and desert tortoise.

3.2 FORMER, CURRENT, AND FUTURE LAND USE(S) OF THE SITE AND SURROUNDING AREAS

The limits of the South AFRL CZ include an area located partially within the AFRL and partially within the PIRA; both are secure areas entirely within Edwards AFB.

As noted in Section 3.1.1.1, the nearest residential community (the town of West Boron with a population of approximately 2,000) is located off-Base, approximately 4.3 miles to the north of the northern CZ boundary. The nearest city is Lancaster, located approximately 30 miles to the southwest with a population of approximately 160,000 people. The AFRL does not have a permanent resident population; the daytime personnel population at AFRL is approximately 650, divided among military personnel, civilians employed by the government, and contractor support personnel. The buildings are primarily occupied between the hours of 7 a.m. and 4 p.m. One exception to the typical work schedule is that the fire station is manned using 72-hour work shifts per week (3 days on and 4 days off). Assuming a 2-week vacation, this equates to a workplace potential exposure duration of 3,600 hours annually, versus 2,000 hours for workers assumed to be on the job 8 hours per day, 250 days per year.

In the Base's General Plan (GP) (USAF 2011b), most land at the AFRL and PIRA is designated as Research and Development (R&D) for current and future land use; areas around the test stands are designated in the miscellaneous military land category (Figure 3.2-1). The R&D designation indicates land used directly in basic or applied research while the miscellaneous military land designation indicates DOD controlled land used for military functions that cannot be classified elsewhere

(e.g., service type facilities and structures that support airfields; land which does not have a specific land use; land required for safety or security clearances; and buffer zones between incompatible uses). Land designated for R&D is normally close to land designated as miscellaneous military; both are compatible with industrial land use; normally separate from lands designated as forest and wildlife, institutional, or parks and historic uses; and incompatible with housing. The current and long-term planned land uses within the South AFRL CZ are industrial in nature; residential uses (including day care facilities or other uses that would result in potential exposures beyond worker exposures) are prohibited within the VICB, as is the extraction of groundwater within the South AFRL CZ for use as a potable water source or for municipal, industrial, or agricultural supply. Due to the possibility that unexploded ordnance (UXO) remains on the PIRA (formerly used as a practice range for target bombing), there is no plan to develop the otherwise relatively undisturbed acreage down gradient from AFRL sites.

The *Water Quality Control Plan for the Lahontan Region* (Basin Plan, CRWQCB-LR 1995 amended through May 2008) designates the following beneficial uses for groundwater in the Antelope Valley hydrologic basin (including the Lancaster subbasin, which is the closest subbasin to the South AFRL): municipal, agricultural, industrial, and freshwater replenishment. However, the nearest active drinking water well (Well C in the Lower Well Field) is located outside the South AFRL CZ boundary, more than 5 miles southwest of the downgradient extent of the TCE plume at Site 133 (refer to Figure 3.1-2). The Lower Well Field extracts groundwater from the alluvial Lancaster Sub-basin; no production wells tap the water-bearing fractured bedrock of the Hi Vista area in which the South AFRL CZ is located. There are no current or long-term uses of groundwater for drinking water supply or any other purpose at the South AFRL. The AFRL has not been designated as a critical recharge area.

No permanent surface water bodies exist inside the South AFRL other than man-made retention ponds at the WWTP and associated with Downfall (operations control on the PIRA). Engineered drainages and stormwater runoff ultimately drain to Rogers Lake bed where standing water collects during most winters.

3.3 HISTORY OF CONTAMINATION

Sections 3.3.1 through 3.3.4 present, for each of the South AFRL sites (37, 133, 120, and 321): a description of historical activities that led to groundwater contamination and when it took place; the specific types of hazardous substances and a rough approximation of release volumes; and how the contamination was discovered. Section 3.3.5 summarizes problems resulting from contamination at South AFRL sites.

3.3.1 SITE 37 – BUILDING 8595 PCE PLUME

The PCE groundwater plume at Site 37 originates at Building 8595 (refer to Figure 3.0-1), located on the southwestern flank of Leuhman Ridge, approximately 300 ft southwest of the intersection of Mars Blvd and Ara Street. Building 8595 was used from 1960 to 1997 for maintenance and repair of rocket components. Since 1998, Building 8595 has been used as a laboratory and not for rocket component maintenance; the electronics work performed in the laboratory does not include the use or release of chlorinated solvents or other hazardous materials.

3.3.1.1 Historical Activities That Caused Contamination and When They Took Place

Past practices at Building 8595 (Figure 3.3-1) from 1960 through the early 1980s led to the release of chemicals into the subsurface. PCE was used to clean rocket nozzles and components in a vapor degreaser (measuring 25 ft long by 5 ft wide) that was formerly located inside a shallow concrete pit (identified as AOC 170) inside the building. Based on interviews conducted during the ESI/RFA, from approximately 1963 to 1970, the vapor degreaser was in use for up to 8 hours per day in support of tests on the F-1 rocket. After 1970, the unit was used several times a year at most, until its removal in 1992, at which time the shallow containment pit was covered with 1-inch thick steel plates.

A major source of PCE contamination to groundwater underlying Site 37 is attributed to a release from a 10,500-gallon aboveground storage tank (AST) that supplied PCE to the vapor degreaser. The AST was located on the south side of the building. Reportedly, the tank's contents spilled onto the ground surface when a valve was inadvertently left open sometime in the early 1980s. The AST was later refilled and used until its removal in 1994.

Record drawings dated November 1960 indicate that an 8-foot by 10-foot degreaser was initially located on the steel grating overlying an indoor sump (identified as AOC 171), which measured approximately 20 ft by 10 ft by 7.5 ft deep (with a capacity of 11,700 gallons). The sump was used since at least 1977 to collect rinseate from three "hot" acid dip tanks that straddled the grating; a fourth tank containing rinsewater and a parts polisher were located on concrete adjacent to the sump's southeastern corner. Once cleaned, rocket components were rinsed with deionized water over the sump. Reportedly, contents of the dip tanks (containing acids and caustics) were pumped into drums approximately every 6 months.

Liquids that collected in the inside waste sump were originally discharged via pipeline to the sanitary sewer; and later to a collection box south of Building 8595 that was connected to the outdoor waste sump (identified as Site 172). This sump, constructed in 1972, had outside dimensions of 20 ft square by 8 ft, and 8 inches deep with a capacity of 19,000 gallons. The sump contained three concrete chambers separated by reinforced concrete weirs. Each chamber was originally connected to the sanitary sewer via a valved drain line and floor drain. The third chamber also had an overflow line that connected to the sanitary sewer.

Before these units were decommissioned in 1997 (Earth Tech 1998), PCE and other chemicals were likely released via leakage from cracks in the indoor and outdoor waste sumps and their associated pipelines; and leaks in sanitary sewer lines. Prior to the 1980s, parts cleaning using solvents (TCE and possibly PCE) was also conducted outside and to the north of Building 8595. Other release mechanisms may have included surface dumping of spent solvent or spillage during transfer of PCE into or out of the AST. It is assumed that all releases of either free product or dissolved PCE (and other solvents) occurred fairly close to Building 8595, probably within 50 ft of its southern wall.

Between 2005 and 2007 (as described in Section 3.4) fracture blasting was tested (unsuccessfully) to evaluate whether aquifer permeability could be increased, thus enhancing groundwater extraction from the tight bedrock fractures (Earth Tech 2008a). This testing was conducted in an area of Site 37 identified as the fractured bedrock zone (FBZ) (refer to inset A on Figure 3.0-4). As an unintended consequence, the fracture blasting resulted in the release of perchlorate (a constituent in the Chilean nitrate used in the explosives); an estimated 0.15 pounds was released, resulting in a perchlorate plume that covers approximately 2,500 square feet.

3.3.1.2 Specific Types of Hazardous Substances and Rough Estimate of Released Volume

As documented in the RISR for OU4 (Earth Tech 2005a) and the Focused FS for the South AFRL (Earth Tech 2005c), a wide variety of chemicals were used, and potentially released to the subsurface at Building 8595, including:

- Solvents - PCE, TCE, 1,1,1-trichloroethane (TCA), acetone, trichlorotrifluoroethane (chlorofluorocarbon [CFC] 113), and isopropyl alcohol (IPA); and
- Caustics (sodium hydroxide) and acids (nitric, sulfuric, hydrochloric, hydrofluoric, and phosphoric).

Perchlorate, petroleum products, and heavy metals (chromium, zinc) were among the contaminants removed during vapor degreasing and parts cleaning operations. The additive 1,4-dioxane was probably present as a stabilizer in 1,1,1-TCA (at concentrations up to 5 percent) and at lesser concentrations in PCE and TCE. Cis-1,2-DCE detected in the groundwater is believed to be a biodegradation product from the reductive dechlorination of PCE and TCE, with released waste petroleum providing electron donor for anaerobic reductive dechlorination (ARD).

There are no records allowing an accurate estimate of chemical volumes used and/or released (via spills or in wastewater) in the vicinity of Building 8595 over its first 37 years of operation; the 1980s release to ground surface of PCE that drained from the 10,500-gallon AST is believed to be the greatest one-time release volume. Assuming the tank was filled to a capacity of 10,500 gallons, one can estimate a maximum release of 136,000 pounds PCE from this spill.

3.3.1.3 How Contamination was Discovered

In the mid-1980s, the Outdoor Waste Sump south of Building 8595 was found to be leaking. Reportedly, impacted soil surrounding the unit was excavated and replaced with clean fill. Repairs and modifications were made in 1987. Liquid and solid wastes were removed from the sump chambers, and the existing floor drains were taken out of service. A 4-inch layer of clean sand was placed on the chamber floors, after which a fiberglass-reinforced plastic liner was installed in each chamber. Beginning in 1992, all wastewater from the sump was pumped into one of two aboveground ASTs for storage until removed off-Base for disposal.

Possibly based on observations made during modifications to the Outdoor Waste Sump as summarized above; and the reported 1980s release of PCE from the 10,500-gallon AST, Site 37 was identified by Base Environmental Management (EM) as an ERP site even before Edwards AFB was listed on the NPL in August 1990. As summarized in Table A.1-1, the ESI/RFA conducted between 1991 and 1993 identified several discrete AOCs (170 through 175) in the vicinity of Building 8595; and an SI that included the collection of soil samples at each of these potential release locations was initiated in 1993.

In 1994, the first groundwater monitoring wells were installed: Well 171-MW05 located approximately 50 ft south of Building 8595 and Well 37-MW06 located approximately 500 ft down slope. In groundwater samples collected in February 1994, PCE was found at concentrations of 130,000 μg/L in Well 171-MW05 and 48,000 μg/L in Well 37-MW06. Beginning with the RI (conducted between 1996 and 2004) and continuing through 2010, more than 40 monitoring wells have since been installed to delineate the groundwater plume's lateral and vertical extent.

Early removal actions completed at Building 8595 include the cleaning, inspection, and backfill of the vapor degreaser pit (AOC 170) and indoor sump (AOC 171) between January 1997 and November 1997; the outdoor waste sump (Site 172) was also cleaned and inspected (Earth Tech 1998). Because inspection of the vapor degreaser pit showed no sign of damage, cracks or holes, regulatory agencies (the Kern County Environmental Health Services Department [KCEHSD] and CERCLA remedial project managers [RPMs]) agreed that no sampling was required below this secondary containment unit. In soil samples collected from coreholes drilled through the floor of the indoor sump, low concentrations of PCE (ranging from 0.0072 milligrams per kilogram [mg/kg] to 0.0074 mg/kg) were detected. Based on a review of these data and results from grab air samples collected inside the pit and sump (as summarized in Tables 1.5-1 and 1.5-2 of the *South AFRL VI Report* [AECOM 2012c]), the regulatory agencies concurred with a USAF recommendation to proceed with backfilling the two indoor units without further investigation.

Due to high concentrations of PCE detected in a sandy fill layer beneath the sump, an IRA consisting of SVE and treatment using vapor-phase granular activated carbon (VPGAC) was implemented in 2000 beginning with three extraction wells; the number of extraction wells was expanded to seven in 2002. Between April 2000 and July 2006, over 7,500 pounds of vapor-phase PCE were removed, reducing concentrations in the sand beneath the sump from a maximum of 1,200 mg/kg to below 20 mg/kg. In

July 2006, the system was taken off line to allow monitoring (through June 2007) for rebound in VOC concentrations in the soil vapor (Earth Tech 2007a). Figure 3.3-2 shows a conceptual site model (CSM) that was developed based on results from the rebound monitoring (the location of cross section line G-G' is provided on Figure 3.3-1). The drilling lithology and high concentrations of PCE detected in soil vapor at some monitoring points suggest that a fraction of residual PCE may be adsorbed to clayey material and loose sand associated with highly degraded weathered bedrock, where it acts as a continuing source of solvent in the shallow subsurface. This diagram also depicts the infiltration of PCE through fractures into the competent granitic bedrock and into groundwater.

Indoor air samples were first collected inside the refurbished Building 8595 in 2003; through February 2012, there have been eight rounds of indoor air sampling – four with the SVE system off-line; and four when the SVE system was operating. In general, PCE has been detected at concentrations that slightly exceed its ROD-established IAVML-ind of 1.7 micrograms per cubic meter ($\mu g/m^3$) (refer to Table 3.5-2) at some locations during sampling events when the SVE system was off-line but did not exceed this level when the system was operating. VIP sampling results are discussed in more detail in Section 6.4.3.3.

3.3.2 SITE 133 - AFRL CIVIL ENGINEERING YARD

Site 133 encompasses a large groundwater plume that extends south from various source areas located east of Mercury Blvd and north of Mars Blvd, merging into the Site 120 contaminant plume to the southwest (refer to Figure 3.0-2). Site 133 was first identified as the AFRL CE yard, but was expanded to include groundwater impacted by additional sources as detailed in Section 3.3.2.1.

3.3.2.1 Historical Activities That Caused Contamination and When They Took Place

The Site 133 groundwater plume includes source areas associated with Buildings 8400 through 8408 in the AFRL CE Yard; Facilities 8409 and 8411 in the AFRL gas station; two former machine shops (Buildings 8421 and 8425); the AFRL chemistry laboratory (Building 8451); former missile assembly Buildings 8419, 8423, 8424, and 8431; and a former fire training area (Figure 3.3-3). Most of these facilities date to the late 1950s (or even earlier); the former missile assembly buildings have been converted for use other than missile assembly since the 1970s (Building 8431 is currently used as a

gymnasium) but CE facilities and the chemistry laboratory are still used for their historic mission. The major sources contributing to the groundwater contaminant plumes identified as Site 133 include:

1. Former waste discharge (dry) wells associated with Buildings 8431 (Dry Well E), 8423 (Dry Well F), and 8425 (Dry Well G); these units, and Dry Wells A through D associated with Building 8421 plus a former waste discharge area associated with this building, are also identified as ERP Sites 153 and 396. The dry wells were formerly connected to floor drains, grease interceptor pits, cesspools, and/or air conditioning systems inside their associated buildings; but prior to 2001, had been isolated from all inlet sources except the air conditioning systems, which discharged only clean water from the condensers. Based on groundwater sampling results, Dry Wells E, F, and G were used in the past (assumed between the late 1950s to as late as the early 1980s) for disposal of spent TCE solvent. The former waste discharge area associated with Building 8421 reportedly received hundreds of gallons of waste from this former machine shop; however no contaminants were detected in soil samples collected during the SI and RI at concentrations that exceeded risk-based screening levels (preliminary remediation goals [PRGs] formerly published by USEPA Region 9).

2. Two former waste evaporation/percolation ponds (Site 150) associated with the chemistry laboratory (Building 8451); one waste evaporation pond was reportedly used for waste inorganic materials (e.g., beryllium) and the other was used for waste organic materials (e.g., solvents) but (as labeled on Figure 3.3-3), the usage of each pond later became blurred.

    - The Former Beryllium/Organic Waste Evaporation Pond, located approximately 120 ft east of Building 8451, is fenced and surrounded by a berm, with the area inside the berm measuring approximately 40 ft by 40 ft. The bentonite-lined pond was reportedly 10 ft deep prior to being backfilled with clean soil in 1968. Its depth in 1994 was approximately 2 ft. As-built drawings dated 1963 indicate that drainage lines from Building 8451 discharged to this area, which was designated as an evaporation pond for organic chemicals. A memo and an as-built drawing dated 1968 indicate that these drain lines were capped off and rerouted to the Former Inorganic Waste Evaporation Pond located to the south.
    - The Former Inorganic Waste Evaporation Pond, located approximately 200 ft south of Building 8451, reportedly was active from the 1950s to the early 1970s. Currently, there is no surface evidence of the pond. A 1963 as-built drawing shows drains leading from Building 8451 to the bentonite-lined pond, which had dimensions of 36 ft by 50 ft. A 1967 aerial photograph indicates that the pond was about 60 ft by 65 ft. The pond was reportedly filled with clean soil when deactivated.

3. A former fire training area (Site 26) that was used three to four times per year through the early 1970s to train personnel to fight aircraft fires; however, it has been inactive since 1975. During training exercises, JP-4 and/or gasoline were sprayed onto a small decommissioned jet aircraft, ignited, and then extinguished using water and chemical foam

consisting of surfactants and glycol ether. The fuel was supplied by an AST, underground pipeline and two aboveground nozzles.

4. The AFRL gas station where past releases (circa late 1950s through the early 1980s) include discharge or leakage to the ground surface of waste oils, spent solvents, and constituents of petroleum fuels including MTBE.

5. The AFRL CE Yard, specifically a former waste discharge area located south of Building 8405 and a former drum storage area located approximately 50 ft further south; reportedly, waste oils and spent solvents were formerly discharged to ground surface although no contaminants were detected in soil samples collected during the SI at concentrations that exceeded PRGs.

6. The closed AFRL landfill (Site 13).

3.3.2.2 Specific Types of Hazardous Substances and Rough Estimate of Released Volume

Based on information in the ESI/RFA and/or RI sampling results, chemicals that may have been released in the vicinity of the six source areas described in Section 3.3.2.1 include:

1. TCE discharged to Dry Wells E and F associated with Buildings 8431 and 8423. To provide some indication of the mass that may have been released, it was assumed in the ROD that the equivalent of ten 55-gallon drums may have been disposed to each of these dry wells during the 30-plus years over which releases may have occurred. This assumption leads to an estimated release approaching 15,000 pounds of TCE. Dry Well G is suspected to have received waste liquids ranging from spent solvents and waste oil to rinsewater from shower and sink drains in Building 8425. Waste oil and solvents are the materials reportedly discharged to dry wells and/or the waste discharge area associated with the former machine shop in Building 8421.

2. Chemicals released in the vicinity of Building 8451 include beryllium, acids, solvents (TCE, PCE, acetone, and alcohol), 1,4-dioxane, and NDMA (a by-product from hydrazine).

3. Chemicals released at the former fire training area include gasoline and JP-4 and chemical foam containing surfactants and glycol ether. Based on groundwater sampling results, PCE and TCE were also released into groundwater at this site.

4. Chemicals released inside the AFRL gas station potentially include waste oils, spent solvents, and constituents of petroleum fuels including MTBE.

5. Releases in the CE Yard are believed to have included waste oil, paints, and solvents in low quantity.

6. The AFRL landfill was operated without regulatory oversight from 1961 to 1976, and as a permitted landfill from 1976 to 1992. A review of the available historic data indicated that

the landfill received non-hazardous commercial and construction wastes, and was restricted from receiving liquid or hazardous wastes. In 1984, the site was designated a Class III non-hazardous solid waste landfill under Chapter 15 of CCR Title 23. However (as documented in the *As-Built Certification and Construction Quality Assurance Report for Final Closure of AFRL Landfill (Site 13)* (Earth Tech 2003a), the discovery of buried waste oil drums along the landfill perimeter during the 2001/2002 construction of a final cover system indicates that an unknown (but believed to be small) volume of hazardous liquids were disposed in, or at least near, the landfill cells.

3.3.2.3 How Contamination was Discovered

The AFRL landfill was first identified as Site 13 under the Edwards AFB ERP in 1984; and the former fire training area was identified as Site 26. All other source areas for the Site 133 groundwater plume were identified during the ESI/RFA conducted (between 1991 and 1993) after Edwards AFB was listed on the NPL. The first subsurface investigations were undertaken as part of Solid Waste Assessment Tests (SWATs) at the AFRL landfill between 1990 and 1992; and at Sites 26, 133, 150, and 153/396 as part of an SI conducted in 1993 and 1994. TCE was detected in all four of the groundwater monitoring wells (13-MW01 through 13-MW04) installed at the Site 13 landfill in 1992; and in Wells 133-MW04 (inside the CE Yard) and 26-MW08 (inside the former fire training pit) installed in 1994. During the RI (conducted between 1996 and 2004), a number of monitoring wells were installed to delineate source areas (at Sites 26, 133, 150, and 153/396); in total (through 2010), more than 70 monitoring wells (many with a well identification [ID] that begins with 13-MW) have been installed to delineate the groundwater plume's lateral and vertical extent.

3.3.3 SITE 120 - AFRL FORMER SEWAGE TREATMENT PLANT

Site 120, the former STP, is located outside the AFRL security gate along the entry road to the PIRA. As shown on Figure 3.0-2, the Site 133 TCE plume merges with the Site 120 groundwater plume from the north.

3.3.3.1 Historical Activities That Caused Contamination and When They Took Place

The STP was constructed in the early 1950s and included an Imhoff Tank for sedimentation of suspended solids, two unlined sludge-drying beds, seven unlined evaporation/percolation ponds, and three unlined overflow ponds (Figure 3.3-4). The original STP had a reported treatment capacity of 137,000 gpd but prior to renovation between 1995 and 1999, the facility was treating approximately

85,000 gpd. The renovated WWTP, which went on line in May 1999, includes secondary treatment and is permitted to treat 125,000 gpd. Through 2011, the WWTP was reportedly treating an average just below 40,000 gpd.

Before the plant was renovated in 1995, the partially-treated wastewater was discharged from the Imhoff Tank to the evaporation/percolation ponds and allowed to evaporate or seep into the soil.

3.3.3.2 Specific Types of Hazardous Substances and Rough Estimate of Released Volume

Although unlikely today, in theory any chemical used at AFRL could have been discharged in the past to sinks, drains, or stormwater drainages, ultimately flowing to the Imhoff Tank and thence discharged to the former sludge drying beds at the original STP. Based on results for groundwater samples, the water discharged to these ponds in the past may have contained dissolved solvents (PCE and TCE); it is assumed that cis-1,2-DCE (found at a concentration above 2,000 μg/L in Well 120-MW02 down gradient from the Imhoff Tank) is a biodegradation product generated by the reductive dechlorination of these solvents, probably enhanced by the presence of organics in the wastewater.

3.3.3.3 How Contamination was Discovered

The potential source areas associated with facilities at the former STP were identified during the ESI/RFA conducted between 1991 and 1993. The first subsurface investigations were undertaken as part of an SI conducted in 1994. Soil samples were collected from inside the overflow ponds and sludge drying beds (AOC 121), adjacent to the Imhoff Tank (AOC 119), and adjacent to the evaporation ponds (Site 120); and monitoring Wells 121-MW09 and 120-MW10 were installed and sampled. PCE, TCE, and cis-1,2-DCE were detected in the groundwater.

In 1995, five additional monitoring wells were installed in accordance with requirements of Board Order No. 6-95-34 adopted for the new WWTP; and later (during and subsequent to the RI), additional wells were installed to delineate the plume's lateral and vertical extent. The dissolved-phase, commingled Sites 133 and 120 TCE plume (exceeding 1 μg/L) is estimated to extend approximately 3.2 miles from Well 153-MW10 north of Building 8431 to the south (2 miles southwest of Mars Blvd) and to cover a surface area of approximately 1,500 acres.

3.3.4 SITE 321 - LIQUID PROPELLANT STORAGE COMPLEX CATCH TANKS

Site 321 includes three removed catch tanks that were formerly associated with Buildings 9423, 9424, and 9425 at the Liquid Propellant Storage Complex (LPSC) along Mars Blvd (Figure 3.3-5).

3.3.4.1 Historical Activities That Caused Contamination and When They Took Place

Building 9423 was built in 1964 as a storage facility for hydrazine (used in auxiliary power units) stored in 55-gallon drums on wooden pallets. An 18,000-gallon catch tank (removed in 1995) was located approximately 100 ft northeast of the buildings; the top of the single-walled steel tank was flush with the ground surface. A pipe from a floor drain in the building discharged to the tank, which served as a containment system for spills or leaks of hydrazine and later, nitrogen tetroxide (N_2O_4). Waste hydrazine contained in the tank was neutralized with chlorine and then collected in a 55-gallon drum for disposal as a hazardous waste. Reportedly, trace amounts of spent solvent were also discharged to the tank.

The Building 9424 catch tank was a 10,000-gallon, single-walled steel tank that reportedly contained spills of N_2O_4; these wastes were neutralized with sodium hydroxide before being discharged to the surrounding soil. The Building 9525 catch tank was an 8,000-gallon single-walled steel tank that contained potential spills of hydrazine or monomethyl hydrazine (MMH) from Building 9425. Rinse water released to the catch tanks during the 1960s and 1970s may have contained dilute amounts of spent solvent. Both tanks were removed in 1995.

Surface runoff including rainwater drained to all three tanks, which were removed in 1995.

3.3.4.2 Specific Types of Hazardous Substances and Rough Estimate of Released Volume

The chemicals reportedly released to the subsurface in the vicinity of the LPSC catch tanks include hydrazine, MMH, N_2O_4, and solvents. Due to its high reactivity, hydrazine does not persist in the environment; however NDMA found at low concentrations in Site 321 groundwater (refer to Figure 3.0-5) is likely a hydrazine degradation product. Nitrate is detected at very high concentrations (exceeding 900 mg/L) in groundwater from Well 321-MW01; its source is believed related to the past release of N_2O_4 from Building 9423. PCE is detected in Well 321-MW02 at a concentration of 850 μg/L, suggesting that this chemical may have been released in greater than trace quantities.

3.3.4.3 How Contamination was Discovered

The potential source areas associated with facilities at the former LPSC were identified during the ESI/RFA conducted between 1991 and 1993; and an SI was conducted in 1993 and 1994. PCE and TCE were detected in soil vapor samples, and in the groundwater from Well 321-MW01 installed to the north of the Building 9423 catch tank. The three catch tanks were removed in June 1995 by Aman Environmental Construction, Inc. (1996). After Aman detected PCE at a concentration of 2.7 mg/kg in shallow soil near drains located on the southwestern side of the pad at Building 9423, additional soil sampling was conducted during the RI; the highest PCE concentration detected was 0.040 mg/kg. Between 2001 and 2003, 11 monitoring wells (including nested Wells 321-MW05a/b and 321-MW08a/b) were installed to delineate the lateral and vertical extent of groundwater contamination; a 12th well (321-MW10) was installed in 2010.

3.3.5 PROBLEMS RESULTING FROM CONTAMINATION

As a result of releases from source areas at the South AFRL sites, the groundwater plumes identified as Sites 37, 133, 120, and 321 are contaminated with a number of COCs at concentrations that exceed drinking water pMCLs and thus do not meet ARARs. Because groundwater inside the South AFRL CZ is not extracted for use as a drinking water source, there is no current exposure to the contaminated groundwater. However, LUCs are required to prevent future uses; and containment inside the CZ is required to prevent impact to the alluvial aquifer and drinking water production wells in the Lower Well Field down gradient from the site.

As introduced in Section 3.1.1.2, it is suspected that subsurface vapors may intrude into the indoor air of buildings that overlie groundwater concentrations of VOCs exceeding the GWVCLs-ind (refer to Table 3.1-2), potentially posing a cancer risk greater than 10^{-6} to current workers. Sampling conducted in Building 8595 as described in Section 3.3.1.3 confirmed the intrusion of PCE into Building 8595 via the VIP. The potential for risks via the VIP in administrative buildings that overlie the GWVCLs-ind in the Site 37 groundwater plume down gradient from Building 8595 and in buildings that overlie the Site 133 groundwater plume (refer to areas outlined in green on Figure 1.0-3) has been evaluated as presented in Section 6.4.3. There are no occupied buildings overlying concentrations above the GWVCLs-ind at Site 120 or at Site 321. However, inside the VICBs that encompass groundwater contamination at all four sites (blue outlines on Figure 1.0-3), groundwater concentrations that exceed

GWVCLs-res (as listed in Table 3.1-1) potentially pose a cancer risk greater than 10^{-6} to future (hypothetical) residential receptors, thus LUCs are required to prevent this exposure.

In summary, contaminants are present both in the groundwater and subsurface vapors at South AFRL sites above levels that allow for UU/UE.

3.4 INITIAL RESPONSE ACTIONS

After Edwards AFB was listed on the NPL on 30 August 1990, the USAF entered into an FFA with the USEPA, California DTSC, and CRWQCB-LR in September 1990 (refer to Section 1.6); and as required under the FFA, a Basewide ESI/RFA was undertaken between 1991 and 1993. Subsequently, an SI was conducted for potential release locations identified at the AFRL (OU4 and OU9), with results summarized in individual SI summary reports. Based on results from the SI, Sites 37, 120, and 133 in OU4 and Site 321 in OU9 advanced to RI. Either prior to or during the RI, the following initial response actions were completed to prevent ongoing or future release to groundwater at the South AFRL:

- Site 37.
    - Decommissioned, cleaned, and backfilled the shallow vapor degreaser pit (AOC 170) and indoor waste sump (AOC 171) at Building 8595 in 1997 (Earth Tech 1998). Replaced the flooring inside the building. Also decommissioned and cleaned the outdoor waste sump (Site 172), and began extraction of vapors below the sump using SVE as described in Section 3.3.1.3. In 2002, the outdoor waste sump was filled with concrete slurry and capped by a reinforced concrete pad (Earth Tech 2003b). Because these actions effectively removed the pit and sumps as release pathways, a final remedy of no further action was selected for AOCs 170 and 171 and Site 172 as documented in Sections 2.7.6 and 2.7.7 of the *AFRL Soil and Debris Sites ROD* (USAF 2008). However, the ROD states that "the closure of Site 172 is largely for administrative purposes. The land surrounding Building 8595 (including that on which Site 172 lies), and the groundwater below the building will continue to be managed as part of the final remedy presented in the ROD for the South AFRL area."
- Site 133.
    - Outside the ERP program, the USAF capped drain lines leading from Building 8451 to one of two former waste evaporation ponds in 1968; and discontinued use of the second pond by the early 1970s, when the pond was filled in with clean soil. Results of soil sampling conducted under the RI for Site 150 were presented in

Section 2.7.3 in the *AFRL Soil and Debris Sites ROD*; and a final remedy of no further action was selected for the soil medium at Site 150.

- Removed USTs from the AFRL gas station in 1995. The KCEHSD closed out these petroleum-only USTs under the Edwards AFB Underground Storage Tank Investigation (USTI) program.
- Removed the AST and associated pipelines from the former fire training area (Site 26) and excavated petroleum-contaminated soil in 2000 and 2001. The actions taken were presented in Section 2.7.2 in the *AFRL Soil and Debris Sites ROD*; and a final remedy of no further action was selected for the soil medium at Site 26.
- Destroyed waste discharge Wells A and D through G by redirecting active inlet lines; cleaning out contaminated soil, sludge and water; and backfilling with cement/sand slurry in 2001 (Dry Wells B and C could not be located and were assumed destroyed by the USAF – outside the ERP – prior to 1993.) The actions taken were presented in Sections 2.7.4 in the *AFRL Soil and Debris Sites ROD*; and a final remedy of no further action was selected for the soil medium at Sites 153 and 396 (including Dry Wells E and F associated with Buildings 8431 and 8423).
- Installed a final cover system at the AFRL Landfill (Site 13) in 2001 to 2002. This cover system, in conjunction with engineering and administrative LUCs and vapor monitoring, was selected in Section 2.5.1.9 of the *AFRL Soil and Debris Sites ROD,* as the long-term remedy for Site 13.

As noted in the bullets above, the *AFRL Soil and Debris Sites ROD* (USAF 2008) selected a final remedy of no further action for the soil medium at Sites 26, 150, and 153/396; however, for each of these sites, the ROD states, "The groundwater below the site will continue to be managed as part of the final remedy for the South AFRL." Further, for Site 13 (where LUCs and LTM to monitor and maintain the final cover system were selected as the long-term remedy), the ROD states that "groundwater below Site 13 is subject to LUCs as part of the selected remedy presented in the South AFRL ROD."

- Site 120. Decommissioned the Imhoff Tank, sludge drying beds, and former waste evaporation/percolation ponds; and upgraded the WWTP between 1995 and 1999. The renovated WWTP now includes secondary treatment.
- Site 321. Removed below-grade catch tanks at the LPSC in 1995.

In addition, the following pre-ROD treatability studies and/or interim response actions were implemented at Sites 37 and 133:

- Operation of a small-scale GETS as a treatability study for hot spot containment at Site 37 from January 1999 until November 2007; pilot study data during the RI/FS phase did not indicate air sparging would be a preferred alternative at Site 37. The GETS system was expanded from two extraction wells at startup in January 1999 to seven wells (wells shown in orange on Figure 3.1-9) in September 2002 and operated until shutdown in November 2007. A treatability study evaluation report (Earth Tech 2000) concluded that the GETS demonstrated success in slowing the lateral spread of near-surface dissolved contaminants above a targeted PCE concentration of 10,000 μg/L. During 9 years of operation, the GETS removed an estimated 650 pounds of PCE at an average total flow rate of 0.9 gpm. In its last year of operation, two other extraction wells (37-EW09 and 37-EW10, shown in red on Figure 3.1-9) located in the FBZ, were briefly tied in.

- Operation of a small-scale GETS at Site 133 from April 2001 until November 2007. The system included four groundwater extraction wells located down the axis of the plume source area (wells shown in green on Figure 3.1-9); the volume of water extracted from the wells was limited by the volume of treated water that could be discharged to the AFRL WWTP (15 gpm, or 21,000 gpd). In 7 years of operation, the system removed an estimated 530 pounds of TCE at an average total flow rate of 10 gpm. Perchlorate was also treated (through tailored liquid phase granular activated carbon [t-GAC]) at this GETS between 2004 and 2007.

- Operation (as described in Section 3.3.1.3) of an SVE system south of Building 8595 (in Site 37) from January 2000 until July 2006. During this period over 7,500 pounds of vapor-phase PCE were removed. Since the ROD was signed in September 2007, the SVE system has been operated periodically; and was reactivated in March 2012 following a 10-month shutdown (in April 2011), as further discussed in Section 4.5.3.1.

- A test of blast fracturing at the Site 37 FBZ to evaluate this method for increasing well yield and its practicality for large-scale designs. In December 2004 and January 2005, explosives were loaded and detonated in 31 boreholes at a depth from approximately 80 ft to 140 ft bgs to create the FBZs (see inset on Figure 3.0-4). Nine wells were installed inside and surrounding the FBZs and two long-term (3 to 4 months) pumping tests were conducted. Based on results from the pumping tests, well yields remained very low (between 0.002 gpm and 0.12 gpm) in the limited FBZ area, indicating that blast fracturing (as currently practiced) is neither an effective nor practicable method for increasing well yield (to aid in groundwater remediation) within the South AFRL CZ (Earth Tech 2008a).

Results of the RI conducted at Sites 37, 120, and 133 from 1996 through 2004 were summarized in the OU4 RISR (Earth Tech 2005a); and results of the RI conducted at Site 321 between 2001 through 2005 were summarized in the OU9 RISR (Earth Tech 2006a). The *Focused Feasibility Study to*

Support a Technical Impracticability Evaluation/Containment Zone Application for the South AFRL (Sites 37, 133, 120, and 321) (Earth Tech 2005c) was completed in June 2005; and the Proposed Plan was available for public comment between 7 April to 13 May 2006, with public meetings held on 12 and 26 April 2006. After the ROD was signed on 24 September 2007, the *South AFRL Remedial Action Work Plan* (RAWP) Version 1.0 (Earth Tech 2009a) was prepared, and LUCs and LTM components of the remedy were implemented as documented in Section 4.0 of this report.

3.5 BASIS FOR TAKING REMEDIAL ACTION

As documented in the ROD Section 2.7, the remedial action selected in the ROD "is necessary to prevent exposure to COC concentrations in groundwater that exceed pMCLs." The groundwater COCs identified at the South AFRL (with their respective pMCLs or other RBCGs) are listed in Table 3.5-1. The estimated distributions of the four primary COCs (PCE, TCE, cis-1,2-DCE, and perchlorate), based on sampling results through 2011 (2010 for Site 321), are shown on Figures 3.0-1 through 3.0-5. Compounds identified as vapor-phase COCs posing a risk via the VIP are listed in Tables 3.1-1, 3.1-2, and 3.5-2, along with their respective IAVMLs-res and IAVMLs-ind.

Baseline HHRAs and PERAs were conducted for OU4 Sites 37, 133, and 120 as documented in Earth Tech (2004b) and Tetra Tech (2004). A baseline HHRA and a SERA were conducted for OU9 Site 321 as documented in Earth Tech (2004c) and USGS (2004a). The baseline HHRAs were amended by Appendix B-1 in the ROD, which presented a re-evaluation of potential indoor air risks for sites at the South AFRL (using the J&E model version 3.1); for details on input parameters, please refer to Tables 1.1-3 and 1.1-4 in the *South AFRL Post-ROD Monitoring for Vapor Intrusion* report (AECOM 2012c). Depth to water is the site-specific distance from the surface to first-encountered groundwater, which at Site 37 was 2,319 centimeters (cm, or 76 ft) and for Site 133 was 405 cm (13.3 ft). These depths were approved as site-specific inputs to the risk assessment update and received concurrence during the ROD phase.

This section presents a summary of findings of the baseline HHRA as amended for the VIP (Section 3.5.1); a summary of findings in the PERA and SERA (Section 3.5.2); a re-statement of ROD Section 2.7.3 that provided the risk basis for taking a response action at the South AFRL

(Section 3.5.3); and CSMs for each site that summarize the exposure pathways retained for a CERCLA response (Section 3.5.4).

3.5.1 SUMMARY OF HUMAN HEALTH RISK ASSESSMENTS

The baseline HHRAs were conducted for Sites 37, 133, and 120 using SI and RI sampling results collected through August 2001; and for Site 321 used sampling results collected through January 2003. For all sites, the re-evaluation of VIP risk used groundwater sampling results (as input to the J&E model) collected between 2003 and 2005.

For the baseline HHRAs, a preliminary evaluation of health impacts from exposure to the soil and groundwater media was performed for all detected organic chemicals, and inorganic chemicals that exceeded upper limits on background established for AFRL soil (The Earth Technology Corporation 1995a) and groundwater (Earth Tech 1999b revised 2000). This evaluation consisted of a comparison of the maximum detection for each chemical in soil to residential and industrial USEPA Region 9 PRGs (USEPA 2000 for OU4 and USEPA 2002 for OU9). For groundwater, the maximum detections for each chemical were compared to tap water PRGs (USEPA 2000 for OU4 and USEPA 2002 for OU9) under a residential exposure scenario. Although some OU4 and OU9 sites advanced to a detailed assessment of risk, the baseline risk assessments for soil and groundwater media at the four South AFRL sites did not advance past this conservative preliminary evaluation.

Appendix B-1 in the ROD provides details regarding how VIP risks under residential and industrial exposure assumptions were simulated by the J&E model version 3.1 using the 95 percent upper confidence limits (UCLs) of the mean concentration for soil and groundwater sampling results and other site-specific inputs such as building size, soil type, and depth to contamination.

3.5.1.1 HHRA Results for Site 37

<u>Soil</u>

For exposure to the soil medium under both residential and industrial scenarios, the baseline HHRA indicated that carcinogenic risk exceeded 1×10^{-6} due to the maximum concentration of naturally-occurring arsenic. Under the residential scenario, the non-cancer hazard index (HI) was greater than 1 due to the maximum detections of naturally-occurring iron and manganese. Based on a

review of the HHRA results and an evaluation of the background distributions of these elements in soil, the USAF, USEPA and State regulators agreed that risks associated with soil contact at Site 37 are acceptable and require no response action.

Groundwater

The preliminary risk and hazard results based on the maximum detections of chemicals in groundwater as compared to tap water PRGs under a hypothetical residential groundwater use scenario were an estimated cancer risk of 2.3×10^{-1} and an HI of 445, with PCE as the major contributor to carcinogenic health risk (risks associated with the maximum detections of a number of other VOCs, and naturally-occurring arsenic, also exceeded 1×10^{-6}) and naphthalene primarily as the major contributor to an HI above 1 (non-cancer hazard quotients [HQ] above 1 were also estimated based on the maximum detected concentrations of nitrate and several inorganic elements including molybdenum, nickel, and vanadium). Based on a review of the distribution results for arsenic, molybdenum, nickel, and vanadium, the USAF, USEPA, and State regulators agreed that risks and/or hazards associated with the listed (and naturally-occurring) inorganic elements in groundwater are acceptable and require no response action; and that the following 15 chemicals (listed in Table 3.5-1) are the COCs in groundwater posing potential risks at Site 37: 1,1,1-TCA, 1,1-dichloroethane (DCA), 1,1-DCE, 1,4-dioxane, benzene, cis-1,2-DCE, CFC 113, methylene chloride, NDMA, naphthalene, PCE, TCE, vinyl chloride, perchlorate, and nitrate.

Soil Vapor

The carcinogenic risk and non-cancer HI under a residential scenario via the VIP were estimated at 1.6×10^{-3} using a groundwater input to the J&E model (1.1×10^{-3} using a soil input) and 18.4 (21.1), respectively. PCE was the primary contaminant contributing to both the cancer risk and HI, followed by TCE and benzene. The carcinogenic risk and non-cancer HI under an industrial scenario via the VIP were estimated at 3.5×10^{-5} using a groundwater input (1.8×10^{-6} using a soil input) and 1.2 (0.17), respectively.

3.5.1.2 HHRA Results for Site 133

Soil

For exposure to the soil medium under both residential and industrial scenarios, the baseline HHRA based on the maximum concentrations indicated that carcinogenic risks were less than 1×10^{-6} and the non-cancer HI was less than 1. Therefore, the USAF, USEPA and State regulators agreed that risks associated with soil contact at Site 133 are acceptable and require no response action.

Groundwater

The preliminary risk and hazard results based on the maximum detections of chemicals in groundwater as compared to tap water PRGs under a hypothetical residential groundwater use scenario were an estimated cancer risk of 1.53×10^{-2} and an HI of 216, with arsenic and several VOCs (including TCE, PCE and MTBE) as major contributors to the carcinogenic health risk. The majority of non-cancer hazards were associated with maximum detected concentrations of naphthalene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene associated with past releases from the AFRL gas station (also the source of MTBE). Non-cancer HQs above 1 were also associated with maximum detected concentrations of the following inorganic chemicals: aluminum, cadmium, fluoride, lead, mercury, molybdenum, nickel, thallium, and vanadium. Based on a review of the groundwater distributions for trimethylbenzene, fluoride, and inorganic elements by comparison with upper limits on background established for the AFRL, pMCLs, and tapwater PRGs, the USAF, USEPA, and State regulators agreed that risks and/or hazards associated with the trimethylbenzenes and the listed inorganics are acceptable and require no response action. The following 12 chemicals (listed in Table 3.5-1) were identified as the COCs in groundwater posing potential risks at Site 133: 1,2-DCA, 1,4-dioxane, benzene, cis-1,2-DCE, MTBE, NDMA, PCE, trans-1,2-DCE, TCE, vinyl chloride, perchlorate, and nitrate. Note that during a March 2004 risk management meeting, RPMs agreed that naphthalene, although detected in Well 133-MW02 at a concentration that exceeded the 2004 California notification level (NL) of 170 μg/L (decreased to 17 μg/L in April 2005), was not widely distributed and could be eliminated as a COC for the Site 133 groundwater plume. A similar decision was made for 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene. As part of this FYR the sampling results for naphthalene were evaluated for groundwater samples collected through 2011 and compared to the California NL of 17 μg/L. This evaluation indicated that distribution of the chemical in Site 133

groundwater at concentrations that exceed the NL remains limited to wells in the vicinity of the AFRL gas station (133-MW02, 186-MW01), with a single exceedance in Well 150-MW04 near Building 8451.

Soil Vapor

The carcinogenic risk and non-cancer HI under a residential scenario via the VIP were estimated at 1.2×10^{-4} using a groundwater input to the J&E model (4.6×10^{-6} using a soil input based on detections of TCE and methylene chloride) and 3.3 (<1), respectively. TCE followed by PCE were the primary contaminants contributing to both cancer risk and the HI. The carcinogenic risk and non-cancer HI under an industrial scenario via the VIP were estimated at 2.9×10^{-6} using a groundwater input (6.9×10^{-9} using a soil input) and 0.23 (<1), respectively.

3.5.1.3 HHRA Results for Site 120

Soil

For exposure to the soil medium under both residential and industrial scenarios, the baseline HHRA based on the maximum concentrations indicated that carcinogenic risks were less than 1×10^{-6} and the non-cancer HI was less than 1. Therefore, the USAF, USEPA and State regulators agreed that risks associated with soil contact at Site 120 are acceptable and require no response action.

Groundwater

The preliminary risk and hazard results based on the maximum detections of chemical in groundwater as compared to tap water PRGs under a hypothetical residential groundwater use scenario were an estimated cancer risk of 3.83×10^{-3} and an HI of 674, with PCE as the major contributor to the carcinogenic health risk (risks associated with several other VOCs also exceeded 1×10^{-6}) and thallium the major contributor to an HI above 1. Non-cancer HQs above 1 were also associated with maximum detected concentrations of cadmium and nickel. Based on a review of the groundwater distributions for cadmium, nickel, and thallium by comparison with their upper limits on background established for the AFRL and pMCLs, the USAF, USEPA, and state regulators agreed that risks associated with these naturally-occurring elements in groundwater are acceptable and require no response action. The following eight chemicals (listed in Table 3.5-1) were identified as the COCs in groundwater posing

potential risks at Site 120: 1,4-dioxane, cis-1,2-DCE, PCE, trans-1,2-DCE, TCE, vinyl chloride, perchlorate, and nitrate.

Soil Vapor

The carcinogenic risk and non-cancer HI under a residential scenario via the VIP were estimated at 1.6×10^{-3} using a groundwater input to the J&E model (2.0×10^{-6} using a soil input based on the maximum detection of methylene chloride) and 22.2 (<1), respectively. PCE followed by TCE were the primary contaminants contributing to both cancer risk and the HI; the HQ for cis-1,2-DCE also exceeded 1. The carcinogenic risk and non-cancer HI under an industrial scenario via the VIP were estimated at 9.2×10^{-5} using a groundwater input (2.1×10^{-8} using a soil input) and 3.8 (<1), respectively.

3.5.1.4 HHRA Results for Site 321

Soil

For exposure to the soil medium under both residential and industrial scenarios, the baseline HHRA based on the maximum concentrations indicated that carcinogenic risks were less than 1×10^{-6} and the non-cancer HI was less than 1. Therefore, the USAF, USEPA and State regulators agreed that risks associated with soil contact at Site 321 are acceptable and require no response action.

Groundwater

The preliminary risk and hazard results based on the maximum detections of chemicals in groundwater as compared to tap water PRGs under a hypothetical residential groundwater use scenario were an estimated cancer risk of 4.24×10^{-3} and an HI of 118.6, with PCE and TCE as major contributors to the carcinogenic health risk and nitrate and cis-1,2-DCE contributing to an HI above 1. The following five chemicals (listed in Table 3.5-1) were identified as the COCs in groundwater posing potential risks at Site 321: cis-1,2-DCE, PCE, TCE, vinyl chloride, and nitrate.

Soil Vapor

The carcinogenic risk and non-cancer HI under a residential scenario via the VIP were estimated at 1.5×10^{-4} using a groundwater input to the J&E model (9.3×10^{-6} using a soil input) and 1.8 (1.1),

respectively. PCE followed by TCE were the primary contaminants contributing to both cancer risk and the HI. The carcinogenic risk and non-cancer HI under an industrial scenario via the VIP were estimated at 6.4×10^{-6} using a groundwater input (3.3×10^{-7} using a soil input) and < 1, respectively.

3.5.2 SUMMARY OF ECOLOGICAL RISK ASSESSMENTS

A 3-step ERA was performed to evaluate the potential risk, if any, to environmental receptors associated with chemicals detected in soil and groundwater during the RI. In the first step of the ERA, a pre-scoping ERA was performed for OU4 (USGS 2004b) and OU9 (USGS 2004c) sites to identify whether habitat was present. For the second part of the ERA, based on the results of the pre-scoping ERP, sites were recommended for SERA. The primary goal of the SERAs for OU4 and OU9 (USGS 2004d and 2004a, respectively) was to identify complete or potentially complete pathways existing between site-related contaminants and potential ecological receptors. Finally, PERAs for OU4 and OU9 (Tetra Tech 2004 and 2005) were performed for sites advancing beyond the SERA stage. The PERA documents combine site-specific data from applicable media into plant and animal exposure models that quantify the potential risk to representative ecological receptor groups.

A validation study (USGS 2002) was completed at Site 25 (in OU8) on Main Base and Sites 37 and 133 at the AFRL. The validation study evaluated potential effects of TCE, PCE, and associated breakdown products of these chemicals on the health and dynamics of small mammal and reptile populations. Results of the validation study showed very low concentrations of the chlorinated solvent chemicals in soil gas samples from artificial burrows installed above relatively high concentrations in groundwater at these sites; and concluded that there were no observable adverse impacts on small mammal and reptile populations.

Some potential risks to wildlife were identified in the OU4 PERA for Sites 37, 133, and 120 due to inorganic elements in soil detected at concentrations exceeding upper limits on background established for the AFRL; however after evaluating the distribution and magnitude of these detections at each site, and taking into consideration that there is no evidence of their release as part of site activities, the USAF, USEPA, and State regulators agreed that the elevated concentrations of these inorganic elements likely do not indicate a release but rather represent the high end of concentrations that are naturally

occurring. Site 321 did not advance to the OU9 PERA because no complete exposure pathways to ecological receptors were identified.

3.5.3 DETERMINATION OF RISK BASIS FOR REMEDIAL ACTION AT THE SOUTH AFRL

Based on the risk summaries presented in Sections 3.5.1 and 3.5.2, the ROD Section 2.7.3 presented the following determination of risk basis for taking remedial action at Sites 37, 133, 120, and 321 in the South AFRL.

3.5.3.1 Soil

Based on results of HHRAs and ERAs, no action is required for soil at Sites 37, 133, 120, and 321 in the South AFRL.

3.5.3.2 Groundwater

Results of the HHRA for Sites 37, 133, 120, and 321 indicate that groundwater at the South AFRL, if it were to be used as a drinking water source (which is not currently the case) would pose unacceptable risk to human health. VOCs and other chemicals (1,4-dioxane, NDMA, perchlorate, and nitrate) identified as contributing to an unacceptable cancer risk or non-cancer HI were identified as COCs as listed in Table 3.5-1. The response action selected for groundwater in the South AFRL ROD is necessary to protect the public health or welfare or the environment from contact with the COCs in groundwater listed in Table 3.5-1, including use of the groundwater as a drinking water supply.

3.5.3.3 Soil Vapor

Results of the risk evaluation presented as Appendix B-1 in the ROD indicate that the vapor-phase COCs listed in Tables 3.1-1 and 3.5-2 pose a potential risk to human receptors via the VIP under the hypothetical future residential and current industrial exposure scenarios, respectively. The response action for soil vapor selected in the South AFRL ROD is necessary to protect the public health or welfare from exposure at unacceptable risk levels to VOCs intruded from subsurface vapors into the indoor air of buildings via the VIP.

3.5.4 CONCEPTUAL SITE MODEL: EVALUATION OF EXPOSURE PATHWAYS

Exposure pathways at Sites 37, 120, 133, and 321 are depicted on Figures 3.5-1, 3.5-2, 3.5-3, and 3.5-4, respectively. These figures have been updated from those presented on ROD Figures 2.5-13 and 2.5-14 to clearly indicate which exposure pathways are retained for a CERCLA response. Footnotes are included for complete and potentially complete pathways to explain (1) why pathways are not addressed as part of the remedial action (RA) because of risk management decisions; or (2) the remedial actions that have been implemented in accordance with the ROD. Groundwater impacts are addressed by the selected remedy that includes a TI waiver with institutional controls (ICs) and LUCs. The South AFRL ROD selected a final remedy of no further action for the soil medium at Sites 37, 133, 120, and 321 based on risk management decisions reached in 2004. In general, the inorganic chemicals identified as present at concentrations within the risk management range for human health or as potentially posing a risk to certain environmental receptors are considered to be naturally occurring and not associated with USAF operations at the site. Following actions to remove solvent and petroleum sources, the 2008 *AFRL Soil and Debris Sites ROD* (USAF 2008) selected no further action for AOCs 170 to 172 at Building 8595 within the Site 37 source area and Sites 26, 150, 153, and 396 in the Site 133 groundwater plume; LUCs and LTM to maintain and monitor the final cover system at Site 13, the AFRL closed landfill, remain in effect (refer to Section 3.4 above). Sampling conducted previous to the ROD confirmed the VIP is complete inside Building 8595 in Site 37; the USAF has been monitoring PCE levels inside this building and will evaluate whether and what further actions are required over the next 5-year period.

4.0 REMEDIAL ACTIONS

This FYR addresses response actions selected and implemented for groundwater and subsurface vapor at Sites 37, 133, 120, and 321 in OU4 and OU9 at the South AFRL, Edwards AFB, CA. As introduced in Section 1.6, OU4 and OU9 are among 10 CERCLA OUs identified at Edwards AFB (OU5 and OU10 have since been merged); and the South AFRL ROD is the first of five RODs (two completed and three planned) to address groundwater and soil contamination in OU4 and OU9 sites. Section 1.6 provides information on the number, description, and status of OUs at Edwards AFB; Figure 1.6-1 shows OU locations. The four groundwater areas in OU4 and OU9 are presented on Figure 1.6-2, and the locations of AFRL soil and debris sites are shown on Figure 1.6-3.

4.1 REMEDY SELECTION

The ROD for the South AFRL was signed on 24 September 2007; and the *South AFRL RAWP* (Sites 37, 120, 133, and 321) Version 1.0, which details actions to be taken to implement the remedy selected in the ROD, was finalized on 27 March 2009. Remedy implementation is discussed in Section 4.4.

4.2 REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) were developed as a result of data collected during the RI (Earth Tech 2005a and 2006a); an evaluation of the technical impracticability (TI) of groundwater restoration and detailed analysis of remedial alternatives presented in the FS (Earth Tech 2005c); and presentation of the USAF's preferred alternative in the Proposed Plan (USAF 2006b). The RAOs were further refined during development of the ROD (USAF 2007).

RAOs for groundwater at the South AFRL were developed based upon CERCLA and NCP requirements, HHRA and ERA findings, ARARs, and site characteristics including an evaluation of the potential for groundwater restoration. Site-specific factors considered in the development of remedial action alternatives include the TI, from an engineering perspective, of restoring the groundwater to drinking water pMCLs or removing dense non-aqueous phase liquid (DNAPL) solvents from fractured granite, and the lack of current or anticipated future use of the groundwater. The FS for the South AFRL (Earth Tech 2005c) explains the basis (as summarized in Section 2.5.8 of the ROD) for a

TI waiver of ARARs within a 16.4-square mile area identified as the South AFRL CZ (refer to Figure 1.0-2), based upon criteria for statutory and regulatory ARARs waivers provided for in CERCLA §121 (d)(4)(C) and NCP §300.430(f)(l)(ii)(C)(3). There is no unacceptable risk to human health or the environment posed by direct contact with soil or groundwater under the current or reasonably anticipated future industrial land use, but due to designation of the groundwater at the South AFRL as a potential drinking water source, a response action is necessary to protect the public health or welfare by preventing future contact with the contaminated groundwater medium including use as a drinking water supply. Also, there are potentially unacceptable risks in localized areas of the South AFRL posed by soil vapor via the VIP into indoor air both for the current industrial and hypothetical future unrestricted land uses.

As presented in the ROD Section 2.8, the primary RAOs for the South AFRL are as follows:

1. Protect human health by preventing (through LUCs) ingestion of groundwater contaminated by COCs (listed in Table 3.5-1) at concentration levels exceeding their respective pMCLs or other RBCGs (for those COCs without pMCLs).

2. Protect human health by preventing (through LUCs and engineering controls) inhalation of vapor-phase COCs in indoor air that pose an unacceptable risk (greater than 1×10^{-6}) under a residential or industrial exposure scenario.

3. Prevent migration outside of the South AFRL CZ boundary of groundwater impacted by COCs at concentration levels exceeding their respective pMCLs or other RBCGs (for those COCs without pMCLs).

4.3 REMEDY DESCRIPTION

4.3.1 SOILS

The selected remedy for soil is No Action.

4.3.2 GROUNDWATER

The selected remedy for groundwater at the South AFRL includes a TI waiver from attaining ARARs, namely the drinking water pMCLs, within a 16.4-square-mile area (named the South AFRL CZ) to a depth of 500 ft bgs; LUCs to prevent exposure to groundwater within this zone; and LTM to confirm

that groundwater impacted by contaminant concentrations above pMCLs or RBCGs (for those chemicals without pMCLs) does not migrate outside the South AFRL CZ (TI waiver zone).

The main remedy components for groundwater, as listed in Section 2.13.2 of the *South AFRL ROD,* are excerpted in Section B.1.1 of Appendix B.1, and paraphrased below:

1. Implement, monitor, maintain, enforce, and report LUCs on groundwater within the South AFRL CZ in accordance with the Base GP. The location of the CZ (and groundwater LUC compliance) boundary, as shown on Figure 1.0-2, was selected with the objective of preventing contaminants from impacting the alluvial aquifer to the west (Lancaster Sub-basin shown on Figure 3.1-2). Details on the groundwater LUCs are provided in Section 4.3.4.

2. Contain impacted groundwater within the South AFRL CZ by natural processes (dilution, dispersion). The strategy and schedule for monitoring hydrogeologic conditions within the CZ is provided in the *South AFRL RAWP* Version 1.0, Section 3.0 and summarized in Section 4.3.5.

3. Demonstrate containment of groundwater impacted by COCs at concentrations above the pMCL (or other RBCGs for chemicals without pMCLs) inside the South AFRL CZ by LTM of the groundwater to track contaminant migration.

4. When triggered by (1) detection of any COC in groundwater samples from sentinel wells outside the CZ or (2) the projected arrival (based on contaminant transport modeling as validated using actual sampling results) of impacted groundwater at the CZ boundary within the next 10 years, take the following actions:

    a. Conduct a technical and economic feasibility analysis (TEFA) as defined in California State Water Board Resolution 92-49, Section III.G; and

    b. Institute active containment measures to ensure that COCs do not migrate outside the CZ.

5. Continue to review and evaluate technologies as part of the FYR and report the results of this evaluation. The required evaluation, as summarized in Section 6.4.2.4, is presented in Appendix A.5 of this report.

4.3.3 SOIL VAPOR

The main remedy components for soil vapor (intrusion into indoor air), as listed in Section 2.13.2 of the *South AFRL ROD,* are excerpted in Section B.1.2 of Appendix B.1, and paraphrased below:

1. Implement, monitor, maintain, enforce, and report LUCs on soil vapor intrusion into indoor air within the VICB (refer to Figure 1.0-3). Details on soil vapor LUCs are provided in Section 4.3.4.

2. Monitor and map groundwater plume migration to assess the need to update the VICB boundary (i.e., VOC concentrations in groundwater that exceed GWVCLs-res and GWVCLs-ind, respectively, as listed in Tables 3.1-1 and 3.1-2).

3. Incorporate engineering controls to reduce risk via the VIP to less than 1×10^{-6} for industrial use into all new construction within the VICB. These controls may include, but are not limited to, actions such as sub-slab depressurization (SSD); installation of vapor barriers; foundation ventilation systems; and design of heating, ventilation, and air conditioning (HVAC) systems.

4. Conduct a sampling program (that may include soil vapor sampling adjacent to and/or beneath buildings) to assess whether the VIP is complete at existing buildings where groundwater contains chemical concentrations in excess of the GWVCLs-ind for Sites 37, 120, 133, and 321 (refer to green outlines on Figure 1.0-3). If a completed pathway is confirmed, periodically monitor indoor air for COCs in those existing buildings where groundwater contaminant concentrations exceed GWVCLs-ind. If measured indoor air COC concentrations exceed the risk-based IAVMLs-ind (listed in Table 3.5-2), activate appropriate mitigation measures (these may include, but are not limited to, actions such as continued monitoring, SVE, building controls such as sub-slab depressurization or HVAC modifications, or foundation repairs or ventilation). The strategy for implementing post-ROD VIP monitoring is provided in the *South AFRL RAWP* Version 1.0, Section 4.0 and summarized in Section 4.3.6 below.

4.3.4 LAND USE CONTROLS

The *South AFRL RAWP* Version 1.0 (Earth Tech 2009a), Section 2.0, details actions to be taken to implement LUCs inside the South AFRL CZ; the following sections explain how these actions have been implemented.

4.3.4.1 Base-Level Administration and Implementation of LUCs

The Base GP (USAF 2011b) provides a general explanation regarding the purpose of LUCs, and directs readers to the GIS database for the specific LUC language.

The primary mechanism for LUC implementation is documentation of all LUCs recorded in CERCLA RODs in the Edwards AFB GIS database by EM; and evaluation of the need for restrictions on an activity during review of required forms. Until a site is cleaned up to levels appropriate for UU/UE, the GIS database will reflect the restrictions on development and land use. The GIS database, which is

available to any Base worker with access to the USAF intranet, is required to be reviewed as part of the Environmental Impact Analysis (Air Force [AF] IMT 813) permit approval process. It provides links or references to LUCs selected as part of CERCLA RODs, GIS-based maps, and associated databases for all sites and groundwater contaminant plumes where LUCs are in effect.

The need for restrictions on an activity is evaluated primarily by EM (412 TW/CEV) during the permit process initiated by one or more of the following forms:

- Base Civil Engineer Work Request (AF IMT 332) – required for all construction
- Edwards AFB Civil Engineering Work Clearance Request (also referred to as a digging permit) (Air Force Flight Test Center [AFFTC] IMT 5296 [former name is Form 103]) – required for any intrusive work or compaction that has the potential to impact underground utilities
- Requests for Environmental Impact Analysis (AF IMT 813) – required for large or complex projects and any projects that may have impact to the environment of the health of workers.

While all three permit processes require review by EM, the work request (AF IMT 332) and digging permit (AFFTC IMT 5926) forms are approved by Base CE. EM completes Environmental Impact Analyses (AF IMT 813) for projects with the potential for impact to human health or the environment; such projects would include the construction of new buildings and installation of groundwater production wells. The AF IMT 813 form requires a description of the work being accomplished, a justification for the work, and a checklist for implementation of the work. The checklist documents conformance with all existing Federal, State, and local laws, permits, and licenses (where applicable); codes and board orders; and AFFTC plans and policies established by applicable Air Force Instructions (AFIs). The EM (412 TW/CEV) review includes an evaluation of the activity's purpose, location (footprint), and duration; and whether (based on location and medium intercepted) any LUCs apply to the activity. After the applicability of a LUC is established, the 412 TW/CEV will take the following steps to enforce the LUC:

1. Specify restrictions and compatibility. If the activity cannot be made to conform to the requirements of applicable LUCs, the activity will be prohibited.
2. Specify organizational responsibilities. Depending on the complexity and duration of the project, multiple organizations may have roles in LUCs implementation.

3. Specify inspection/monitoring requirements.

4. Documentation. Copies of submitted and approved forms and requirement checklists will be kept in the Environmental Impact Analysis Process (EIAP) files.

5. Institute a process for modifications. The requesting group is required to submit an amendment to the AFFTC Form 5926 or AF Form 332 if a proposed change in the activity would alter the applicability of the LUCs. A listing of the changed conditions should be attached to a copy of the original form. Similarly, a change in site conditions as a result of remedial action would trigger modifications to the Requirements Checklist initiated by EM.

4.3.4.2 Implementation Measures Common to All CERCLA Remedies Requiring LUCs

The RAWP Section 2.2 lists 10 measures that the USAF has agreed to implement at all sites and OUs on Edwards AFB where the selected CERCLA remedy requires LUCs. Among these, Items 3 through 8 concern notifications in the event of property transfer or changes in land use or activities inconsistent with LUC objectives or use restrictions (there has been no transfer of property or change in land use or activities at the South AFRL CZ since the ROD was signed in September 2007); and Items 9 and 10 concern requirements for annual monitoring and reporting (these are addressed in Section 4.5.1). Items 1 and 2 listed below (with updates as applicable to reflect implementation via the Base GIS rather than Base GP) are addressed in Section 4.3.4.1:

1. Include in the Base GIS a link to CERCLA RODs containing specific restrictions required at each site, a statement that restrictions are required because of the presence of hazardous substances, pollutants or contaminants; the current land users and uses of the site; the geographic control boundaries; and the objectives of the land use restrictions. Unless a site is cleaned up to levels appropriate for UU/UE, the Base GIS will reflect the prohibitions on residential development (including child development centers, kindergarten through 12th grade schools [K-12], play areas and hospitals). Upon completion of a remedial action at a site, the Base GIS will be updated to modify the site-specific use restrictions as appropriate. The section describing the specific restrictions will also refer the reader to the Base Environmental Management (412 TW/CEV) office if more information is needed. The Base GIS will contain links to generate maps depicting the geographic boundaries where LUCs are in effect. Workers will obtain coordinates from the Base GIS in UTM format (refer to Section 3.1.1.1) to locate the LUC boundaries in the field using handheld GPS receivers.

2. While LUCs are in place, maintain administrative control of the integrity of current and future remedial or monitoring systems. LUCs shall remain in place as long as contaminant concentrations remain above levels allowing for UU/UE. The USAF shall not modify or terminate LUCs, implementation actions, or modify land use without USEPA and State approval. The USAF shall seek prior concurrence before any anticipated action that may

disrupt the effectiveness of the LUCs or any action that may alter or negate the need for LUCs.

4.3.4.3 Geographic Control Boundaries of the South AFRL CZ

LUCs in the South AFRL may be applicable to the entire CZ or portions thereof. Groundwater LUCs are implemented within the entire CZ boundary whereas LUCs designed to prevent exposure to chemicals presenting risks via the VIP into indoor air are implemented only within the VICB.

The geographic control boundaries for the South AFRL CZ (groundwater compliance) and VICB (VIP compliance) are shown on Figures 1.0-2 and 1.0-3 and discussed in Sections 3.1.1.1 and 3.1.1.2. The shape files providing the spatial outline of the VICB, and the outline for areas overlying groundwater concentrations exceeding the GWVCLs-ind (listed in Table 3.1-2), were entered into the GIS database (see examples of the screen views in Appendix B.2), and LUCs listed in Section 4.3.4.5 are tied to these VICB and GWVCLs-ind outlines.

Future changes to any component of the South AFRL CZ, such as revisions to the area encompassed by the VICB or the GWVCLs-ind, must be incorporated into the GIS database.

4.3.4.4 Groundwater LUCs

The remedy selected for groundwater in the South AFRL requires long-term LUCs to be in place where contaminant levels do not allow for UU/UE. These LUCs are intended to prevent exposures to extracted groundwater at concentrations of COCs (listed in Table 3.5-1) that exceed pMCLs or RBCGs (for chemicals that lack pMCLs). Pursuant to Section 2.4 in the *South AFRL RAWP* Version 1.0, the Edwards AFB GIS database should link the following language to the area bounded by the South AFRL CZ:

- Restrictions are required inside the South AFRL CZ because chemical contaminants are present in the groundwater at concentrations above drinking water standards. Groundwater within the South AFRL CZ will not be remediated because it is not feasible to achieve drinking water standards in the fractured granitic bedrock; therefore, the USEPA has granted a TI waiver of cleanup standards within the South AFRL CZ.
- The Base GP (USAF 2011b) designates current and planned future land uses within the South AFRL CZ (including a portion of the AFRL and a portion of the PIRA) as rocket testing, research and development, industrial, and administrative (refer to Section 3.2).

Current land users are Air Force and civilian workers; there are no residential land uses within the South AFRL CZ.

- The geographic control boundaries are the nine CZ boundary coordinates listed in the GIS database (shown on Figure 2.1-2 in the *South AFRL ROD*, Figure 1.0-1 in the *South AFRL RAWP* and Figure 1.0-2 in this FYR Report). These coordinates are to be used in conjunction with hand-held GPS receivers in the field to determine whether activities fall within the CZ boundary.

- The objectives of the LUCs are to: (1) prevent exposures to groundwater underlying the South AFRL CZ; (2) prevent existing ERP wells from providing a conduit for further contamination of the groundwater; (3) maintain access to future and existing monitoring wells for LTM and routine maintenance; and (4) protect the integrity of existing or future remedy infrastructures and minimize the occurrence of accidental spills.

- The duration of these LUCs is indefinite but anticipated to exceed 100 years (LUCs shall remain in effect for as long as the TI waiver applies inside the South AFRL CZ).

The LUCs corresponding to each LUC objective are summarized in Table 2.4-1 in the *South AFRL RAWP* (included as Table 4.3-1 in this report) with details provided in the RAWP Version 1.0 Sections 2.4.1 through 2.4.4; these sections have been cloned into Section B.1.3 in Appendix B.1 of this report.

4.3.4.5 LUCs on Buildings within South AFRL VICB

LUCs designed to protect potential receptors at the South AFRL from unacceptable risk by exposure to chemicals in indoor air are of the following two types:

1. New construction: Prohibitions and/or restrictions to prevent unrestricted (residential) land use of areas where groundwater concentrations of COCs exceed the GWVCLs-res listed in Table 2.13-1 of the *South AFRL ROD* (Table 1.6-1 in the *South AFRL RAWP* Version 1.0, and Table 3.1-1 in this report), which are modeled to present an unacceptable cancer risk (greater than 1×10^{-6}) via the VIP into indoor air for residential use. The area requiring these more restrictive LUCs is shown as the VICB on Figure 2.7-1 in the *South AFRL ROD* (Figure 1.6-1 in the *South AFRL RAWP*, and Figure 1.0-3 in this report). Any new buildings and any significant additions to or renovations of existing structures constructed within the VICB must incorporate engineering controls (discussed in Section 2.5.3 of the *South AFRL RAWP* as included in Appendix B.1.4 of this report) to reduce risk via the VIP to less than 1×10^{-6} for the intended land use (residential or industrial).

2. Existing occupied buildings: Initiation of a monitoring program (described in Section 4 of the *South AFRL RAWP* Version 1.0 as summarized in Section 4.3.5 of this FYR report) in areas where groundwater concentrations of COCs exceed the GWVCLs-ind listed in

Table 2.13-2 of the *South AFRL ROD* (Table 1.6-2 in the *South AFRL RAWP*, and Table 3.1-2 in this report), which are modeled to present an unacceptable cancer risk (greater than 1 x 10^{-6}) via the VIP into indoor air for industrial use. The areas currently exceeding GWVCLs-ind are shown in orange on Figure 2.7-1 in the *South AFRL ROD* (Figure 1.6-1 in the *South AFRL RAWP*, and in green on Figure 1.0-3 in this report). Where a completed pathway is confirmed, and if measured indoor air concentrations of COCs exceed the risk-based IAVMLs-ind listed in Table 2.13-3 of the *South AFRL ROD* (Table 1.6-3 in the *South AFRL RAWP*, and Table 3.5-2 in this report), activate appropriate mitigation measures (as presented in Section 2.5.3 of the *South AFRL RAWP* [Section B.1.4 in Appendix B.1 of this report]).

The objectives of the LUCs are to: (1) restrict sensitive uses (including residential building, child development centers [day care facilities], K-12 schools, play areas, and hospitals) where contamination is at levels that do not allow for UU/UE; (2) assess worker safety in existing buildings where there is a potential for unacceptable risk by exposure to indoor air under an industrial scenario; (3) disrupt the VIP (a) in existing buildings inside the VICB where indoor air concentrations indicate an unacceptable risk to workers and (b) in future buildings that may be constructed inside the VICB; and (4) revise the VICB periodically to maintain protectiveness as groundwater contaminant plumes continue to expand inside the South AFRL CZ. The duration of the LUCs inside the VICB will extend until vapor concentrations reach acceptable levels for UU/UE.

The LUCs corresponding to each LUC objective are summarized in Table 2.5-1 in the South AFRL *RAWP* (included as Table 4.3-2 in this report) with details provided in RAWP Sections 2.5.1 through 2.5.4; these sections have been cloned into Appendix B.1.4 of this report.

4.3.4.6 LUCs Reporting Requirements

Section 2.6 of the *South AFRL RAWP* requires the USAF to timely submit to the USEPA and the State, an annual monitoring report on the status of LUCs and how any LUC deficiencies or inconsistent uses have been addressed. As described in Section 4.5.1, Appendix B.4 includes letters submitted annually by the USAF to USEPA Region 9 that meet these reporting requirements.

4.3.5 GROUNDWATER MONITORING

The *South AFRL RAWP* Version 1.0 (Earth Tech 2009a), Section 3.0 presents the plan for LTM of the groundwater to track contaminant migration and validate/refine the groundwater flow and transport models.

4.3.5.1 Objectives of the LTM Program

As presented in Section 3.0 of RAWP Version 1.0, objectives of the LTM program are to demonstrate containment and allow an evaluation of the continuing protectiveness of the remedy during FYRs. The strategy presented in RAWP Section 3.1 was designed to satisfy the following specific components of the selected remedy for groundwater and/or soil vapor:

- Demonstrate containment (inside the South AFRL CZ) of groundwater impacted by COCs at concentrations above the pMCL; or above the RBCG for perchlorate, 1,4-dioxane, and NDMA, which did not have pMCLs at the time the ROD was signed. Note that CA adopted a pMCL for perchlorate in October 2007; the impact of this change to protectiveness of the remedy is evaluated in Section 7.2.2.

- Assess hydrogeologic conditions within the CZ to provide greater confidence in the distribution of groundwater contaminants and to evaluate the plumes' actual behavior against the site conceptual and computer groundwater models. As appropriate, use monitoring data to update and refine groundwater flow and contaminant transport models, which (based on the 2005 flow and transport model) project containment within the South AFRL CZ for at least 1,000 years.

- Monitor and map groundwater plume migration for those plume contours that are at contaminant concentrations that present a potential cancer risk exceeding 1×10^{-6} in indoor air, via the modeled VIP for residential use and industrial use scenarios. These concentrations are termed GWVCLs-res and GWVCLs-ind and presented in Tables 3.1-1 and 3.1-2, respectively.

4.3.5.2 Strategy to Meet LTM Objectives

As presented in the RAWP Version 1.0 Section 3.2, the strategy for attaining the LTM objectives progresses from a detailed plan in the short-term (2008 through the first FYR to be completed by 24 September 2012), through an outline of activities to be accomplished in the mid-term (to approximately the mid-21st century), and finally a highly conceptualized plan for the long-term (extending 30-40 years from the date of the plan in 2009). The short-to-midterm strategy, as summarized in Steps 1 through 7 below, was designed to:

1. Determine the locations of the PCE and TCE plumes' leading edges (both at the 1-μg/L RL and the 5-μg/L pMCL). The focus of this evaluation is on the leading edges of those plumes with the projected potential to eventually reach the CZ boundary, i.e., the Site 37 plume at its western extent and the Site 133 TCE plume at its southern extent (refer to maximum projected extent of the combined PCE and TCE plumes shown in red on Figure 1.0-2).

2. Assess whether transport velocity near the plumes' leading edges can be estimated.

3. Confirm that contaminants migrating at the plume fronts are transported more rapidly in the first water-bearing zone than at depth (i.e., COCs are not detected in vertical extent wells at the plumes' leading edges).

4. Assess concentrations in selected wells (inside and outside the plumes' current extent) at a sufficient frequency (annually to biennially in the short-term) to allow early detection of contaminants migrating more rapidly or in a different direction than anticipated. The initial list of wells to be sampled on an annual to biennial basis was presented in Table 3.3-2 of the *South AFRL RAWP* (included as Table A.3-1 in Appendix A.3).

5. Assess plume distributions at a sufficient frequency (comprehensive plume sampling at least once in 5 years) to:

    a. Support validation of the contaminant transport model;

    b. Update plume distribution contours and evaluate whether changes are required in the VICB.

6. In an iterative process, select locations and install "interim sentinel" (IS) wells projected to detect COCs within some acceptable timeframe (a 30-year period is proposed in the RAWP Version 1.0). An IS well is a well located down gradient and outside the current plume extent, but within the expected path of future contaminant migration. Note that the 500- to 1,000-foot linear distances between wells proposed in RAWP Version 1.0 for monitoring of plume migration does not imply a definitive distance at which flow can be effectively monitored as isotropic (where hydraulic gradient is the predominant factor affecting flow direction) rather than anisotropic (influenced predominantly by secondary porosity and fracture orientation). Rather, an initial 500-foot well spacing near the toe of the plume was proposed for primary IS wells as implementable within a time frame (15 to 30 years) and cost deemed reasonable to provide a rough estimate of advection rates for refining the CSM and validation of the groundwater model. Thereafter, a 1,000-foot spacing (or travel time of 30 years) between secondary and tertiary IS wells was proposed as adequate for the continued tracking of plume movement, with the planned spacing for wells to be installed in out-years to be refined based on accumulated information obtained in the interim.

    a. Primary IS wells (three each) are to be installed within 500 ft down gradient from, and outside, the leading edge of (1) the Site 37 PCE plume at its western extent; and (2) the Site 133 TCE plume at its southern extent. The primary IS wells are to be sampled annually to biennially until PCE or TCE is detected at a concentration above the RL (and confirmed the following year). Confirmation of the detection will trigger installation of at least three secondary IS wells.

    b. Secondary IS wells (at least three) are to be installed another 1,000 ft down gradient of the primary IS well with a confirmed detection, and within the direct flow path of contaminant migration. Secondary IS wells will be sampled biennially. The detection (and subsequent confirmation) of a COC in a secondary IS well will allow an estimate

of the transport velocity (distance between the secondary IS well and primary IS well divided by the years lapsed between detection in the secondary versus the primary IS wells), and will trigger installation of at least three tertiary IS wells.

c. Tertiary IS wells were intended to be located at a distance projected to monitor the plume's migration in 30 years. The tertiary IS wells would be sampled periodically (not less frequently than each 5 years); by design, results from these wells are anticipated to be non-detect for approximately 30 years.

7. Continuously optimize the LTM strategy, and identify wells for re-development, replacement, and/or destruction.

4.3.5.3 Plan for the First 10 Years of LTM – Fieldwork

The *South AFRL RAWP* Version 1.0 Section 3.3 listed the following as specific field tasks to be conducted prior to the first FYR in 2012:

1. Continue to measure groundwater levels at least annually to aid in validating the groundwater flow model.

2. Update the plume distributions of COCs using data obtained from sampling a large number of wells in 2008 (baseline plume monitoring event for recalibration of contaminant transport model) and again in 2011 (initial validation of updated transport model).

3. Refine the estimated location of the plumes' leading edges by installing and sampling new monitoring wells.

4. Assess vertical extent of groundwater impact at the toe of the Sites 37 and 133 contaminant plumes.

The rationale and proposed locations for 11 wells (as presented in Table 3.3-1 and on Figures 3.3-1 and 3.3-2 in the *South AFRL RAWP*) are included in Table A.3-2 and on Figures A.3-1 and A.3-2 in Appendix A.3 of this report. Field tasks to be continued into the second FYR period (i.e., between 2012 and 2017) include:

1. Sampling a small number of wells inside and outside the plumes' leading edges annually to demonstrate containment and assess transport velocity (if VOCs are detected in any primary IS well).

2. Installing secondary IS wells when triggered; and

3. Conducting a third plume monitoring event in 2015 to allow further validation of the contaminant transport model 2 years prior to the second statutory FYR (in 2017).

4.3.5.4 Groundwater Contaminant Transport Model Validation

The South AFRL RAWP Version 1.0 Section 3.4 describes how simulated distributions of PCE and TCE contaminants based on the 2005 groundwater flow and transport models will be updated to incorporate 2008 sampling results; and steps to validate the flow and transport models for future FYRs. A revised *2012 South AFRL Groundwater Modeling Report* (AECOM 2012b) was developed and submitted as a draft to the RPMs in June 2012.

4.3.5.5 Inspection and Optimization of Plume Monitoring Network and Frequency

The South AFRL RAWP Version 1.0 Section 3.5 includes the strategy for inspection, maintenance, and optimization of the plume monitoring network. The condition of each monitoring well is to be assessed and documented during water level monitoring, and no less frequently than biennially. Each well will be inspected to evaluate the integrity of its monument, padlock, and well casing. Surface conditions surrounding well monuments with concrete pads will be inspected for surface erosion, and subsurface conditions within the well bore (depth to water, or whether the well is dry) will be noted. Wells are to be renovated or replaced as needed. Optimization will include consideration of a well's (1) functionality (i.e., identifying damaged wells or wells that are dry for potential destruction); (2) location (i.e., evaluating the relevancy of sampling a given well in meeting the LTM objectives and strategy); (3) and redundancy (i.e., does another well in the LTM program provide essentially the same information toward a decision output). Optimization of the frequency of sampling will be based on trends identified in previous sampling events and evaluation of what data are needed to enhance the understanding of contaminant transport.

As summarized in Section 4.5.2.3, observations made during well inspections are documented in Appendices B.5 and B.6, with a summary for wells that potentially require repairs provided in Table 4.5-3.

4.3.5.6 Additional Components of the South AFRL Groundwater Remedy

As a component of the groundwater remedy selected in the ROD (refer to Section B.1.1 of Appendix B.1), the USAF is required to undertake additional field investigations to assess hydrogeologic conditions within the South AFRL CZ. These investigations may include, but are not limited to, subsurface geophysical surveys, aquifer pumping tests, and/or installation of additional

monitoring wells to evaluate the nature and location of the alluvial aquifer/fractured bedrock interface at the CZ boundary. As indicated in Section 3.6 of the *South AFRL RAWP* Version 1.0, these types of investigation are perceived as less time-critical than delineation of the plumes' leading edges and validating transport velocity at the plume fronts. The *South AFRL RAWP* Section 3.6.1 includes a conceptual plan to better delineate this zone; however, it was anticipated that this type of hydrogeologic investigation would not be undertaken in the near-term, but rather after PCE or TCE was detected in one or more of the secondary IS wells (defined in Section 4.3.5.2, Item 6-b), by design, within approximately 15 years to 30 years following installation of these wells.

The triggers for instituting containment measures and conducting a TEFA (the detection of a COC in groundwater samples from sentinel wells outside the CZ or the projected arrival of impacted groundwater at the CZ boundary within the next 10 years) are not anticipated to be fulfilled in the near-term; therefore, details on conducting the TEFA and instituting containment measures were not provided in the South AFRL RAWP Version 1.0. As mentioned previously, Section 6.4.2.4 (and Appendix A.5) in this FYR address the groundwater remedy component that requires continuing review and evaluation of technologies to effectively treat similar chemicals at similar concentrations in a similar hydrogeologic setting.

4.3.5.7 LTM Reporting Requirements

Pursuant to Section 2.13.2.2 in the South AFRL ROD, "Periodic monitoring reports providing the results of LTM will be prepared and submitted to USEPA and the State. These monitoring reports will be filed in the information repositories for the South AFRL and used in preparation of the FYR to evaluate the effectiveness of the remedy." Section 3.7 of the *South AFRL RAWP* Version 1.0 describes the planned format for reporting on comprehensive plume monitoring events and groundwater model validation; annual to biennial reports on LTM conducted at the plumes' leading edges; the draft and final interim remedial action report (I-RAR); and documentation of updates and/or revisions to the LTM strategy.

4.3.6 VAPOR INTRUSION MONITORING

The *South AFRL RAWP* Version 1.0 (Earth Tech 2009a), Section 4.3 presented the plan to fulfill the final remedy component addressing soil vapor (refer to Section 4.3.3, Item 4). The stated objectives of

the vapor monitoring program were to: (1) validate the GWVCLs-ind (listed in Table 3.1-2) by evaluating chemical concentrations in soil vapor overlying groundwater inside the GWVCLs-ind boundary depicted on Figure 1.0-3; and (2) assess whether the VIP is complete in existing occupied buildings. Because the AFRL is currently used only for industrial purposes, this investigation was conducted only in the vicinity of occupied industrial buildings overlying the GWVCLs-ind; these buildings, located at Site 37 and Site 133, are listed in the top half of Table 4.3-3. Existing structures within the GWVCLs-ind that are not occupied, and not designed for occupancy (including structures at Sites 120 and 321), are identified in the bottom half of the table; no sampling was conducted at these structures.

4.3.6.1 Rationale and Plan for VIP Monitoring Inside Building 8595

As presented in the *South AFRL RAWP* Version 1.0 Section 4.3.1, the objectives for VIP monitoring in the vicinity of Building 8595 include:

- Evaluate the effectiveness of continued SVE operation to reduce vapor intrusion into Building 8595 to below an indoor air risk of 1×10^{-6} for industrial use.
- If warranted, evaluate the feasibility of alternate mitigation measures (e.g., changes to the building ventilation and/or installation of an SSD) to reduce vapor intrusion into Building 8595 to below an indoor air risk of 1×10^{-6} for industrial use.

The RAWP called for the installation and sampling of four sub-slab vapor wells (37-8595SS01 through 37-8595SS04), two in the original cinderblock portion of the building (constructed in 1960) and two in the western, metal portion of the building (which was added in 1963), and collection of indoor air samples (37-8595IA01 through 37-8595IA04) at these same locations. Samples were to be collected when the SVE system was operating, and 3 months after the SVE system was taken off line.

4.3.6.2 Rationale and Plan for VIP Monitoring at Occupied Buildings Overlying Groundwater Contaminant Plumes at Sites 37 and 133

As presented in the *South AFRL RAWP* Version 1.0 Section 4.3.2, activities to evaluate the VIP in the vicinity of occupied buildings (other than Building 8595) were to be conducted in two phases. In Phase I, near-slab vapor monitoring wells would be installed adjacent to each building to evaluate if soil vapor concentrations of PCE or TCE exceeded soil gas screening numbers (SNs) presented in Table 4.3-4; these SNs were calculated by dividing the IAVMLs-ind (listed in Table 3.5-2) by an

attenuation factor of 0.001. The details and objectives for Phase II (to be conducted inside buildings where near-slab vapor concentrations measured during Phase I exceeded the SNs) were to:

- Evaluate whether sub-slab vapor concentrations beneath occupied buildings within the GWVCLs-ind for Sites 37 and 133 indicate a potential risk to indoor air.
- Collect and analyze indoor air samples inside buildings where near-slab vapor samples exceeded the SNs and evaluate whether concentrations exceed IAVMLs-ind.
- Based on the results from sub-slab and indoor air samples, evaluate whether the GWVCLs for the South AFRL should be recalculated to better predict actual indoor air risk from groundwater concentrations of VOCs.

For Phase I of the investigation, the RAWP called for the installation and sampling of 40 vapor monitoring probes, 19 at Site 37 and 21 at Site 133, with most to be installed as close as feasible to foundations of the occupied buildings listed in Table 4.3-3. Based on results from the Phase I near-slab wells, sub-slab wells were to be installed inside all buildings where near-slab soil gas concentrations exceeded the SNs listed in Table 4.3-4. Sub-slab and indoor air samples would be collected during two rounds of sampling.

4.3.6.3 Reporting Requirements

Pursuant to Section 4.3.2.9 of the *South AFRL RAWP* Version 1.0, the USAF was to prepare a report presenting results of the VIP monitoring program along with any proposed mitigation measures to reduce the indoor air concentrations to levels below the IAVMLs-ind. The *South AFRL Post-ROD Monitoring for Vapor Intrusion* (*South AFRL VI Report)* (AECOM 2012c), considered an important feeder document for the first FYR, was revised pursuant to regulatory input for finalization in August 2012.

4.4 REMEDY IMPLEMENTATION

After the South AFRL ROD was signed on 24 September 2007, the USAF contracted AECOM to develop the *South AFRL RAWP* Version 1.0, which was submitted for regulatory agency review as a draft in June 2008, draft-final in October 2008, and final in March 2009. The final RAWP incorporates revisions made in response to review comments from USEPA and the California DTSC on the draft and draft-final versions of the Plan, as documented in the cover letter transmitting the final

South AFRL RAWP Version 1.0 dated 30 March 2009; and responses to comments included in RAWP Appendix K.

4.4.1 IMPLEMENTATION OF LUCS

Section 4.3.4.1 described the Base-level administration and implementation of LUCs. The Edwards AFB EM group initiated linkage of Base permit processes to the GIS-based maps and associated databases in 1999; and since 2000 has required ERP contractors to provide updated geographic coordinates (survey data), field and laboratory data for all sampling locations, and shape files of estimated plume distributions as available (at least annually).

The Base GP (USAF 2011b) includes (as part of its section on the ERP) an explanation of LUCs, and the following statements: "The Edwards AFB GIS is the primary management tool for implementing, documenting, and managing LUCs. Land Use Control maps based on GIS data are available via web browsers that have access to the Air Force Flight Test Center intranet."

The Base GP identifies LUCs as a constraint in Section 4.1.1, lists GIS as the management tool, and requires coordination with the Environmental Management Office for sites with LUCs. In 2008, the geographic control boundaries (as described in Section 4.3.4.3) for the South AFRL CZ and VICB were entered into the GIS database with links to the *South AFRL ROD*.

4.4.2 IMPLEMENTATION OF GROUNDWATER LTM

To implement the short-term LTM strategy as described in Section 4.3.5.2, specific well locations were proposed in Table 3.3-1 in the RAWP (refer to Table A.3-2) and in the *2010 South AFRL Well Installation Work Plan* (2010 WIWP) (Eco & Associates 2010), with updates as documented in Appendix A of the *South AFRL Well Installation Report for 2010 and 2011* (2010/2011 WIR) (Eco & Associates 2012). Between February and July 2009, nine groundwater monitoring wells were installed as documented in the *South AFRL I-RAR* (AECOM 2009a). Upon approval of this report, USEPA on 26 October 2009 issued a letter (included in Appendix B.3) that states: "EPA Region 9 uses this letter to verify the completion of the RA phase of CERCLA as tracked in our CERCLIS database under Operable Unit 4 for Edwards AFB NPL Site. EPA now considers this Operable Unit to be in the Operation and Maintenance Phase."

Another 10 groundwater monitoring wells were installed between March 2010 and March 2011 as documented in the *2010/2011 WIR* (Eco & Associates 2012). Locations of the 19 monitoring wells are shown in red on Figures 4.4-1 and 4.4-2; and wells are identified in bold font in Table A.2-1, which lists construction specifications for all wells considered part of the South AFRL groundwater monitoring well network. The specific rationale and initial sampling results for each well are summarized in Table 4.4-1; borehole logs and well construction diagrams were provided in Appendix B of the South AFRL I-RAR or 2010/2011 WIR.

Sampling conducted as part of groundwater LTM (and a discussion of groundwater monitoring planned but not accomplished) is summarized in Section 4.5.2; with results evaluated in Section 6.4.2.

4.4.3 IMPLEMENTATION OF POST-ROD VIP MONITORING

As documented in the *South AFRL I-RAR* (AECOM 2009a) (Section 2 Chronology of Events), activities accomplished in March 2009 included the completion of initial surveys for buildings inside the VICB; and the installation and sampling of 46 near-slab vapor probes and 10 sub-slab vapor monitoring wells. Sampling conducted as part of VIP monitoring is summarized in Section 4.5.3.

4.5 OPERATION AND MAINTENANCE

The selected remedy includes the following operation and maintenance (O&M) tasks: maintaining LUCs, fulfilling the requirements of groundwater LTM, and post-ROD VIP monitoring. The relevant details of these activities are presented in the following sections.

4.5.1 MAINTENANCE OF LUCS

The ROD selected LUCs as remedy component 1 for each of the groundwater and soil vapor media (refer to Item 1 in Sections 4.3.2 and 4.3.3). LUCs implemented as documented in Section 4.4.1 are monitored and maintained by Edwards AFB EM (412 TW/CEVR).

Appendix B.4 includes letters submitted by the USAF to USEPA Region 9 that provide performance information for the following periods:

- 25 September 2010 through 24 September 2011 (letter dated 5 March 2012)

- 25 September 2009 through 24 September 2010 (letter dated 2 March 2011)
- 25 September 2008 through 24 September 2009 (letter dated 26 February 2010)
- 24 September 2007 through 24 September 2008 (letter dated 1 May 2009)

The letters (courtesy copies of which were also sent to DTSC and the Water Board) constitute the annual monitoring reports required by the ROD. In addition to confirming the ongoing Base-level administration and implementation of LUCs, the reports provide a status of remedial actions at the South AFRL, including activities performed for groundwater LTM and VIP monitoring.

4.5.2 GROUNDWATER LTM

The *South AFRL RAWP* Version 1.0 Section 3.0 details the LTM plan for groundwater as summarized in Section 4.3.5 of this report. The following sections summarize LTM activities and performance to date; status of flow and transport modeling; inspection/optimization of well field; remedy components beyond LTM; reporting; problems encountered; and costs (original estimates and actual annual costs for fiscal years [FYs] 2008 through 2011).

4.5.2.1 LTM Activities and Performance to Date

Consistent with the objectives listed in Section 4.3.5.1 and the strategy presented in Section 4.3.5.2, LTM activities between October 2007 and December 2011 (summarized in Table 4.5-1) were conducted to achieve the plan (presented in Section 4.3.5.3) for the first 5 years of fieldwork as follows:

1. Semiannual to annual water level measurements in all South AFRL monitoring wells. Water levels were measured semiannually (in April and October of each year) between October 2007 and October 2011 in 177 to 199 groundwater monitoring wells.

2. Comprehensive plume monitoring events (CPMEs) in 2008 and 2011. In 2008, a total of 111 wells were sampled at Sites 37, 133, and 120 and 11 wells were sampled at Site 321. Results of the CPME in 2008 were summarized for Sites 37, 133, and 120 in the 2008 annual groundwater monitoring report (AGMR)-OU4 (AECOM 2009b) and for Site 321 in the 2008 AGMR-OU9 (JT3/CH2M HILL 2010b). Due to contracting issues, the CPME planned in October 2011 was delayed by 9 months, but was completed in June and July 2012 in accordance with the *2012 Groundwater Monitoring Work Plan for the Northeast AFRL and South AFRL Groundwater Areas* (AECOM 2012d). Although results will not be available in time for inclusion in this FYR, the raw (non-validated) results from

the sampling of 104 monitoring wells will be shared upon request by the regulatory agency RPMs within 60 days of sample collection; and the draft report presenting evaluation of validated results will be distributed within 6 months of completing sampling.

3. Refine the estimated location of the plumes' leading edges by sampling a select number of existing and new monitoring wells. For comparison to Table A.3-1 (which lists the wells designated for annual to biennial sampling in the RAWP), Table 4.5-2 summarizes the sampling completed for existing and new wells at the Sites 37 and 133 plume fronts during biennial to annual groundwater monitoring in 2007, 2009, 2010 and 2011; note that most of these wells (if installed) were also sampled during the 2008 CPME. Section 6.4.2.2, Objective 1 provides an evaluation of progress toward the overall goal of refining the location of the plumes' leading edges.

4. Assess vertical extent of groundwater impact at the toe of the Sites 37 and 133 contaminant plumes. This was accomplished by the installation and sampling of Wells 37-MW45s/d (shallow and deep) and Well 13-MW39, as listed in Table 4.4-1.

Results are evaluated in Section 6.4.2.

4.5.2.2 Status of Flow and Transport Modeling

As part of the FS process, groundwater flow and contaminant transport models (Earth Tech 2005b) were developed for the South AFRL and used to simulate remedial alternatives, including the no active containment alternative in support of the TI waiver determination. Because of its importance in providing support for the "no active containment" remedy selected for the South AFRL, a "key objective" of the LTM program as stated in the *South AFRL RAWP* Version 1.0 Section 3.0 is to refine the contaminant transport model developed during the FS, and evaluate how well the refined model simulates the future migration of plume fronts. Section 3.4 in the RAWP presents a plan for near-term refinement and future validation of groundwater flow and contaminant transport models for the South AFRL.

As part of activities conducted for the first FYR, the USAF contracted AECOM to develop updated flow and transport models for the South AFRL. The five-layer 2012 flow and transport model is meant to supersede the two-layer 2005 groundwater flow and contaminant transport model cited in the ROD; its intended use is limited to providing semi-quantitative predictions regarding the rate and direction of future contaminant migration. As used in this report, "semi-quantitative" means that the predictions derived from the flow and solute transport models are quantitative; however, the reliability of these predictions is limited by the accuracy of the input parameters and the presence of data gaps. The

updated flow and transport models were developed (1) as part of a larger effort to provide a consistent approach for flow and transport modeling at the AFRL; and (2) to incorporate results from monitoring wells installed and sampled since 2003 (the base year for the 2005 model). The 2012 flow model was built using the same flow model domain and assumptions consistent with the flow model developed for the Northeast AFRL (AECOM 2012e). The transport model is calibrated to COC distributions based on sampling results through November 2010, including results from wells installed in 2009 and 2010 as listed in Table 4.4-1.

The *2012 Groundwater Modeling Report for the South AFRL* (AECOM 2012b) was submitted as a draft for regulatory agency review in June 2012. Its take-home point can be summarized as follows. Under the most conservative Scenario 1 (that assumes continuing source concentrations for 1,000 years and no degradation of contaminants outside the source area), the calibrated 2012 flow and transport models yield a predictive simulation for plume movement that shows breach of the CZ boundary within 200 years. It should be emphasized that this outcome, which suggests a faster rate of migration than predictive simulations under the 2005 flow and transport models (that indicate no breach of the CZ boundary within 1,000 years), is the result of different assumptions used to develop the two models, and is not due to any sudden increase in concentration near the plume fronts (although please see Section 6.4.2.2, Objective 1, Item (a) for discussion of unexpectedly high concentrations of TCE near the Site 133 plume front; note that results from Wells 13-MW41 through 13-MW43 were not available at the time the transport model was calibrated). Among the many differences in inputs between the 2005 and 2012 models (including non-unique distributions of K, source conditions, and effective porosity) that likely contribute to these differing outcomes, differences in the applied recharge rates and boundary conditions in the western (downgradient) portion of each model domain may be among the most significant. It should be noted that inputs for recharge rates and boundary conditions in the 2012 flow and transport model were selected for consistency with other recent modeling efforts (at the AFRL on Edwards AFB) and incorporated the inputs based on regulatory agency reviews of Edwards AFB modeling reports. It is also important to take into account that long-term predictions carry a degree of inherent uncertainty regardless of the predictive method or model.

A reviewer with DTSC's Geological Services Unit (GSU) commented on the USAF recommendation (see next paragraph) to de-emphasize groundwater modeling efforts pending the completion of fieldwork in the region southwest of the plumes: "Both the 2005 and 2012 versions of the model were

based on a deterministic approach to directly calculate outputs (heads for flow and concentrations for transport in 3-D), but failed to assess the predictive uncertainties of deterministic models. These uncertainties are mainly associated with modeling conceptualization (hydrogeologic conceptualization to a mathematical model) that determines model structure, spatial and temporal variations in hydrogeologic variables that are either not fully captured by the available data or not fully resolved by the model, and scaling behavior of hydrogeologic variables. Each of the two modeling predictions is, at most, two realizations of many possibilities, and hence is likely to fail to provide reliable prediction of the groundwater flow and contaminant transport behaviors. However, the modeling can provide effective predictions if the deterministic approach is combined with an assessment of predictive uncertainties." While conceding that a stochastic approach may be helpful in determining the uncertainty of the predictions, the USAF prefers to address this issue in response to detailed comments anticipated from GSU on the *2012 Groundwater Modeling Report for the South AFRL.*

As indicated in Section 4.3.5.4, the long-term strategy presented in the RAWP Version 1.0 includes validating model inputs for predictive simulations against sampling data collected during future LTM events. The most recent CPME for the South AFRL was conducted in June through July 2012 (refer to Section 4.5.2.1, Item 2); the draft report of these results is scheduled for distribution to RPMs in January 2013. Based on some of the findings presented in this FYR, the USAF recommends a de-emphasis on the groundwater modeling effort pending the completion of fieldwork to better refine plume extents and obtain hydrogeologic information to the southwest approaching the CZ boundary. The Air Force will document its plans regarding modeling in the future RAWP Version 2.0, the final version of which will incorporate revisions based on RPM review comments.

4.5.2.3 Inspection/Optimization of Well Field

In accordance with RAWP Section 3.5 (as summarized in Section 4.3.5.5), the condition of monitoring wells in the LTM network were inspected semiannually (i.e., each time water levels were measured and recorded), with observations for wells that potentially requiring repair summarized in Table 4.5-3 (see letters listing observations regarding well conditions in Appendix B.5 and results of most recent inspection in Appendix B.6).

4.5.2.4 Remedy Components Beyond LTM

The *South AFRL RAWP* Version 1.0 Section 3.6 provides a conceptual plan to address groundwater Remedy Components 2, 4, and 5 selected in the ROD (refer to Section 4.3.2). As indicated in Section 4.3.5.6, at the time the RAWP was developed in 2009, the additional field investigations required (under Remedy Component 2) to assess hydrogeologic conditions within the South AFRL CZ were perceived as less time-critical than delineation of the plumes' leading edges and validating transport velocity at the plume fronts. Therefore, these types of investigation (i.e., subsurface geophysical surveys, aquifer pumping tests, and/or installation of additional monitoring wells to evaluate the nature and location of the alluvial aquifer/fractured bedrock interface at the CZ boundary) were not conducted prior to this first FYR.

The trigger for actions listed under groundwater Remedy Component 4 (conducting a TEFA and instituting containment measures) is the projected arrival of impacted groundwater at the CZ boundary within the next 10 years, or the detection of any COC in groundwater samples from sentinel wells outside the CZ. These triggers did not occur prior to this FYR.

Groundwater Remedy Component 5 commits the USAF to a continuing review and evaluation of technologies as part of the FYR process; this evaluation is presented in Appendix A.5 and summarized in Section 6.4.2.4 of this FYR.

4.5.2.5 Reporting

As indicated in Section 4.4.2, the fieldwork and results associated with installation and initial sampling of 19 monitoring wells during the post-ROD period are presented in the *South AFRL I-RAR* (AECOM 2009a) or *2010/2011 WIR* (Eco & Associates 2012). Table 4.5-1 lists the AGMRs that report results for groundwater samples collected between October 2007 and December 2010. As indicated in Section 4.5.2.2, the *2012 Groundwater Modeling Report for the South AFRL* (AECOM 2012b) was submitted as a draft for regulatory agency review in June 2012.

4.5.2.6 Problems Encountered

Under the RAWP Version 1.0, a CPME was scheduled to be initiated in October 2011; however, due to contracting delays, this event was postponed until June and July 2012. The multi-month delay is not

expected to adversely affect protectiveness of the remedy; however, regulators have commented that this delay in the CPME (and a delay in development of an updated groundwater flow and transport model) has adversely affected the confidence level associated with the protectiveness statement. No other problems were encountered in conducting groundwater LTM in accordance with RAWP Section 3.0. Data gaps or problems identified based on an evaluation of sampling results are presented in Sections 6.4.2.1 through 6.4.2.3 following the evaluation of groundwater monitoring results in Section 6.4.2.

4.5.2.7 Costs

As presented in Table 4.5-4, actual costs for the first 4 years of groundwater LTM ($1,409,000) were 45 percent higher than the estimate (slightly modified from that developed in the 2005 *South AFRL FS*) in the *South AFRL ROD*. The difference is primarily because the cost estimate did not include costs to install additional monitoring wells (an oversight because the need for such wells was anticipated in the ROD). For the sampling component of the LTM program, the estimated cost over the first 4 years was $968,000, based on an assumption that approximately 36 wells would be sampled annually except during the CPME to be conducted in 2008, when 121 wells would be sampled. By comparison, the actual cost to conduct sampling was $828,000; Table 4.5-5 compares the number of monitoring wells actually sampled per year to the number planned.

Note the reason that actual costs for the sampling component are less than the estimate is because samples were not collected in 2011 at Sites 37, 133, or 120. The cost differences discussed above are considered due to revisions in the remedial approach and schedule, and do not reflect failures or shortcomings of the remedy.

4.5.3 POST-ROD VIP MONITORING

The ROD does not include specific VIP monitoring requirements pending further evaluation of risk under an industrial exposure scenario; therefore, O&M activities discussed in this section focus on the sampling program undertaken between June 2009 and January 2011 to support post-ROD evaluation of the VIP; and operation of the SVE system south of Building 8595 as a temporary mitigation to reduce vapor intrusion into the indoor air.

Sections 4.3.6.1 and 4.3.6.2, respectively, provide the specific objectives for sampling conducted inside Building 8595 (where the VIP was previously confirmed to be complete); and at other occupied buildings overlying the GWVCLs-ind at Sites 37 and 133. Because there are no existing occupied buildings at Sites 120 and 321, VIP monitoring was not conducted in these areas.

4.5.3.1 SVE Operation and Summary of Post-ROD VIP Monitoring for Building 8595

The SVE system at Building 8595 was installed in 2000 as an IRA for PCE-impacted soil underlying a former outdoor waste sump (identified as Site 172) located south of Building 8595. Between April 2000 and September 2007, the SVE system was operated to reduce the concentration of PCE in the soil vapor underlying this sump; and in 2008, no further action (NFA) was selected for Site 172 as part of the *Soil and Debris Sites ROD* (USAF 2008).

Although not required as part of the remedy selected in the South AFRL ROD, the USAF continued to operate the SVE system between October 2007 and April 2011 on a temporary basis while evaluating risks to workers potentially exposed to PCE and/or other VOCs in the indoor air of Building 8595 via the VIP. The basis in the *South AFRL ROD* for continued operation of the SVE system is Remedy Component 4 for soil vapor intrusion into indoor air (refer to Section 4.3.3), which lists the following range of options as appropriate if the measured concentrations of COCs in indoor air exceed the site-specific IAVMLs-ind listed in Table 3.5-2: continued monitoring, SVE, building controls such as SSD or HVAC modifications, or foundation repairs or ventilation. Between 29 April 2011 and 14 March 2012, the SVE system was offline.

The post-ROD VIP investigation at Building 8595 included the installation and initial sampling of four sub-slab vapor monitoring wells in March 2009. This was followed by the collection of sub-slab and indoor/outdoor air samples during two events: the first round (in June 2009) with the SVE system operating and the second round (in December 2009) with the SVE system off-line. Another round of sub-slab and indoor/outdoor air samples was collected in January 2011 when the SVE system was operating; these results were added to Appendix J of the *South AFRL Post-ROD Monitoring for Vapor Intrusion* (*South AFRL VI Report* [AECOM 2012c]). Most recently (as documented in a memorandum entitled *Results of Vapor Intrusion Sampling and Reactivation of SVE System at Building 8595* [Building 8595 SVE Memo, AECOM 2012f]), samples were collected in January 2012 (with

confirmation samples collected at one location in February 2012) after the SVE system had been shut down since late April 2011.

VIP sampling conducted at Building 8595 was consistent with the plan presented in Section 4.3.1 of the *South AFRL RAWP*; and results, including location-specific cumulative risks as presented in Appendix E.3 of the *South AFRL VI Report*, are further discussed in Section 6.4.3 of this FYR.

4.5.3.2 Summary of Post-ROD VIP Monitoring and Results for Occupied Buildings (excluding Building 8595) at Site 37 and Site 133

The objectives of the vapor monitoring program, as stated in the *South AFRL VI Report* (AECOM 2012c), were to: (1) assess risks posed to workers in existing occupied buildings overlying groundwater with chemical concentrations in excess of the GWVCLs-ind (refer to Table 3.1-2); and (2) assess whether the VIP is complete in existing occupied buildings.

The VIP sampling program included three monitoring events to complete Phases I and II as follows:

Event 1, conducted between 23 and 27 March 2009, included:

- Completing initial building surveys at 18 occupied buildings within the GWVCLs-ind;
- Drilling and installing a total of 46 near-slab vapor monitoring wells (associated with 18 buildings and three groundwater monitoring wells), and collecting Phase I soil gas samples from each well, with on-site analysis of VOC concentrations by mobile laboratory;
- Collecting vapor samples from underground utility vaults located near Buildings 8350, 8351, 8352, 8356, 8406, 8407, and 8423; and
- Drilling and installing six sub-slab vapor wells (two each inside Buildings 8354 and 8406, and one each inside Buildings 8404 and 8408); and collecting vapor samples, with on-site analysis of VOC concentrations by a mobile laboratory, as part of assessing the integrity of the well seals.

Event 2, conducted between 5 and 11 June 2009, included:

- Phase II (Summer) collection of sub-slab vapor and indoor air samples inside Buildings 8354 and 8595 at Site 37 and Buildings 8404, 8406, and 8408 at Site 133, with off-site analyses of VOCs by a fixed-base analytical laboratory; and
- Re-sampling the near-slab vapor wells adjacent to Building 8411 (it was not possible to install sub-slab vapor wells inside this building), and Phase II (Summer) collection of

indoor air samples inside Building 8411, with off-site analyses of VOCs by a fixed-base analytical laboratory.

Event 3, conducted between 22 December 2009 and 6 January 2010, included:

- Phase II (Winter) collection of sub-slab vapor and indoor air samples inside Buildings 8354 and 8595 at Site 37 and Buildings 8404, 8406, and 8408 at Site 133, with off-site analyses of VOCs by a fixed-base analytical laboratory;
- Phase II (Winter) collection of vapor samples from near-slab wells adjacent to, and indoor air samples inside, Building 8411, with off-site analyses of VOCs by a fixed-base analytical laboratory; and
- A second round of Phase I sampling from a subset of the near-slab vapor monitoring wells.

Based on Phase II sampling results, two additional sampling events (4 and 5) were conducted in 2011 and 2012 as follows:

Event 4, conducted during January 2011, included:

- Collection of indoor air samples inside Building 8403 after TCE at a concentration exceeding its SN (refer to Table 4.3-4) was detected in vapor samples collected from near-slab vapor wells during Event 3.
- Collection of sub-slab and indoor air samples inside Building 8595 with SVE system operating, prior to shutdown in April 2011.

Finally, Event 5, conducted during January and February 2012, included:

- Collection of sub-slab (SS) and indoor air (IA) samples inside Building 8595 with SVE system off-line, preparatory to reactivation of the system in March 2012.
- Re-sampling at the location of 37-8595IA4 for comparison of results with an anomalously high PCE concentration found in the sample in January 2012.

VIP sampling conducted at the occupied buildings overlying GWVCLs-ind at Sites 37 and 133 was consistent with the plan presented in Section 4.3.2 of the *South AFRL RAWP*; results are further discussed in Section 6.4.3 of this FYR.

4.5.3.3 Reporting

Sampling and results of vapor monitoring activities conducted from March 2009 through January 2011 are presented in detail in the *South AFRL VI Report* (AECOM 2012c), including location-specific

cumulative risks in Appendix E.3, while results for the most recent (January and February 2012) sampling conducted in Building 8595 are summarized in the *Building 8595 SVE Memo* (AECOM 2012f) including location-specific cumulative risks in Appendix D.

Summaries of SVE system operation during the post-ROD period were provided in annual operations reports (AORs) for 2007 (Earth Tech 2008b), 2008 (Earth Tech 2009b), and 2009 (AECOM 2010a).

4.5.3.4 Problems Encountered

During the period between transmittal of the draft *South AFRL VI Report* (dated August 2010) and its finalization, the California DTSC issued (in October 2011) its final *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air* (DTSC 2011) and the USEPA IRIS database revised toxicity criteria for both TCE and PCE. The report was updated to cite and/or reflect these changes.

4.5.3.5 Costs

The South AFRL ROD did not present cost estimates to conduct VIP monitoring as described in Sections 4.5.3.1 and 4.5.3.2; however, Appendix B.2 presented cost estimates for various scenarios evaluated to mitigate VIP risks. Of these, Scenario 3 included the continuing operation of the SVE system to mitigate risks in Building 8595; in Table 4.5-6, the cost estimate for this scenario is compared with actual costs to operate the SVE system between October 2007 and April 2011. The 4-year cost estimate to operate the SVE as presented for Scenario 3 in Appendix B.2 of the *South AFRL ROD* was $961,000; not surprisingly, the actual cost to run the system for 3.5 years was 29 percent lower, at $680,000. This cost difference is considered due to adjustment of the remedial approach and schedule; it does not reflect failures or shortcomings of the remedy.

5.0 PROGRESS SINCE LAST REVIEW

This is the first five-year review for South AFRL sites; therefore, this section is not applicable.

6.0 FIVE-YEAR REVIEW PROCESS

This section discusses activities performed during the FYR of Sites 37, 133, 120, and 321 in the South AFRL. The USAF conducted this FYR in accordance with guidance documents cited in Section 1.2. Components discussed in this section include:

- Administrative (Section 6.1)
- Community notification and involvement (Section 6.2)
- Document review (Section 6.3)
- Data review (Section 6.4)
- Site Inspection (Section 6.5); and
- Interviews (Section 6.6)

6.1 ADMINISTRATIVE COMPONENTS

Administrative components of the FYR include notification of potentially interested parties that the FYR will be conducted; developing a review schedule and outline; and establishing a review team.

6.1.1 NOTIFICATION OF REVIEW PROCESS INITIATION

Remedial Project Managers (RPMs) representing USEPA, the California DTSC, and Water Board were notified that the FYR process would soon be initiated during a meeting held at Edwards AFB on 17 November 2011. Mr. Ranney Adams, the Environmental Manager for the AFRL was notified via email from EM (formerly 95ABW/CEVR; reorganized as 412 TW/CEVR as of 13 July 2012) on 15 February 2012; he subsequently notified the AFRL commander and other AFRL management/staff. The USAF provided notice of initiating the South AFRL FYR to members of the RAB via email dated 22 February 2012 (copy included in Appendix C.1), and RAB members were given a briefing during their semiannual meeting on 17 May 2012. A notification to the community that an initial FYR for the South AFRL remedy was underway was published in the *Antelope Valley Press* newspaper on 16 May 2012 (copy included in Appendix C.2).

6.1.2 DEVELOPMENT OF REVIEW SCHEDULE AND OUTLINE

Planning for the FYR process began during the RPM meeting on 17 November 2011, when a tentative schedule for submittals was developed; the schedule was later refined (see next paragraph). The USAF as lead agency followed up with development of an annotated outline that was distributed to regulatory agency RPMs on 26-27 January 2012 and discussed during an RPM meeting on 2 February 2012. On 6 February and 22 February 2012, the USAF submitted revisions to the outline based on RPM inputs; and discussed outstanding comments with the RPM representing California DTSC on 14 March 2012.

The original schedule developed on 17 November 2011 (included as Attachment 1 to the annotated outline presented in Appendix C.4) was refined during an RPM meeting held on 21 March 2012 in Sacramento, CA, with key dates as summarized in Table 6.1-1. A more detailed schedule in Gantt chart format, which includes target dates for submittal of important "feeder" documents, is presented on Figure 6.1-1.

6.1.3 IDENTIFICATION OF FIVE-YEAR REVIEW TEAM MEMBERS

The lead agency for this FYR is the USAF. The South AFRL FYR team is led by Mr. Ai Duong (USAF RPM) and Ms. Patrice Hallman, USAF program manager for OU4 and OU9 (both with the 412 TW/CEVR. Regulatory agency RPMs providing review of FYR submittals include Mr. James Ricks and Joseph Healy, PhD from the USEPA Region 9, Kevin Depies, PG from the California DTSC, and Tim Post, PG from the Water Board (CRWQCB-LR).

Contractor members of the FYR team include AECOM and JT3/CH2MHILL.

6.2 COMMUNITY NOTIFICATION AND INVOLVEMENT

The Edwards AFB Community Relations Plan dated February 1996 (USAF 1996) with several draft updates (the most recent in 2012) provides a framework for making information fully and readily available to on- and off-Base communities; establishing two-way communication between Edwards AFB and the public; responding to community concerns that may arise during Base cleanup efforts; and fulfilling DOD and USAF objectives of "maximum disclosure with minimum delay." In 2012, the USAF initiated a comprehensive revision of the Community Involvement Plan (CIP) to include

community interviews and changes to the Restoration Advisory Board. The revised CIP is expected to be finalized in 2013.

6.2.1 RESTORATION ADVISORY BOARD

The RAB was established in January 1995 to promote community awareness. RAB members include USAF and community co-chairs, the RPMs, and community members representing stakeholders both from on Base and surrounding cities. RAB meetings, which are open to the public, provide a forum for status updates on the South AFRL remedy, and are typically held from 5:30 p.m. to 8 p.m. in the evenings, either at Edwards AFB or in one of the surrounding communities (Rosamond, Lancaster, North Edwards, California City, and Boron). In addition, community members of the RAB share information with the public. RAB meetings were held quarterly through 2010, and semiannually as of March 2011. Concurrent with this reduction in frequency, the USAF established a RAB Facebook page (www.facebook.com/RAB.Edwards) where information on the Edwards AFB ERP is posted.

6.2.2 NOTIFICATIONS REGARDING SOUTH AFRL FYR

As indicated in Section 6.1.1, RAB members were notified of initiation of the FYR for the South AFRL via email transmitted on 22 February 2012 (refer to Appendix C.1); an update on progress of the FYR was provided during a RAB meeting held in California City on the evening of 17 May 2012. Mr. Bruce Davies (RAB Co-chair) and Mr. Milton McKay (who represents the AFRL on the RAB) were interviewed during the FYR process (refer to Table 6.6-1).

A notification to the community that an initial FYR for the South AFRL remedy was underway was published in the *Antelope Valley Press* newspaper on 16 May 2012 (see Appendix C.2 in Appendix C). Following completion of the FYR, a brief summary will be made available in the Report to Stakeholders (RTS), a Base publication distributed every other month to a mailing list of 2,000 and also posted on the RAB Facebook page. The summary will include a short description of the South AFRL remedial action, and results of the FYR including the determinations of whether remedies implemented at Sites 37, 133, 120 and 321 are protective of human health and the environment. The summary will also provide the location of site information repositories where the complete copy of the report can be obtained, and provide the date of the next FYR.

The availability of the completed FYR at public repositories will also be announced in newspapers such as the *Antelope Valley Press*, *Desert Wings*, and *Mojave Desert News*. These repositories are located at the Edwards AFB Library on Base; the Kern County Public Library in Rosamond, CA; and the Los Angeles County Public Library in Lancaster, CA.

6.2.3 OUTREACH DURING SELECTION AND IMPLEMENTATION OF SOUTH AFRL REMEDY

Beyond the RAB, Edwards AFB has an active community outreach program as exemplified by the following actions specific to selection and implementation of the CERCLA remedy at the South AFRL:

- As described in the ROD, Section 3.0, the USAF distributed an RTS providing information about the South AFRL proposed remedy in March 2006. Also, during the public comment period (7 April to 20 May 2006) on the Proposed Plan for the South AFRL, the USAF held public meetings in two sessions at the AFRL Rocket Room (cafeteria) on 12 April 2006; and a third session in the community of Boron on 25 April 2006.
- Prior to initiation of VI sampling in June 2009, the USAF prepared and distributed a Fact Sheet (included in Appendix C.3) that was made available to AFRL workers. The AFRL Environmental Manager has also worked with 412 TW/CEVR and the AECOM contractor to communicate the objectives of indoor air sampling, and facilitate building access including completion of initial surveys.

6.3 DOCUMENT REVIEW

The primary general documents reviewed during preparation of the FYR are listed below; those specific to review of LUCs, groundwater monitoring, and VI monitoring are listed in Sections 6.4.1 through 6.4.3. Section 12.0 (References) provides the complete citations for these and other documents used in the FYR:

- *Remedial Investigation Summary Report, AFRL OU4* (Earth Tech 2005a).
- *Remedial Investigation Summary Report, East AFRL OU9* (Earth Tech 2006a).
- *Focused Feasibility Study to Support a Technical Impracticability Evaluating/Containment Zone Application for the South AFRL (Sites 37, 133, 120, and 321)* (Earth Tech 2005c).
- *Proposed Plan for Cleanup of Groundwater at the South AFRL* (USAF 2006b).
- *Record of Decision, South Air Force Research Laboratory* (USAF 2007).

- *South AFRL Remedial Action Work Plan (Sites 37, 120, 133, and 321)* Version 1.0 (Earth Tech 2009a).
- *Comprehensive Five-Year Review Guidance* (USEPA 2001).
- *Recommended Evaluation of Institutional Controls* (USEPA 2011).

In addition, identified ARARs (see listings in Table D-1 in Appendix D) and the toxicity data used to derive containment levels were reviewed to evaluate whether remedy components are still protective of human health and the environment.

6.4 DATA REVIEW

The data review presented in this section is organized by LUCs (6.4.1), groundwater monitoring (6.4.2), and VIP monitoring (6.4.3).

6.4.1 DATA REVIEW: LAND USE CONTROLS

For LUCs, the data reviewed included the Base GIS, CE records, annual LUC reports (refer to Appendix B.4), and USAF forms used in the EIAP and permit processes (refer to Section 4.3.4.1). As discussed in Section 4.3.4, the LUC remedy component includes approval procedures for any construction and ground-disturbing activities inside the South AFRL CZ boundary and VICB (refer to Figures 1.0-2 and 1.0-3). Table E-1 in Appendix E includes a listing of all projects within the South AFRL CZ that were reviewed by EM personnel (formerly 95 ABW and reorganized as 412 TW/CEV as of 13 July 2012) between October 2007 through December 2011; and indicates the process used (Forms 813, 332, or 103 [an older name for the AFFTC Form 5296]). Dig permits are tabulated in Table E-2; locations shown on Figure E-1. This listing includes project location, description, date of dig permit initiation, status of utility clearance, and excavation depth.

The shape files for groundwater plumes in the GIS database are updated annually (at a minimum) to incorporate the most-recent validated sampling results; plumes shown on Figures 3.0-1 through 3.0-5 were revised most recently in April 2012 to incorporate results from sampling conducted through April 2011. Note that most of the mission-related building projects and excavations occurred in the vicinity of existing buildings, i.e., nearer to source areas than the downgradient extent of groundwater plumes. Because there are no utilities or buildings to the west or southwest of Building 8595 in Site 37,

or to the south of the WWTP in the southern portion of the Sites 133/120 groundwater plumes, it is unlikely that future mission-related excavations will be performed in the area of plume migration.

Letters or text reporting well conditions based on observations during semiannual measurements of groundwater elevations are provided in Appendices B.5 and B.6; observations are summarized in Table 4.5-3 and discussed in Section 6.5.2.

6.4.2 GROUNDWATER

The primary sources reviewed for the assessment of groundwater monitoring were:

- WIRs including the *South AFRL I-RAR* (AECOM 2009a) and *2010/2011 WIR* (Eco & Associates 2012);
- AGMRs-OU4 prepared by AECOM (formerly Earth Tech) for Sites 37, 133, and 120 and AGMRs-OU9 prepared by JT3/CH2M HILL for Site 321 (see listings in Table 4.5-1); and
- Groundwater flow and contaminant transport models including the 2005 *Groundwater Modeling Report, South AFRL Area* (Earth Tech 2005b) and the draft 2012 *Groundwater Modeling Report for the South AFRL* (AECOM 2012b).

The overall objectives of the LTM program were listed in Section 4.3.5.1. The evaluation in this section includes: (1) an overview comparing estimated plume distributions in 2003 (the baseline year for plume distributions presented in the ROD), 2008, and 2011 (Section 6.4.2.1); (2) a summary of progress toward meeting objectives of the LTM strategy (Section 6.4.2.2); (3) performance evaluation based on questions listed in RAWP Version 1.0, Section 5.1.1 (Section 6.4.2.3); and (4) a summary of the technology review presented in Appendix A.5 (Section 6.4.2.4).

6.4.2.1 Overview Comparison of Plume Distributions (2003, 2008, and 2011)

The estimated plume distributions for PCE and TCE, based on CPMEs in 2003 and 2008, and updates to the 2008 CPME using sampling results through 2011, are presented on Figures 6.4-1 and 6.4-2. Inspection of these figures indicates only minor changes in the overall plume footprints, mostly due to: (1) an upward or downward contaminant concentration trend in one or more wells driving revision in the placement of a concentration contour (wells identified in orange); and (2) results from new monitoring wells, allowing refinement of COC distributions, primarily at the plume fronts (wells identified in green). For an alternative interpretation of the TCE plume based on sampling results for

Wells 13-MW41 through 13-MW43 near the toe of the Site 133 plume, please refer to discussion in Section 6.4.2.2, Objective 1, Item (a).

More significant changes are seen in the 2011 estimated distribution for perchlorate (Figure 6.4-3) as compared to distributions based on sampling results in 2003 and 2008. In addition to results from new monitoring wells installed in 2009 and 2010 at the plume fronts (wells identified in green), the primary factors driving the revised 2011 distribution of perchlorate include a greater number of wells sampled for this component of solid rocket propellant in 2008 (as compared to 2003) after (1) a California pMCL of 0.006 mg/L was established for perchlorate in October 2007 (i.e., the month after a perchlorate RBCG of 24 μg/L [0.024 mg/L] was adopted in the final *South AFRL ROD*); and (2) a change in the laboratory analytical methodology in 2008, allowing detection at a lower RL (0.0005 mg/L by Method 6850 as opposed to 0.004 mg/L by Method 314 used through September 2006 and 0.0005 mg/L by Method 8321 used in the interim prior to 2008). This change in the analytical methodology was required by a DOD Policy issued in 2008. It is important that the 2011 revisions be interpreted correctly as a refinement in the USAF's understanding of perchlorate distribution in South AFRL groundwater due to the filling of data gaps since the ROD signing; and not misinterpreted as significant expansion in the volume of water impacted by this COC.

Plate 1 presents trend analyses (evaluated by use of the Monitoring and Remediation Optimization System [MAROS] program [Groundwater Services, Inc. [GSI] 2004]) for selected wells, based on Mann-Kendall (MK) statistical analysis of sampling results over the time period from 2000 through April 2011, for PCE, TCE, and perchlorate. On this plate, analytes interpreted to have a stable (S) or no trend (NT) (including wells that have never had a detection [ND]) are shown in green; wells interpreted to show an increasing (I) or probably increasing (PI) trend are shown in red; wells with a decreasing (D) or probably decreasing (PD) trend are shown in blue; and wells with too few sampling results to denote a MAROS trend are shown in orange. Results of the trend analysis are discussed in greater detail in Section 2 of the *2012 Groundwater Modeling Report for the South AFRL*.

Tables A.4-1 through A.4-7 present, for each well, the 2003, 2008, and historic high (prior to 2003) concentrations of PCE, TCE, cis-1,2-DCE, perchlorate, 1,4-dioxane, NDMA, and nitrate; these tables also show which wells were sampled for each analyte during the CPME in 2012.

6.4.2.2 Progress Toward Strategy to Meet LTM Objectives

As an aid to the evaluation presented below, the most recent results for COC concentrations in wells located near and outside the leading edge of groundwater plumes at Sites 37 and 133 are compared to ROD-selected standards in Tables 6.4-1 and 6.4-2. The following discussion also references estimated distributions of PCE, TCE, cis-1,2-DCE, and perchlorate as presented on Figures 3.0-1 through 3.0-5; estimated distributions of 1,4-dioxane, NDMA, and nitrate are presented on Figures A.4-1 through A.4-3 for Sites 37, 133, and 120; and on Figure 3.0-5 for Site 321.

Objective 1: Delineate the leading edge of the Site 37 PCE plume at its western extent; and the Site 133 TCE plume at its southern extent. **Status:** As shown on Figure 3.0-1, PCE was not detected in Wells 37-MW40 and 37-MW46s/d (based on sampling results from October 2010), thus these wells provide an approximation of the Site 37 PCE plume's southern extent while Wells 37-MW12, 37-MW30, 37-MW32, and 37-MW47 provide non-detect wells to the west of this plume. All of these wells, and Well 37-MW44, were more recently sampled in June or July 2012; results will be presented in a groundwater monitoring report to be submitted as a draft in January 2013. As shown on Figure 3.0-2, TCE was not detected above an RL of 1 μg/L in Wells 13-MW35, 13-MW36, 13-MW37 or 13-MW40, based on sampling results dated between October 2009 and April 2011; thus these wells provide an approximation of the Site 133 TCE plume's southern extent (but see below regarding USEPA's concern that TCE detected in Wells 13-MW41 through 13-MW43 may be flowing through fractures not encountered by the shallower Wells 13-MW34 through 13-MW37). Wells 13-MW34 through 13-MW37 and 13-MW40 through 13-MW43 were more recently sampled in June or July 2012; as mentioned above, results will be presented in a groundwater monitoring report to be submitted as a draft in January 2013. **Data gaps and/or potential issues**:

a. Due to relatively high TCE concentrations found in Wells 13-MW41, 13-MW42, and 13-MW43 near the toe of the Site 133 TCE plume, the *2010/2011 WIR* proposes that one additional monitoring well (13-MW45 shown in purple on Figure 3.0-2) be installed approximately 2,600 ft southwest of Well 13-MW42. The USAF will program installation of this well early in the next FYR period. If, based on issues raised by regulatory agency RPMs as discussed in Items i through iii below, a determination is made that more monitoring wells supplemented by other techniques are needed in this area, a plan to complete those investigations will be included in RAWP Version 2.0 to be prepared during the next FYR period. Note based on Figure 6.4-4 (adapted from Figure 4-1 in the *2010/2011 WIR*), the estimated outer extent of VOC contamination at Site 133 is still more than 5,000 ft upgradient of the South AFRL CZ boundary.

i. The RPM for DTSC, in a comment on the draft final FYR report (refer to Appendix H), states: "The plume configurations and known hydrogeology at the South AFRL are indicative of contaminant transport via preferential flow pathways via relatively narrow fracture zones consistent with the alternative Conceptual Site Model of contaminant transport that DTSC has been advocating for contaminant plumes for several of the EAFB Operable Units…Adding a single additional well will not provide the required information to meet the Long Term Monitoring (LTM) objectives. A more robust set of information (e.g., identifying preferential pathways and installing wells at sufficient density both horizontally and vertically to ensure that the downgradient extent has been identified) will be required to meet the LTM objectives… Note [that] concern regarding confidence in determining the downgradient extent of groundwater contamination [applies] also to the Sites 37 and 120 plumes as the plume maps in the FYR indicate the potential that downgradient extent of these plumes may also not be adequately assessed."

ii. The RPM for the Water Board (Mr. Post) in his interview form (received via email dated 5 April 2012) provided the following comment in response to Question 10: "A trend cannot be established with one round of sampling; however, the discovery of unexpectedly high concentrations of trichloroethene in recently installed monitoring wells 13-MW40, 13-MW41, and 13-MW42 could warrant a reassessment of the modeled maximum projected extent of contamination."

iii. The USEPA, in Specific Comment 3 on the draft May 2012 FYR report requested that: "given the elevated concentrations [in Wells 13-MW41 to 13-MW43] it is likely that the TCE plume extends farther than shown on [Figures 3.0-2, 3.1-1, and 6.4-2] (i.e., the 350 to 500 feet from 13-MW41, 13-MW43, and 13-MW42 to the 1 μg/L plume boundary). The extent of the TCE plume should be estimated based on these elevated concentrations, the distance at which these concentrations were found from likely source areas, and the lack of retardation or sorption in granitic bedrock fractures." While not in concurrence with this interpretation, the USAF developed Figure 6.4-5 in an attempt to present the USEPA hypothesis, i.e., that groundwater impacted by contaminants has migrated beyond Wells 13-MW35 and 13-MW37 in a shallower water-bearing zone not monitored by those two wells. The figure shows two alternate depictions for the estimated extent of TCE at a concentration above 1 μg/L, based on methods used to evaluate USEPA's alternate interpretation (note these calculations do not take into account hydraulic gradient nor non-detects in Wells 13-MW34 through 13-MW37):

1. Using the 2010 simulated contour (shown on Figure 4.3-2 in the 2012 Groundwater Modeling Report for the South AFRL), the estimated distance between the 100 μg/L contour and the 1 μg/L contour is approximately 4,000 feet; applying a similar distance, the plume would extend approximately 4,000 feet southwest of Well 13-MW42.

2. If a straight linear relationship is assumed between concentration and distance using the slope between Wells 13-MW15 and 13-MW42, the

1 μg/L contour would extend approximately 5,000 feet down gradient from Well 13-MW42.

iv. Note that plumes shown on Figures 3.0-2, 3.1-1, 6.4-2 and 6.4-4 depict what the USAF believes to be a stronger hypothesis, that groundwater impacted by higher TCE concentrations has migrated more rapidly within a narrow channel down the central axis of the plume; with a rapid fall-off in concentration near the toe of the plume as indicated by non-detects in Wells 13-MW34 through 13-MW37. This CSM has the benefit of not ignoring sampling results from the downgradient wells. Although there is a significant vertical separation between the water-bearing fractures monitored by Wells 13-MW38, and 13-MW41 through 13-MW43 as compared with the water-bearing fractures monitored in Wells 13-MW34, 13-MW35, 13-MW37, and 13-MW39, a review of borehole logs for the latter three wells does not indicate that a shallower water-bearing zone exists but was "missed" at these locations. Therefore, drilling observations do not support the concept that a water-bearing fracture is carrying TCE-impacted groundwater in a shallower zone not monitored by these wells.

b. As shown on Figure 3.0-4, the downgradient extent of perchlorate has not been fully delineated at the western extent of the Site 37 plume. Further, the DTSC has commented that local sources of perchlorate in isolated plumes at the WWTP (Site 120) and southern part of Site 133 have not been adequately characterized. The DTSC RPM (Mr. Depies) in his interview form (received via email dated 3 April 2012) provided the following comment in response to Question 7: "As expressed in our comments on the 2010 Well Installation Report, DTSC believes the Air Force needs to develop a groundwater monitoring plan that facilitates monitoring frequency changes in reaction to water quality trends that indicate potential remedy failure and/or are inconsistent with the South AFRL CSM. Also, to determine remedy effectiveness a clear and comprehensive understanding of contaminant nature/extent needs to be achieved including better vertical plume control and an understanding of the newer-discovered perchlorate plume in the vicinity of the water treatment facility (downgradient of the South Plume VOC sources)." Note, however, based on Figure 6.4-6 (adapted from Figure 4-2 in the *2010/2011 WIR*) that the estimated outer extent of perchlorate groundwater contamination is still more than 6,000 ft from the South AFRL CZ boundary.

Objective 2: Assess whether transport velocity near the plumes' leading edges can be estimated. **Status:** This objective is not yet achieved; as indicated in Note 2 on Figure 3.2-1 in RAWP Version 1.0, the expectation is that once primary IS wells are installed, it may take another 5 years to 16 years to detect COCs, allowing an estimation of transport velocity based on sampling results. **Potential issues**: Please see issues identified under Objective 1.

Objective 3: Confirm that contaminants migrating at the plume fronts are transported less rapidly at depth than in the first water-bearing zone (i.e., COCs are not detected in vertical extent wells at the

plumes' leading edges). **Status**: Neither VOCs nor perchlorate were detected in Well 37-MW45d near the toe of the Site 37 PCE plume; or in Well 13-MW39 near the toe of the Site 133 TCE plume. The bullets below focus on well clusters designed to monitor contaminant vertical extent near the toe of each plume (refer to Table 3.0-1 for well screen intervals).

a. **Site 37**. As shown on Figure 3.0-1 (see also Table 6.4-1), at the toe of the plume, a PCE concentration of 6.2 μg/L was detected in shallow Well 37-MW44; PCE was detected at trace levels (0.38 μg/L) in Well 37-MW45s and was non-detect (<1.0 μg/L) in the deepest water-bearing zone screened in Well 37-MW45d. Similar trends were seen for perchlorate (0.013 mg/L, 0.0063 mg/L, and <0.00050 mg/L in Wells 37-MW44, 37-MW45s and 37-MW45d, respectively) and nitrate (as N) (12 mg/L, 11 mg/L, and <0.20 mg/L, respectively). No other COCs were detected in these three wells. Note that the perchlorate concentration in downgradient Well 271-MW01 (0.009 mg/L), screened from 85 ft to 100 ft, is slightly higher than in shallower Well 37-MW45s (screened from 67 ft to 77 ft). **Potential issue:** None identified beyond the need to better delineate perchlorate extent at the toe of the Site 37 plume, as previously discussed.

b. **Site 133**. As shown on Figure 3.0-2 (see also Table 6.4-2), at the toe of the Site 133 plume the highest concentration for TCE (190 μg/L) was detected in Well 13-MW42, the shallowest well near the leading edge; TCE was not detected (<1.0 μg/L; last sampled in 10/10) in the next water bearing zone screened in Well 13-MW39. Similar trends in Wells 13-MW42 and 13-MW39 were seen for perchlorate (0.0063 mg/L and <0.00050 mg/L, respectively) and nitrate (as N) (1.6 mg/L and <0.10 mg/L, respectively). No other COCs were detected. **Potential issue:** In a comment on the *2010/2011 WIR*, the California DTSC requested the USAF to "Initiate a program to further assess a nearly 100-foot water table disparity between Well 13-MW39 (where first groundwater was encountered at a depth of 177 ft bgs) and nearby Wells 13-MW38 and 13-MW43 (where first groundwater was encountered at depths of 103 ft bgs and 83 ft bgs, respectively)" (refer to Table A.2-1). The DTSC further recommended monitoring water levels in these and other nearby wells more frequently than semiannual to annual as specified in Section 3.3.1 of the *South AFRL RAWP*.

c. **Site 120**. In Well 120-MW10 located down gradient from the former STP, PCE, TCE, cis-1,2-DCE, and perchlorate (as shown on Figures 3.0-1 through 3.0-4) were detected at 2.0 μg/L, 3.6 μg/L, 0.64 μg/L, and 0.019 mg/L (see also Table 6.4-3), respectively; and were non-detect (<1.0 μg/L, <1.0 μg/L, <1.0 μg/L, and <0.00050 mg/L, respectively) in Well 120-MW15 screened over a deeper water-bearing zone. **Potential issue:** None identified.

d. **Site 321**. As shown on Figure 3.0-5 (see also Table 6.4-4), VOCs were not detected in either the shallow or deep well of the pair 321-MW08b and 321-MW08a. Nitrate (as N) was detected in both wells at approximately the same concentration (1.1 mg/L in 321-MW08b and 2.2 mg/L in 321-MW08a). No other COCs were detected in either well. **Potential issue:** None identified.

Objective 4: Assess concentrations in selected wells (inside and outside the each plume's current extent) at a sufficient frequency (annually to biennially) to allow early detection of contaminants migrating more rapidly or in a different direction than anticipated. **Status:** The annual to biennial monitoring of wells near the plume fronts is ongoing and considered adequate for early detection. **Potential issue**: The RPMs have requested further investigation of low-level VOC contamination in wells located outside and to the southwest of the South AFRL CZ (see Items a through c below):

a. As described in Appendix D.3 of the RAWP Version 1.0, Well 13-MW33 located approximately 2 miles down gradient of the Site 133 plume's leading edge and outside the CZ (refer to Figure 3.1-1) was known to contain COCs (PCE, TCE, and cis-1,2-DCE) at or near their respective pMCLs at the time of ROD signing; these contaminants were detected in the latest sample collected at this well (in July 2009). TCE at low concentrations (below the pMCL of 5 μg/L) was also detected in a second well (13-MW32) located outside the CZ in 2007 through January 2009; however, following redevelopment of this well in June 2009, TCE has not since been detected in samples collected between July 2009 and April 2010. Both wells were sampled as part of a comprehensive plume monitoring event in 2012.

b. The source of low-level VOCs in Well 13-MW33 outside the CZ is unknown but believed to be localized and not due to contaminant sources associated with South AFRL sites located at least 3 miles to the northeast. As shown on Figure 3.1-1, no VOCs have been detected in the groundwater from several monitoring wells located between the leading edge of South AFRL plumes and Well 13-MW33; neither VOCs nor perchlorate were detected in Wells 442/1-MW01 and 442/2-MW01 (located in OU7 and installed as part of the CWM investigation) last sampled in August 2003. The RAWP Section 3.6.2 includes the following plan for future investigation in this area: "Because the low-level contamination in Well 13-MW33 appears unrelated to the South AFRL plumes, any potential source not included in the South AFRL sites will be identified and investigated as a new AOC outside the scope of this RAWP. …annual sampling of Wells 13-MW32 and 13-MW33 will be discontinued under the South AFRL LTM program."

c. The RPM for USEPA (Mr. Healy) in his interview form (received via email dated 4 April 2012 provided the following comment in response to Question 7: "I recommend … [an update regarding] the status of some groundwater samples taken in OU7 [i.e., from Site 442 wells] and situated relatively close to the sub-basin boundary for the South AFRL plume migration direction."

Potential resolution: The USAF will accomplish investigation of AOC 538 in the vicinity of Well 13-MW33 (TCE in groundwater east of Mary's well field) outside of the South AFRL FYR process.

Objective 5: Assess plume distributions at a sufficient frequency (conduct CPMEs at least once per 5 years) to support validation of the contaminant transport models and update plume distribution contours. **Status:** Refer to plume analysis presented in Section 6.4.2.1. Results from the CPME conducted in 2008 were used for development of the 2012 contaminant transport model; estimated distributions based on the 2008 CPME were updated to incorporate results from the smaller number of wells sampled in 2009, 2010, and 2011. Results from the most recent CPME, conducted in June and July 2012, were not available for inclusion in this report. **Potential issues**:

a. Reflecting the high degree of uncertainty in the development of flow and transport models for AFRL groundwater, the calibrated 2012 flow and transport models (as introduced in Section 4.5.2.2) yield a predictive simulation for plume movement under the most conservative Scenario 1 that shows a breach of the CZ boundary within 200 years (refer to Appendix A.3, Figures A.3-3 and A.3-4), which is a different outcome than the predictive simulation under the 2005 flow and transport models (that indicate no breach of the CZ boundary within 1,000 years, refer to Appendix A.3, Figure A.3-5). It should be emphasized that this differing outcome is not based on new monitoring data but rather on revised groundwater modeling assumptions. Further, it should be clarified that the 2012 model simulates breach of the CZ boundary within 200 years under the assumption that no degradation occurs outside the source areas and sources do not diminish over time. Because these assumptions are likely to be overly conservative, migration rates in the South AFRL plume may be closer to those simulated in Scenario 2 (source depletion after 100 years; refer to Figures A.3-6 and A.3-7) or Scenario 3 (degradation outside source areas, refer to Figures A.3-8 and A.3-9) as described in Section 6 of the *2012 Groundwater Modeling Report for the South AFRL* (AECOM 2012b). See also Figures A.3-10 through A.3-15; and text included at the end of Appendix A.3 that further discusses the uncertainties associated with transport modeling at the AFRL.

b. Note that USEPA conceptualizes that contamination may have already reached, or may in the near future reach, the CZ boundary, based on TCE results in several wells near the toe of the Site 133 plume and an assumed fracture flow velocity that may range as high as 10 meters/day (2.25 miles per year) (refer to Appendix H responses to comments).

c. In response to Issues (a) and (b):

   i. Although the USAF does not expect impact to protectiveness of the selected remedy within the next 150 years, the revised predictive simulations, when considered in combination with new information regarding the location of transition to alluvium in the Arroyos groundwater area (AECOM 2012g), suggest that it may be desirable to initiate additional field investigations to assess location of the alluvial aquifer/fractured bedrock interface sooner than proposed in the RAWP Section 3.6 (refer to Section 4.3.5.6).

   ii. Further, to assess the potential that more rapid contaminant transport than modeled has and/or is occurring, future groundwater modeling should be optimized to incorporate

groundwater sampling results from Wells 13-MW41 through 13-MW43 near the toe of the Site 133 groundwater plume; and evaluate the benefit of supplementing the equivalent porous media modeling approach with localized fracture flow modeling; e.g., such as the discrete fracture network approach developed by Parker (2007) as discussed in Chapman and Parker (2011).

iii. Finally, the revised predictive simulations (in combination with other factors including revisions in toxicity factors for both TCE and PCE) have implications for future revisions to the VICB in accordance with soil vapor Remedy Component 2 (refer to Section 4.3.3).

b. The RPM for USEPA (Mr. Healy) in an email dated 21 February 2012 provided a comment regarding estimated plume distributions presented in the *2010/2011 WIR*: "Please … briefly consider … the potential future need for an evaluation of South AFRL …well positioning in terms of verifying at a future Five Year Review (e.g., the Second Five Year Review in 2017) how well your conceptual site model is holding up for describing the plume movement in the shapes you have currently been using versus a possible different conclusion that might involve a more "fingered" shape along preferential pathways."

Objective 6: In an iterative process, select locations and install IS wells projected to detect COCs within some acceptable timeframe (to aid with estimating transport velocity near the plumes' leading edges). **Status:** Because the remedy is in an early stage, this objective is not yet achieved (refer to Objective 2). **Potential issues**: None identified.

Objective 7: Continuously optimize the LTM strategy, and identify wells for re-development, replacement, and/or destruction. **Status:** This objective is not yet achieved; the strategy presented in the RAWP Version 1.0 should be updated during the next FYR. Refer to recommendations included in Section 9. **Potential issues**: None identified.

6.4.2.3 Performance Evaluation

The following questions were included in the *South AFRL RAWP* Section 5.1.1, Item 1 to aid evaluation of LTM performance monitoring:

a. Is extent of the plume adequately delineated? With regard to lateral extent: as indicated in the evaluation of LTM Objective 1, the answer is **no**. Initially, one additional well is proposed to better delineate the extent of the VOC plume near the southern leading edge of the Site 133 TCE plume; additional wells supplemented by techniques to be identified in the RAWP Version 2.0 may be needed in this area and one or more additional wells may be needed to better characterize the extent of the perchlorate plume at Site 37. With

regard to the vertical extent near the plume front: as indicated in the evaluation of LTM Objective 3, the answer is **yes**; the vertical extent is adequately characterized.

b. Is the plume contained within the CZ? Based on the estimated distributions of PCE, TCE, and perchlorate presented on Figures 6.4-4 and 6.4-6, the answer is **yes**.

c. Can it be determined whether the plume is growing, shrinking, or stable? **No**. Based on the comparison of plume distributions (and trend analysis) presented in Section 6.4.2.1, the plumes are characterized by stable concentrations at most sampling locations; with evidence of increasing trends in a small number of wells (wells shown in red on Plate 1), including Well 37-MW13 located down the axis of the western lobe of the Site 37 plume and Well 120-MW02 at the former STP. Expansion at the plume front remains under investigation.

d. If the plume is growing, has the rate of migration been estimated? As indicated in the evaluation of LTM Objectives 2 and 6, the answer is **no**. Due to the short timeframe during which the remedy has been implemented (relative to the anticipated timeframe for LTM), definitive trends have not been established. Obtaining an estimate of plume migration at the plume front remains a work in progress.

e. Are there sufficient data to determine whether it is likely that the plume will continue to be contained within the CZ? Based on the estimated distributions of PCE, TCE, and perchlorate presented on Figures 6.4-4 and 6.4-6, and predictive simulations of groundwater modeling, the answer is **yes** in the short-term (covering the next 5 to 30 years) and in the long term (to 150 years). As indicated in the evaluation of LTM Objective 5, additional data are required to evaluate the rate of migration at the plume front, and to better characterize location of transition to an alluvial aquifer.

It should be noted that both USEPA and State regulatory agencies, based on review of the May 2012 draft FYR report (refer to Appendix H), have commented that the USAF's multi-month delay in completing a second CPME (initiated in June 2012 rather than in October 2011 as intended in the RAWP Version 1.0), and lack of a finalized transport model, have impacted performance evaluation for the groundwater remedy.

6.4.2.4 Technology Review

The last component of the groundwater remedy selected in the *South AFRL ROD* requires a technology review to evaluate whether, over the past 5 years, any promising technologies have been demonstrated to effectively treat the same types of chemicals at similar concentrations and in a similar hydrogeologic setting to the South AFRL (extensive plumes in fractured bedrock with probable DNAPL in the source

areas). In addition to new technologies, new approaches or perspectives for existing technologies were also reviewed.

The review, included as Appendix A.5, was conducted from the perspective of hot spot containment and/or source treatment, and considered the following criteria:

1. Has the technology/approach been proven at the field scale?
2. Has the technology/approach been applied to similar COCs in competent crystalline bedrock?
3. Has the technology/approach been applied as source area treatment and/or hot spot containment on a similar scale to that of the South AFRL?

A literature search indicated advances were made or new perspectives were developed for the use of existing technologies in fractured bedrock aquifers including: (1) enhanced in situ delivery; (2) in situ remediation; (3) thermal remediation; and (4) groundwater pump-and-treat. Of the evaluated technologies, only two – recirculation and infiltration of treatment reagents – were shown to be at least partially successful in treating PCE and TCE in crystalline bedrock at the field scale; moreover, both have already been pilot tested at Edwards AFB. However, because these technologies have not been applied at the scale estimated for effective source reduction and/or hot spot containment, it is uncertain whether these technologies applied to the source area would significantly aid in reducing source and plume longevity, or the life-cycle cost of plume containment.

Additional advances in the field application of three other promising technologies – bioaugmentation to enhance DNAPL dissolution, in situ biogeochemical transformation, and hydraulic fracturing to enhance distribution of treatment amendments in crystalline rock – in fractured bedrock aquifers is anticipated within the next 5 to 10 years. Because these technologies have previously been or are currently being pilot-tested at Edwards AFB, and further advances in the treatment of chlorinated solvents in crystalline bedrock are anticipated within the next two FYR periods, the USAF does not recommend the pilot testing of any source area treatment technology at the South AFRL during the next 5 years.

6.4.3 VAPOR INTRUSION PATHWAY

The primary sources reviewed for the assessment of VI monitoring were:

- *South AFRL Post-ROD Monitoring for Vapor Intrusion* (AECOM 2012c);
- AORs for the SVE system south of Building 8595 covering the periods October through December 2007 (Earth Tech 2008b); calendar year 2008 (Earth Tech 2009b), and calendar year 2009 (AECOM 2010a); and
- *Results of Vapor Intrusion Sampling and Reactivation of SVE System at Building 8595 (Site 37 in South AFRL at Edwards AFB, CA)* (Building 8595 SVE Memo, AECOM 2012f).

In addition, documents reviewed to aid in the evaluation of VIP at the South AFRL included:

- Updated DTSC guidance documents including *Advisory – Active Soil Vapor Investigations* (draft dated March 2010 and final dated April 2012, DTSC 2010, 2012) and *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air* (final dated October 2011, DTSC 2011);
- New USEPA technical documents including *Conceptual Model Scenarios for the Vapor Intrusion Pathway* (final dated February 2012, USEPA 2012a) and *Vapor Intrusion Database: Evaluation and Characterization of Attenuation Factors for Chlorinated Volatile Organic Compounds and Residential Buildings* (final dated March 2012, USEPA 2012b);
- *Basewide Vapor Intrusion Evaluation Protocol, Edwards AFB* (BW VI Protocol, AECOM 2012h); and
- Updates to chemical toxicity criteria for PCE, TCE, and other chemicals in IRIS and Office of Human and Ecological Risk (HERO) databases.

Objectives of the VIP monitoring program were listed in Section 4.3.6. The evaluation in this section includes: (1) an overview summarizing results of the South AFRL VI sampling program (Section 6.4.3.1); (2) an evaluation of the CSM and methodology used for the South AFRL VI evaluation as compared with new guidance and evolving protocol for VI sampling at Edwards AFB (Section 6.4.3.2); (3) results of VI sampling and SVE operation specific to Building 8595 (Section 6.4.3.3); (4) an evaluation of whether the VICB designated in the ROD (refer to Figure 1.0-3) requires an update (Section 6.4.3.4); and pathway assessment based on questions listed in the RAWP Section 5.1.1 (Section 6.4.3.5).

6.4.3.1 Overview Summarizing Results of the South AFRL VI Sampling Program

As described in Section 4.5.3.2, a total of 18 buildings (seven in the administrative area of Site 37 and 11 near the CE complex at Site 133) were included in the Phase I VI investigation conducted in March 2009, during which 46 vapor monitoring wells were installed and sampled, with analysis by an onsite mobile laboratory. The objectives were to assess risks to workers in existing occupied buildings overlying groundwater with chemical concentrations in excess of the GWVCLs-ind (refer to Table 3.1-2 and Figure 1.0-3); and (2) assess whether the VIP is complete in existing occupied buildings. As listed in Table 4.3-3 and shown on Figure 6.4-7 (respectively adapted from Table 1.2-3 and Figure 1.5-1 in the *South AFRL VI Report*) the Phase I investigation included all occupied buildings (except Building 8595 discussed in Section 6.4.3.3) inside the GWVCLs-ind delineated in the *South AFRL ROD*. PCE and TCE concentrations detected in the 46 near-slab vapor monitoring wells were screened against SNs established in the *RAWP* Version 1.0 and listed in Table 4.3-4 (adapted from Table 1.6-1 in the *South AFRL VI Report*) based on an assumed attenuation factor (i.e., ratio of expected indoor air to near-slab soil vapor concentration) of 0.001. Results of the Phase I screening are summarized on Figures 6.4-8 and 6.4-9 (adapted from Figures 2.2-1 and 2.2-2 in the *South AFRL VI Report*) and in Tables 6.4-5 and 6.4-6 (adapted from Tables 2.5-1 and 2.5-2 in the *South AFRL VI Report*). Based on these results, no further evaluation was conducted at six buildings (8349, 8351, 8356, 8423, 8424 and 8431) where PCE and TCE concentrations in the soil vapor samples did not exceed 10 percent of the SNs. A second round of samples was collected from near-slab wells associated with six other buildings (8350, 8352, 8353, 8402, 8403, and 8407); based on results from this second round of sampling, no further evaluation was conducted except at Building 8403, where TCE was detected above its SN in vapor samples collected from both near-slab wells during the second sampling event (in January 2010).

For five buildings (8354, 8404, 8406, 8408 and 8411) where PCE or TCE concentrations in the near-slab wells exceeded SNs, a Phase II investigation that included installation of sub-slab wells and sampling the indoor air was conducted in June 2009 and December 2009 or January 2010; results are summarized in Table 6.4-7 (adapted from Table 3.2-1 in the *South AFRL VI Report*). One round of indoor air sampling was conducted inside a sixth building (8403) in January 2011 and these results were added to the table. Except in Building 8595 (see Section 6.4.3.3 for discussion of results), neither PCE nor TCE were detected in indoor air samples at concentrations above the IAVMLs-ind established in

the ROD. As described in Section 1.8 of the *South AFRL VI Report,* the building-specific summaries of Phase II sampling results (presented in Section 3.2 of that report) make reference to Appendix E (of the *South AFRL VI Report*), which includes a detailed analysis of chemicals detected in each medium sampled, as follows:

1. In Appendix E.1 [of the *South AFRL VI Report*], the soil vapor results from near-slab vapor monitoring wells are compared against soil vapor screening levels for industrial exposure (SVSLs-ind) and indoor air concentrations are compared against indoor air screening levels for industrial exposure (IASLs-ind), both derived as explained in the BW VI Protocol for use at Edwards AFB (AECOM 2012h). The toxicity criteria (inhalation unit risk factors [IURs] for carcinogens and reference concentrations [RfCs] for non-carcinogens) used in the derivation of IASLs were selected in accordance with the hierarchy in USEPA (2003b) Office of Solid Waste and Emergency Response (OSWER) Directive 9285.7-53, *Human Health Toxicity Values in Superfund Risk Assessments* (December 5, 2003), as cited in Enclosure 3 of the Department of Defense Instruction (DODI) 4715.18, *Emerging Contaminants* (DOD 2009).

    a. Tier 1 - USEPA's IRIS database, located at http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showSubstanceList.

    b. Tier 2 - USEPA's Provisional Peer-Reviewed Toxicity Values (PPRTVs) accessible through USEPA risk assessors.

    c. Tier 3 - Other toxicity values including USEPA and non-USEPA sources of toxicity information. Priority should be given to sources of information that use sound science and are the most current, peer-reviewed, transparent, and publically available. Example sources for Tier 3 include the California Environmental Protection Agency (Cal EPA) Office of Environmental Health Hazard Assessment (OEHHA) toxicity criteria database (available at www.oehha.ca.gov/risk/ChemicalDB/index.asp) and the USEPA's Health Effects Assessment Summary Table (HEAST).

    Note that the IASLs-ind for TCE and PCE use toxicity criteria updated in the IRIS database in September 2011 and February 2012, respectively; based on updates to cancer criteria, TCE is more toxic by a factor of approximately 2 and PCE is less toxic by a factor of approximately 23 than OEHHA toxicity criteria used to establish the IAVMLs-ind selected in the *South AFRL ROD*.

    Also in Appendix E.1, results are compared against CA-IASLs-ind and CA-SVSLs-ind developed using the more protective of toxicity criteria available from USEPA's IRIS database or California's OEHHA database (thus for PCE, the CA-IASL-ind retains use of the OEHHA toxicity criterion) as preferred by the State of California.

2. Appendix E.2 [of the *South AFRL VI Report*] provides an evaluation of which chemicals detected in indoor air were attributed as likely due to the VIP.

3. Finally, Appendix E.3 [of the *South AFRL VI Report*] presents estimates of the cumulative risk and HI based on chemicals detected in each indoor air sample; and the cumulative risk and HI for those chemicals attributed to the VIP. For carcinogens, the concentration of each individual chemical was divided by its IASL-ind; that ratio was then multiplied by 10^{-6}, and the resultant risks summed to give an estimate of cumulative risk for that location. For non-carcinogens, the simple ratio of each chemical concentration to its IASL-ind gave the HQ for that chemical; these HQs were summed to give the HI for the VIP at that location. Cumulative risks and HIs at the bottom of each table are presented for (1) all VOCs detected and (2) that subset of VIP-related VOCs detected. Additionally, cumulative risks and HIs are presented based on ratios to CA-IASLs-ind rather than IASLs-ind (i.e., using the more protective toxicity criteria preferred by the California DTSC) for benzene, carbon tetrachloride, cis-1,2-DCE, PCE, and vinyl chloride.

A fuller explanation of how the IASLs-ind and the SVSLs-ind were derived, and the procedure used to interpret several lines of evidence to determine the likelihood that chemicals entered the building from the subsurface via the VIP is provided in Sections 1.8.1 and 1.8.2 of the *South AFRL VI Report*. Table 6.4-8 (adapted from Table E.3-1 in the *South AFRL VI Report*) presents a summary of cumulative risk results (maximum cancer risk and HI calculated for each individual indoor air sampling location in each building). This summary table indicates that cumulative risks (USAF) for that subset of chemicals identified as attributable to the VIP generally do not exceed 1.5×10^{-6} (4.4×10^{-6} using the more protective [CA] OEHHA toxicity criteria) and (with the exception of a single sampling result from 37-8595IA3 collected in June 2009 inside Building 8595), all HI values were less than 1. Subsequent samples collected (in 2009, 2011 and 2012) inside Building 8595 have not confirmed the elevated trans-1,2-DCE concentration that led to an HI of 2 at the one location in June 2009.

6.4.3.2 Methodology Used at South AFRL Compared to Evolving Protocol for VI Evaluations

Based on results as summarized in Section 6.4.3.1, the VIP does not appear to pose unacceptable risk to site workers at the South AFRL under the current industrial exposure setting. However, in the 3 years since the sampling protocol proposed for use at the South AFRL was approved in the *South AFRL RAWP* Version 1.0, the DTSC published (in October 2011) its final *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air*; the USEPA (in early 2012) published two new technical documents (refer to Section 6.4.3); the RPMs provided review comments on the draft BW VI Protocol (draft dated October 2011); and work plans for VIP investigations in other areas of the

AFRL underwent several iterations. In light of the evolving consensus on what constitutes an acceptable VIP evaluation, Table 6.4-9 was prepared to compare the CSM, sampling protocol, and analytical methods used for the South AFRL VI evaluation with more recent protocols developed for Edwards AFB; and assess the impact and recommendations. The USAF plans to conduct a follow-on VIP assessment in 2016 to aid with the protectiveness evaluation in the next FYR report (scheduled in 2017).

6.4.3.3 Summary of Sub-Slab and Indoor Air Results for Building 8595; and Impact of SVE System Operation

As summarized in Section 3.3.1.3, through February 2012 there have been eight rounds of indoor air sampling inside Building 8595 – four with the SVE system off-line; and four when the SVE system was operating. The last four of these sampling rounds (in June and December 2009, January 2011, and January/February 2012) have also included sub-slab sampling. In general, PCE has been detected at concentrations that slightly exceed its ROD-established IAVML-ind of 1.7 $\mu g/m^3$ at some locations during sampling events when the SVE system was off-line; however, PCE did not exceed this level when the system was operating. Results are summarized on Figure 6.4-10 (adapted from Figure 2 in the *Building 8595 SVE Memo* cited in Section 6.4.3); on this figure, results shown outside boxes are from sampling events with the SVE system operating whereas results shown inside boxes are for samples collected 4 months or longer following system downtime.

During the four sampling events conducted since the 2007 *South AFRL ROD*:

- With the SVE system online in June 2009, PCE was detected at 40,000 $\mu g/m^3$ in sub-slab Well 37-8595SS2 and 130 $\mu g/m^3$ in Well 37-8595SS3 but was not detected in any of the indoor air samples. A significant negative differential pressure was measured in sub-slab Wells 37-8595SS2 (-62.5 Pascals [Pa]) and 37-8595SS3 (-11.5 Pa); it is likely that operation of the SVE system helped to prevent the intrusion of subsurface vapors into the southern portion of the building. When samples were collected while the SVE system was operating in January 2011, the PCE concentration in 37-8585SS2 was much lower at 1,500 $\mu g/m^3$ while a similar result (PCE at 82 J $\mu g/m^3$) was found in 37-8595SS3.

- In December 2009 while the SVE system was off line, PCE was detected at 53,000 $\mu g/m^3$ in sub-slab Well 37-8595SS2 and at 47,000 $\mu g/m^3$ in Well 37-8595SS3; the large increase in concentration at the latter well while the SVE system was off line suggests that SVE operation may significantly reduce vapor intrusion beneath the laboratory portion of Building 8595. Similar results were found in January 2012 while the SVE system was off

line; PCE was detected at 54,000 $\mu g/m^3$ in Well 37-8595SS2 and at 70,000 $\mu g/m^3$ in Well 37-8595SS3.

- PCE concentrations in indoor air samples from 37-8595IA2 and 37-8595IA3 slightly exceeded the IAVML-ind (1.7 $\mu g/m^3$) in December 2009 and January 2012 when the SVE system was offline. Based on the OEHHA toxicity criterion, these results indicate a risk due to PCE in indoor air at levels slightly above 10^{-6}; however, based on the recently updated IRIS criterion, PCE concentrations detected in the indoor air of Building 8595 do not pose a risk level above 10^{-6} even when the SVE system is offline. The one exception is that an anomalously high level of PCE (60 $\mu g/m^3$) was detected in Sample 37-8595IA4 in the western part of the building in January 2012 (the H qualifier shown on Figure 6.4-10 indicates this sample was analyzed a few hours out of holding time; the expected effect, if any, would be to bias the sampling result low). Because the elevated result from Sample 37-8595IA4 was inconsistent with previous sampling results at this location, a February 2012 re-sampling event was conducted at this location, and duplicate samples were collected for comparison to earlier results. PCE concentrations in the February 2012 duplicate samples (0.89 $\mu g/m^3$ and 1.1 $\mu g/m^3$) are consistent with previous data and do not exceed the IAVML-ind (AECOM 2012f).

- Cumulative risk estimates (using IRIS toxicity criteria for TCE and PCE) based on indoor air sampling results (through January 2011) inside Building 8595 are presented in the *South AFRL VI Report*, Appendix E.3, Tables E.3-2 through E.3-6; cumulative risk estimates for indoor air samples collected inside Building 8595 in January/February 2012 are presented in the *Building 8595 SVE Memo*, Appendix D. Based on the concentrations of VOCs attributed to the VIP, inhalation of air inside Building 8595 was calculated to pose a lifetime cancer risk under industrial exposure assumptions slightly above 10^{-6} (less than or equal to 4×10^{-6} using California toxicity criteria) at the locations of 37-8595IA1 and -IA3, primarily due to the concentration of benzene. At 37-8595IA4 in January 2012, the cancer risk from VIP-related VOCs was 1.6×10^{-6} (3×10^{-5} using California toxicity criteria) due to PCE detected at 60 $\mu g/L$. This result, which is not consistent with results for samples collected previously or in February 2012, is considered anomalous, as is a trans-1,2-DCE concentration of 500 $\mu g/m^3$ detected at the location of 37-8595IA3 in June 2009 that resulted in an HI above 1 (trans-1,2-DCE has not been detected at such a high concentration before or since).

Continued operation of the SVE system south of Building 8595 is not a component of the remedy selected in the *South AFRL ROD*, but is listed as one of several possible mitigations to address risk via the VIP.

6.4.3.4 Review of VICB

As mentioned in Section 3.1.1.2 and Item 2 under Section 4.3.3, a component of the ROD-selected remedy to address the VIP at the South AFRL is the requirement to revise the VICB when "subsequent

plume migration modeling during a future Five-Year Review predicts that the residential risk contours will exceed the current VICB in less than 10 years." Neither results from groundwater LTM nor the results to date from evaluation of the VIP trigger an update to the VICB; however, due to recent updates in the IRIS toxicity criteria for PCE and TCE, and the USAF agreement to use a standard industrial exposure duration of 25 years (rather than 10 years used in the ROD as specific for military bases), the GWVCLs-res and GWVCLs-ind were recalculated as presented in Table 6.4-10. Using updated simulations based on the *2012 Groundwater Modeling Report for the South AFRL*, Figures 6.4-11 and 6.4-12 present the existing VICBs (outlined in blue) and:

1. On Figure 6.4-11, the 30-year projected extent (based on the 2012 groundwater model) of groundwater PCE concentrations above 300 μg/L (outlined with a dashed brown line); this is the groundwater concentration (based on J&E modeling and using the revised IRIS toxicity criterion) that could result in an indoor air concentration at the IASL-res (posing a 10^{-6} risk via the VIP). Also shown for the purpose of comparison are the 30-year projected extent of PCE concentrations exceeding 13 μg/L (outlined in dotted purple), which is the value used to designate the VICB in the ROD based on the OEHHA toxicity criterion; and the estimated current (2011) extent of PCE at the 1 μg/L contour (outlined using a solid black line) based on groundwater sampling results.

2. On Figure 6.4-12, the 30-year projected extent (based on the 2012 groundwater model) of groundwater TCE concentrations above 30 μg/L (outlined with a dashed brown line); this is the groundwater concentration (based on J&E modeling and using the revised IRIS toxicity criterion) that could result in an indoor air concentration at the IASL-res (posing a 10^{-6} risk via the VIP). By contrast, the contour used to designate the VICB in the ROD was the 30-year projected extent (based on the 2005 groundwater model) of TCE at a concentration of 60 μg/L (based on J&E modeling and using the older OEHHA toxicity criterion). Also shown for the purpose of comparison is the estimated current (2011) extent of TCE at the 1 μg/L contour (outlined in black) based on groundwater sampling results.

Figure 6.4-13 shows the combined outlines of the projected 30-year extent of PCE at 300 μg/L and TCE at 30 μg/L, with the combined outlines of current extent. This figure demonstrates that revised VICBs which incorporate a change in the toxicity criteria for TCE and PCE (even using the predictive simulations of the 2012 transport model) would (for the most part) fit inside the existing VICB for the combined Sites 37, 133, and 120 plumes; therefore, an official update is not recommended at this time.

The GWVCLs-ind, as drawn in the South AFRL ROD, are shown in green on Figure 6.4-14; by comparison, the GWVCLs-ind based on updated IRIS toxicity criteria are shown as the hatched areas. Because IRIS updates to the PCE toxicity criteria indicate that PCE may be less toxic than considered

by OEHHA, the ROD-selected GWVCL-ind for PCE (based on the OEHHA criterion) is considered to be protective; and in any event, indoor air sampling results obtained during the VIP investigation supersede the outcome of J&E modeling predictions. However, because IRIS updates indicate that TCE may be more toxic than indicated by the OEHHA criterion, the updated GWVCL-ind for this chemical (calculated to be 457 µg/L and rounded to 500 µg/L) encompasses a larger area than the GWVCL-ind of 2,000 µg/L adopted in the ROD. Nonetheless, for existing buildings at the South AFRL, this revision in the GWVCL-ind makes no difference, as it does not encompass any additional buildings, and (as with PCE) results from indoor air sampling supersede the outcome of J&E modeling predictions.

6.4.3.5 Pathway Assessment

The following questions were included in the *South AFRL RAWP* Section 5.1.1, Item 2 to aid in assessment of the VIP:

a. Do soil vapor monitoring results indicate a potential for vapor intrusion into indoor air? Although initial Phase I sampling results suggested the answer is **yes** for six of 18 buildings investigated (as summarized in Section 6.4.3.1), Phase II indoor air sampling results indicate that risks posed by the VIP fall below or within the low end of the 10^{-6} to 10^{-4} risk range (refer to Item d).

b. Do vapor monitoring results in utility vaults exceed SNs listed in Table 4.3-4, and thereby confirm a potential for vapor intrusion into indoor air? **Yes**; PCE concentrations in two (37-8356VL1 and 133-8406VL1) of eight samples collected from utility vaults associated with South AFRL buildings exceeded the SN as summarized in Table 6.4-11 (adapted from Table 2.5-3 in the *South AFRL VI Report*); see also Figures 6.4-8 and 6.4-9. Note, however, that lack of a completed exposure pathway (i.e., absence of receptors in utility vaults) combined with results of indoor air sampling (as summarized in Item d), suggest overall protectiveness.

c. Do sub-slab monitoring results confirm a potential for vapor intrusion into indoor air? The answer is **yes** for all buildings investigated during Phase II monitoring; see results summarized in Table 6.4-7. Although the results from sub-slab samples confirm there is a potential for a complete VIP, risks due to the VIP were further evaluated via indoor air sampling; and results (as summarized in Item d), suggest overall protectiveness.

d. Do indoor air samples confirm the presence of chemicals (that volatilized from the subsurface and migrated into the building as a vapor) at concentrations that pose an unacceptable inhalation risk to workers? No. Based on the summary presented in Table 6.4-8, cumulative cancer risks posed by VOCs attributed to the VIP in the indoor air of South AFRL buildings under an industrial exposure scenario are at the low end of the

risk management range (at or below 1.5 x 10^{-6} [at or below 4.4 x 10^{-6} using California toxicity criteria]) in Buildings 8403, 8406, 8408, and 8595; and below the 10^{-6} point of departure (maximum risk of 1.7 x 10^{-6} using California toxicity criteria) in three other buildings (8354, 8404, and 8411) where indoor air samples were collected. Non-cancer HIs are below 1 in all buildings with the exception of one indoor air sample collected during June 2009 in Building 8595; note that this result was not repeated in three subsequent sampling events, where HIs were less than 0.1 as shown in Table 6.4-8.

i. How do concentrations compare with indoor air concentrations modeled by J&E as documented in Appendix B-1 of the *South AFRL ROD*? Some buildings identified as overlying GWVCLs-ind (designed to be protective at a 10^{-6} cancer risk level) exhibited indoor air risk levels slightly greater than 10^{-6} and others exhibited indoor air risk levels that were less than 10^{-6}.

ii. Can the site-specific estimate of the attenuation factor be improved? Attenuation factors were estimated for PCE and TCE (where detected) in each pair of sub-slab and indoor air sampling locations at Buildings 8354, 8404, 8406, 8408, and 8595 as summarized in Table 6.4-12 (adapted from Tables 4.2-1 and 4.2-2 in the *South AFRL VI Report*). The attenuation factors calculated for PCE in Building 8354 ranged from 0.00008 to 0.003, and from 0.00004 to 0.0074 in Building 8595 (except at 37-8595IA4). Attenuation factors calculated for TCE at the three Site 133 buildings ranged from 0.00009 to 0.005. These results compare favorably with an attenuation factor of 0.001 that was used to establish the SNs (used for Phase I screening of results from near-slab soil vapor samples) in Table 4.3-4, and the SVSLs-ind (calculated from IASLs-ind) presented in Appendix E.1 of the *South AFRL VI Report*.

e. Where engineering controls are implemented, do monitoring results indicate that concentrations of chemicals in indoor air have been reduced below a risk level of 10^{-6}? Operation of the SVE system at Building 8595 is the only engineering control implemented to date. The answer is **yes**; as shown by results that are not boxed in the summary presented on Figure 6.4-10, indoor air concentrations of PCE are reduced below its IAVML-ind (established in the ROD to be protective at a cancer risk level of 10^{-6}) when the system is operating. As previously discussed (see 4th bullet in Section 6.4.3.3) and presented in Table 6.4-8, cumulative risks based on the detection of all VI-related chemicals in the indoor air of Building 8595 are generally less than 1.5 x 10^{-6} (4 x 10^{-6} using California toxicity criteria); effectiveness of the SVE system is most apparent in reducing the concentration of PCE.

6.5 SITE INSPECTION

A site inspection involving the USAF and RPMs representing the California Water Board and DTSC was conducted at the South AFRL on 12 April 2012. Additionally, the USAF Contractor (AECOM) performed LUCs monitoring on 3 April 2012 and during the week of 23 April 2012 as part of the FYR to verify that physical controls inside the South AFRL CZ and VICB are consistent with LUCs, and to

verify that subsurface activities comply with the Base permitting procedures that implement these LUCs.

6.5.1 SITE INSPECTION

The site inspection conducted on 12 April 2012 included visits to Site 37 (Building 8595), Site 133 (CE Yard) and Site 120 (the former STP); see visited areas shown in pink numbers on Figure 6.5-1. Participants agreed that a visit to Site 321 was unnecessary. Photographs taken during the site inspection and the completed FYR Site Inspection Checklist are presented in Appendix F. The following individuals met at the AFRL gatehouse at approximately 1300 hours on 12 April 2012 for the inspection:

- Ms. Patrice Hallman (412 TW/CEVR);
- Mr. Ranney Adams (AFMC AFRL DET7/SE);
- Mr. Tim Post (CRWQCB-LR), RPM for the Water Board;
- Mr. Kevin Depies (California EPA DTSC), RPM for DTSC;
- Mr. Ron Fair (Media Fusion), Base photographer;
- Ms. Sarah Grossi (AECOM); and
- Mr. Mark Henkes (AECOM).

Location 1 (Building 8595 in Site 37) – After signing into the building security log, the party was taken to locations for each of the four sub-slab wells (37-8595SS1 through 37-8595SS4) where indoor air samples had also been obtained. At sub-slab Well 37-8595SS3 (Photo 1), the approximate locations of a former indoor sump and vapor degreaser were pointed out. Mr. Depies inquired about the rationale for selected locations for the sub-slab wells. Mr. Henkes responded that locations were selected: (1) next to potential sources (former sump at Well 8595SS3 and floor drain at Well 8595SS2 [Photo 2]); (2) to provide adequate coverage throughout the building (Well 8595SS4 in the workshop area, western half of the building [Photo 3]); and (3) in the vicinity of offices where workers spend a majority of their time (Well 8595SS1 in an office in the northeastern half of the building). Note that a table (3.0-4) has been added in the *South AFRL VI Report* to provide the rationale for sampling locations inside Building 8595. Mr. Henkes noted that indoor air sampling results have shown

concentrations of PCE remain below the IAVML-ind for PCE (1.7 $\mu g/m^3$) when the SVE system south of the building is operating. By contrast, in indoor air samples collected from locations near Sub-slab Wells 8595SS2 and 8595SS3 following periods when the system has been shut down, PCE has been detected at concentrations that slightly exceed the IAVMLs-ind. Before leaving the area, the party visited the SVE system (Photo 4) located on the south side of the building; this system was reactivated in March 2012 following a 10-month shutdown.

Location 2A/2B (drive-by tour of buildings in Sites 37 and 133) – Other buildings at which samples were collected as part of the South AFRL vapor intrusion evaluation were viewed; note tables (3.0-2 and 3.0-3) have been added to the *South AFRL VI Report* to provide the rationale for sampling locations at these buildings. The tour included a drive around AFRL administration buildings (part of Site 37 and indicated as 2A on Figure 6.5-1) and CE buildings and AFRL workshop/office buildings (part of Site 133 indicated as 2B on Figure 6.5-1). Mr. Depies noted he had inspected the sub-slab wells and near-slab wells at Building 8406 during a previous site visit in April 2009.

Location 3 (Lookout Point) – The South AFRL was viewed from a hill top near the intersection of Range Rd and Mercury Blvd (Photo 5). From this vantage point, Mr. Henkes pointed out the approximate locations of source areas and groundwater plumes at Sites 37, 133, 120, and 321, and the approximate location of the VICB. A map similar to Figure 6.5-1 that shows these features was provided to Mr. Depies and Mr. Post to assist with orientation.

Location 4 (Groundwater Monitoring Well at the STP - Site 120). Mr. Depies inquired about the location of perchlorate plumes in the vicinity of the STP. Mr. Henkes showed the party a copy of the estimated perchlorate plume distributions as presented in the *South AFRL Well Installation Report for 2010 and 2011* (Photo 6). Mr. Depies inquired why groundwater contour maps for the South AFRL do not indicate mounding underneath evaporation ponds at the WWTP. It was discussed that the number of monitoring wells in this area may not be sufficient to contour the small groundwater mound that likely exists under the evaporation ponds. Mr. Henkes opened the protective lid of Well 120-MW11 for Mr. Depies and Mr. Post to inspect the general condition of the well (Photo 7).

6.5.2 LUC MONITORING – GIS AND GROUNDWATER MONITORING WELL NETWORK

Because the GIS is the primary management tool for implementing, documenting, and managing LUCs, the GIS was inspected by Mr. Mark Henkes with the help of Mr. Julio Barrios (412 TW/CEVR) and Mr. Stephen Watts (412 TW/CEVR) on 24 February and again on 3 April 2012. The inspection was performed by accessing South AFRL information by Webmap. The inspection verified that land use restrictions are described in the GIS and a full description of the restrictions are available through GIS via hyperlink to the *South AFRL ROD* (see examples of the screen views in Appendix B.2). Additionally, the GIS includes the geographic control boundaries (CZ and VICB), up-to-date shape files for groundwater plumes, and location of existing groundwater wells.

Inspection of the monitoring well network for the South AFRL was completed during the week of 23 April 2012 by Mr. Mack Miles, Ms. Chrysta Wells, and Ms. Amanda Lopez with AECOM. Generally the 185 wells visited (as part of the network of 209 wells currently used to monitor groundwater at the South AFRL) were observed to be in good shape. Minor issues observed by AECOM in April 2012 included: damaged concrete pads at 10 wells; damaged or broken well lids/hinges at seven wells; well monuments need paint at 25 wells; Well IDs on monuments need to be replaced at 14 wells, and flush mount wells require additional drainage holes at four wells. Issues observed during previous inspections in the FYR period are documented in Appendix B.5 and also used to prepare the summary of well issues listed in Table 4.5-3. Issues observed during the April 2012 inspections are documented in Appendix B.6.

Security measures such as manned security check points, fencing, and security access gates are intrinsic to AFRL and PIRA operations, and complement the administration of LUCs performed through Base permitting processes.

6.6 INTERVIEWS

Interviews were conducted during the weeks of 2 April and 9 April 2012. The interview process was initiated by email transmittals as follows:

- Email on 28 March 2012 from Ms. Sarah Grossi (AECOM) to each of the RPMs requesting return of completed interview forms by 5 April 2012.

- Email on 30 March 2012 from Mr. Ranney Adams (AFMC AFRL Det 7/SE) to stakeholders at the AFRL (including the AFRL RAB representative) and PIRA requesting in-person interviews on 3 April 2012 or 5 April 2012 at the AFRL Safety Building 8255.
- Email on 30 March 2012 from Ms. Patrice Hallman (412 TW/CEVR) to personnel at Main Base involved in LUC implementation via the Base GIS and/or the LTM of groundwater at the South AFRL. The email requested participation in an in-person interview during the week of 2 April 2012.

Note that the emails to all prospective interviewees other than the RPMs included a brief Word file with background information and a portable document format (pdf) figure showing the South AFRL CZ and VICB.

6.6.1 INTERVIEW PARTICIPANTS AND DOCUMENTATION

Table 6.6-1 documents the listing of interviewees, date of the interview, and contact information. The completed interview forms are included in Appendix G. In all, 21 interviews were conducted. Specific interview results for the South AFRL FYR are discussed below.

6.6.2 INTERVIEW SUMMARY

The following sections summarize interview responses for the areas of (1) access to information and community concerns; (2) management/optimization of remedy; (3) and other comments and suggestions.

6.6.2.1 Access to Information and Community Concerns

None of the interviewees were aware of any LUC violations or of any community concerns related to the remedy. No concerns regarding the protectiveness of the remedy or accessibility of remedy information were voiced by personnel employed by the USAF at Edwards AFB, the AFRL at Edwards AFB, RAB members, or AECOM personnel interviewed. However, Mr. Davies, the RAB co-chair, indicated a concern that reducing the RAB meetings from quarterly to semi-annual could potentially result in a communication lag.

6.6.2.2 Management/Optimization of Remedy

Mr. Greg Hogan (AFRL CE Project Manager) acknowledged that CE had been informed of ongoing ERP activities and expressed a desire that this continue. He suggested that sub-slab vapor sampling

locations be added to each facility's handbook, since these locations are not in the GIS database. Mr. Kevin Depies (DTSC) recommended that groundwater sampling be performed at a variable frequency (i.e., a greater frequency at some wells) to address emerging trends in groundwater contaminant concentrations and expressed the need for more frequent groundwater sampling in sentinel wells to confirm that the remedy remains protective. Mr. Joe Healy (USEPA) recommended that CSMs should be based on all relevant information, regardless of the origin of the information. Mr. Healy also added that recent information collected for the Arroyos and Northeast AFRL areas may be pertinent for refinement of the CSM for South AFRL (this information is discussed in Section 3.1.4 of the FYR report). He cited as an example that VOC results from groundwater samples collected in OU7 near the western boundary of the South AFRL CZ should be a part of a CSM discussion (please refer to Section 6.4.2.2, Objective 4, Potential Issue, Item b).

6.6.2.3 Other Comments/Suggestions

A common comment was that the remedy should take into consideration emerging contaminants and/or changes in the understanding of the toxicity of previously identified contaminants and should continue to consider new remedies as they become available. The USAF and Contractor expressed a desire for a more collaborative approach with RPMs. Mr. Ranney Adams (AFRL EM Manager) expressed a desire to balance the need for more monitoring wells against the potential localized environmental disturbance associated with well construction and monitoring.

7.0 TECHNICAL ASSESSMENT

In accordance with USEPA guidance (USEPA 2001), the technical assessment for this FYR focused on responses to the following three key questions for the site:

1. Question A: Is the remedy functioning as intended by the decision document (2007 *South AFRL ROD*)?
2. Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?
3. Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

7.1 QUESTION A: IS THE REMEDY FUNCTIONING AS INTENDED BY THE DECISION DOCUMENTS?

To assess the answer to Question A, the functioning of remedy components addressing LUCs, groundwater, and the VIP were evaluated as indicated below. This evaluation indicates that the remedy is functioning as intended by the 2007 *South AFRL ROD*.

7.1.1 LAND USE CONTROLS

As recommended in Section 3.1 of the OSWER 9355.7-18 guidance document *Recommended Evaluation of Institutional Controls: Supplement to the "Comprehensive Five-Year Review Guidance"* (USEPA 2011), the technical assessment of whether LUCs at the South AFRL are functioning as intended considered the following factors:

1. *Are LUCs in place and effective for all areas of the site that do not achieve UU/UE?* **Yes**. As indicated in Section 4.3.4.3, LUCs for the groundwater medium apply throughout the South AFRL CZ, and LUCs for the VIP apply throughout the VICB. The LUCs detailed in Sections 4.3.4.4 and 4.3.4.5 are in place (implemented as described in Section 4.4.1; maintained as described in Section 4.5.1; and confirmed by the data review in Section 6.4.1); and effective for both the CZ and VICB.
2. *Are exposures occurring, or likely to occur, because LUCs are not in place?* **No**. As confirmed in the site inspection and site interviews (Sections 6.5 and 6.6), no exposures are known to be occurring, nor considered likely to occur; and LUCs are in place.

3. *Are LUCs tailored to the use restrictions specified in the South AFRL ROD as further detailed in the South AFRL RAWP?* **Yes**, as summarized in Tables 4.3-1 and 4.3-2.

4. *Are the LUCs needed to help ensure protectiveness included in the South AFRL ROD?* **Yes**; LUCs are summarized in Section 2.13.2 of the *South AFRL ROD*.

5. Are any additional LUCs needed to help ensure protectiveness? **No**, none identified.

6. *Is documentation of LUCs adequate?* **Yes**, annual LUCs reports (refer to Appendix B.4) have been transmitted to USEPA (with courtesy copies to RPMs representing State agencies) as described in Section 4.5.1.

7.1.2 GROUNDWATER

The technical assessment of whether groundwater remedy components are functioning as intended considered the following factors:

1. *Is the remedy operating as designed?* **Yes** although a CPME scheduled in 2011 was postponed by approximately 9 months (to June and July 2012) due to contractual delays. The groundwater remedy selected as described in Section 4.3.2 (as detailed in Section 4.3.5) was implemented as described in Section 4.4.2 with LTM ongoing as described in Section 4.5.2. Costs (as presented in Table 4.5-4) for LTM during the first 4 years were approximately 45 percent higher than those estimated in the ROD, primarily because the ROD estimate did not include costs to install additional monitoring wells (refer to Section 4.5.2.7), although the need for additional monitoring wells was anticipated as described in ROD Section 2.13.2.2; and included in the LTM strategy presented in RAWP Version 1.0, Section 3. As the remedy is still in an early phase of implementation (and per the LTM strategy presented in RAWP Section 3.2), it is anticipated that the need to further increase the monitoring well network by approximately five to 10 wells to during each FYR period will continue over the next 10-20 years; therefore, future planning should likely include estimated well installation costs of $250,000 to $500,000 per FYR period over that time period. Based on the evaluation presented in Section 6.4.2, the USAF concludes that the groundwater TI waiver remedy requiring LTM and LUCs is operating as designed. Note, however, that DTSC has expressed doubt as to whether the question with regard to the groundwater remedy component can be fully addressed until a comprehensive groundwater monitoring event is completed and the results evaluated.

2. *Have performance standards been met or are likely to be met?* **Yes.** The performance standard to be met is containment of groundwater contaminants at levels exceeding pMCLs (or other RBCGs for chemicals without pMCLs) within the CZ; monitoring results indicate this standard was met during the FYR period, whether based on the USAF's interpretation of TCE extent (depicted on Figures 3.0-2 and 6.4-4) incorporating results from Wells 13-MW34 through 13-MW47; or the USEPA's alternate interpretation of TCE extent (depicted on Figure 6.4-5) that assumes fracture flow which bypasses these monitoring wells. Based on the USAF's interpretation of distributions and predictive simulations of the

2012 Groundwater Modeling Report for the South AFRL as depicted on Figures A.3-3 and A.3-4 in Appendix A.3, it is likely that containment will continue to be achieved for at least another 150 years to 200 years; however, as indicated elsewhere (see Section 4.5.2.2), the USAF questions the continuing utility of flow and transport modeling as a predictive tool. It should be noted that USEPA recommends the answer to this question should be revised to state that it is not known whether the plume is contained with the CZ, based on the reasoning summarized in Item (b) under Objective 5 in Section 6.4.2.2 (see also USEPA specific comments 13 and 18; and USAF responses, which are included in Appendix H).

3. *Are there problems with the remedy that suggest protectiveness is at risk?* **No**. The land use remains industrial; groundwater underlying the South AFRL CZ is not used as a drinking water source; and LUCs are in place to prevent exposure to the impacted groundwater.

4. *Opportunities for optimization*. The following are identified as opportunities for optimizing the groundwater remedy:

   a. LTM Strategy. Are the number and location of wells and sampling frequency adequate to assess containment inside the CZ?

      i. Initially, one additional well is planned to better delineate the leading (southern) edge of the TCE plume at Site 133; and additional investigation is needed to assess the nearly 100-foot water table disparity between Well 13-MW39 and nearby Wells 13-MW38 and 13-MW43 near the toe of the plume. Additional wells supplemented by techniques to be identified in the RAWP Version 2.0 may be needed to resolve concerns raised by regulatory agency RPMs regarding the delineation of plume extent in this area (see discussion in Section 6.4.2.2, Objective 1, Item a).

      ii. Two wells are recommended to better delineate the leading (western) edge of the perchlorate plume at Site 37.

      iii. As intended when the *South AFRL RAWP* Version 1.0 was prepared, the strategy for future well installations and sampling frequency should be updated to guide fieldwork over the next 20 years; planning for RAWP Version 2.0 should incorporate results from wells installed and sampling conducted through 2012. This update should include a flowchart for assessing the frequency of groundwater monitoring for each existing well. Based on this exercise, it is likely that the frequency of monitoring may be increased in some wells near the leading edges of the Site 37 and Site 133 plumes; and other wells may be identified for permanent destruction.

      iv. During comprehensive plume monitoring to be conducted during the next FYR period, sampling for 1,4-dioxane should be conducted in a sufficient number of monitoring wells at key locations, both current and future, to update the distribution of this chemical particularly with respect to downgradient extent.

   b. Groundwater modeling. Do simulations of groundwater flow and contaminant transport modeling project that the plume will continue to be contained within the CZ?

i. Modeling continues to project that the plume will be contained within the CZ for the foreseeable future (next 150 to 200 years), although simulations of the 2012 flow and transport model indicate a possible breach of the CZ boundary after 200 years, which is a different outcome than simulations presented in the ROD (based on the 2005 groundwater model) that predicted groundwater plumes would not breach the CZ boundary within 1,000 years. It should be noted that these differences are not due to new field data but rather represent different approaches to constructing groundwater flow and contaminant transport models; and demonstrate the considerable uncertainties associated with groundwater modeling over such a large area and long time period.

ii. Due to limitations (cost, access, and technology) that prevent the collection of site-specific data at a sufficient scale to significantly refine input assumptions, the flow and transport models developed for the South AFRL have necessarily entailed a large number of assumptions that cannot readily be tested, thus limiting the utility of predictive simulations. Please refer to Appendix A.3 regarding limitations involving assumptions used in transport modeling. A fundamental assumption affecting the groundwater flow model is that, over the large area and volume of the subsurface impacted by contamination, the bulk flow of groundwater through an extensive network of fractures can be simulated as equivalent to flow through a porous medium. As summarized in Section 1.3.1 of the *2012 Groundwater Modeling Report for the South AFRL* (AECOM 2012b), the use of porous media assumptions is supported by (1) the distribution of groundwater elevations, which suggest that bulk groundwater flow generally follows the topographic slope; and (2) orientation of the delineated plumes, which is generally consistent with groundwater flow direction. Further, results from longer-duration aquifer pumping tests (summarized in Table 7.1-1) have demonstrated a radial response over scales ranging from 28 feet up to 990 feet, consistent with behavior in a more isotropic hydrogeologic setting. On the other hand, results of tracer tests (Earth Tech 2005e, Earth Tech 2008f, AECOM 2012l), confirmed by borehole visualization surveys and early data in aquifer pumping tests, have demonstrated anisotropic flow due to a predominant fracture orientation on a localized scale (typically less than 50 feet). While acknowledging both the limitations with assumptions used to develop the porous media model, and the potential usefulness of fractured flow modeling on a localized scale, the project team maintains that development of a fractured media model at the scale of the 2012 model domain would entail significantly more assumptions to derive inputs such as the frequency, distribution, orientation, and aperture of conductive fractures.

iii. Rather than the iterative validation and updating of flow and transport models as proposed in *RAWP* Version 1.0 Section 3.4, a suggested optimization is to reduce reliance on such computer modeling and develop (as part of RAWP Version 2.0) a robust list of data quality objectives (DQOs) that set measurable metrics for groundwater monitoring over the next 5-10 years. If the need for additional sentinel wells is identified, the field program to install this network

could be designed to aid with evaluating the nature and location of transition to the alluvial aquifer west of the CZ boundary (i.e., accelerate field investigations to assess hydrogeologic conditions in this area).

5. *Are access restrictions and LUCs in place to prevent exposure*? **Yes**; refer to Section 7.1.1.

6. *Is LTM documentation adequate*? **Yes**, AGMRs and well installation reports (WIRs) have been submitted as listed in Table 4.5-1; opportunities for optimization exist as follows:

   a. Provide results for LTM of all South AFRL sites in a single report (over the 5-year period from October 2007 through December 2011 reports were prepared by two different contractors); and

   b. Submit reports and a plan for the upcoming year in a more timely fashion (drafts within 6 months of sample collection and final within 12 months).

7. *Are other actions necessary to ensure that there are no exposure pathways that could result in unacceptable risks*? **No**, none identified.

7.1.3 VAPOR INTRUSION

The technical assessment of whether VIP remedy components are functioning as intended considered the following factors:

1. *Is the remedy operating as designed?* **Yes**. For the VI remedy selected as described in Section 4.3.3 (and detailed in Section 4.3.6), monitoring was initiated as described in Sections 4.4.3 and 4.5.3, with results as summarized in Section 6.4.3. Based on the evaluation of results as presented in Section 6.4.3, the remedy as implemented to date is protective.

2. *Have performance standards been met or are likely to be met?* **Yes**. Based on the evaluation of results as presented in Section 6.4.3, the performance standards (indoor air concentrations of PCE and TCE below IAVMLs-ind as listed in Table 3.5-2) were not exceeded in indoor air samples collected during the past 5 years in South AFRL buildings except at two locations (37-8595IA2 and 37-8595IA3) in Building 8595 during periods when the SVE system was offline (refer to results shown in red on Figure 6.4-10) and at one other location (37-8595IA4) with an anomalous result in January 2012 (not confirmed during re-sampling in February 2012). Note (with the exception of the anomalous result from IA4) that these concentrations of PCE do not exceed the IASL-ind derived using the cancer unit risk factor (URF) for PCE that was updated in the IRIS database in February 2012.

3. *Are there problems with the remedy that suggest protectiveness is at risk?* **No**, none identified.

4. *Opportunities for optimization*. At locations where additional sub-surface vapor sampling is proposed, the next such event will include TO-15 analyses for near-slab and/or sub-slab

samples with naphthalene included on the analyte list; with results confirmed at 5 to 10 percent of sampling locations by the collection of sorbent tubes for analysis by Method TO-17, as recommended by DTSC (2012).

5. *Are access restrictions and LUCs in place to prevent exposure?* **Yes**; refer to Section 7.1.1.

6. *Is VI documentation adequate?* **Yes**, in the short-term (first FYR period). As described in Section 4.5.3.3, sampling and results of vapor monitoring activities conducted from March 2009 through January 2011 are presented in detail in the *South AFRL VI Report* (AECOM 2012c); however, as noted in Section 6.4.3.2 (and first set of bullets in Section 7.3.3), the USAF plans additional evaluation before the next FYR period to incorporate updates to sampling protocol per various guidance documents published since 2009. Results for January 2012 sampling conducted in Building 8595 are summarized in the *Building 8595 SVE Memo* (AECOM 2012f); summaries of the SVE system during the post-ROD period were provided in AORs for 2007, 2008, and 2009. While the USAF continues to operate the SVE system pending concurrence on the long-term strategy for VI at Building 8595, AORs summarizing SVE system operation will be prepared for 2012 and any subsequent years of operation.

7. *Are other actions necessary to ensure that there are no exposure pathways that could result in unacceptable risks?* **No**. None identified.

7.2 QUESTION B: ARE EXPOSURE ASSUMPTIONS, TOXICITY DATA, CLEANUP LEVELS, AND RAOS STILL VALID?

As applicable, the following sections assess the answer to Question B for LUCs, groundwater, and VI components of the remedy selected in the 2007 *South AFRL ROD*.

7.2.1 LAND USE CONTROLS

As recommended in Section 3.1 of the OSWER 9355.7-18 guidance document *Recommended Evaluation of Institutional Controls: Supplement to the "Comprehensive Five-Year Review Guidance"* (USEPA 2011), the technical assessment of Question B with respect to LUCs considered the following factors:

1. *Has there been an actual or potential change in exposure pathways due to changes in land use or zoning?* **No**. As described in Section 3.2, the land uses designated for the South AFRL are industrial in nature, and there have been no changes over the past 5 years. The exposure and land use assumptions (industrial) made during remedy selection are consistent with current site conditions and remain essentially unchanged (changes in toxicity criteria are discussed in Sections 7.2.2 and 7.2.3). No buildings were constructed inside the South AFRL VICB or CZ between October 2007 and December 2011.

2. *Has there been an actual or potential change in exposure pathways due to changes in groundwater or surface water use?* **No**. Groundwater inside the South AFRL CZ is not currently used as a drinking water source and LUCs selected as part of the CERCLA remedy prevent the future use of groundwater inside the CZ as long as contaminant concentrations remain above levels allowing for UU/UE. There are no naturally occurring surface water bodies; the discharge of water to evaporation/percolation ponds following treatment at the WWTP remains unchanged.

3. *Is there new information or changed conditions resulting in new exposure pathways (e.g., VI into homes and other structures)?* **No**.

4. *Have physical site conditions or the understanding of these conditions changed in a way that could affect the protectiveness of the remedy?* **No**. There have been no changes in physical site conditions, and no new data that would affect the understanding of site conditions, that would affect the protectiveness of the remedy.

5. *Is the overall remedy progressing as expected toward meeting RAOs?* **Yes**. The RAOs presented in the ROD and remedies implemented to address these RAOs are still applicable and appropriate. No changes to site conditions have occurred that would affect the remedy performance.

7.2.2 GROUNDWATER

The technical assessment of Question B with respect to groundwater considered the following factors: changes in RBCGs adopted as containment levels; changes in toxicity criteria via oral exposure; changes in risk processes for groundwater exposure; and progress toward meeting groundwater RAOs.

7.2.2.1 Changes in RBCGs Adopted as Containment Levels

Table 3.5-1 (adapted from Table 2.5-1 in the ROD) lists the concentrations of groundwater COCs requiring containment inside the CZ. These containment levels were the more stringent of promulgated federal or state pMCLs for all COCs at the time the USEPA signed the ROD on 24 September 2007; note that neither a state nor federal pMCL had been established for perchlorate, 1,4-dioxane, or NDMA at that time. The following RBCGs were adopted for these three chemicals:

- 0.024 mg/L for perchlorate, which was its drinking water equivalent level (DWEL) based on a USEPA toxicity evaluation in 2005, and adopted as a "level of concern" by the DOD in January 2006.

- 3 μg/L for 1,4-dioxane, which was the California notification level (NL) in drinking water established in 1998.

- 0.01 μg/L for NDMA, which was the California NL in drinking water established in 2002; California adopted this concentration as a public health goal (PHG) in 2006.

As summarized in Table 7.2-1, there were no changes to pMCLs adopted as containment levels in the 2007 ROD; nor was there a change to the CA NL for NDMA. It is anticipated that the pMCL for TCE may be revised during the next FYR period as discussed in Section 7.2.2.2. A State pMCL for perchlorate was selected in October 2007, and the CA NL for 1,4-dioxane was revised in November 2010. The impacts of these changes to the protectiveness of RBCGs selected in the ROD are discussed below:

- Establishment of State MCL for perchlorate. Effective October 2007, the State of California designated perchlorate a regulated drinking water contaminant, with an MCL of 0.006 mg/L. On the federal level, perchlorate remains unregulated and is identified by USEPA as an "emerging" contaminant. There is no impact to the LTM program over the past 5 years because the analytical method used for perchlorate has an RL of 0.001 mg/L, and figures showing the estimated distribution of perchlorate have included contours for both the CA pMCL of 0.006 mg/L and the RL of 0.001 mg/L. However, in terms of the concentration to be contained inside the CZ, the impact is significant; revision of the containment level to adopt the ARAR (State pMCL) would potentially entail implementation of containment measures much sooner than would be required based on the higher containment level adopted in the ROD (with reference to Figure 3.0-4, compare the distribution of perchlorate at concentrations at or above 0.024 mg/L [results shown in red] with the extent inside the 0.006 mg/L contour [outlined in green]).

- Change in NL for 1,4-Dioxane. Effective November 2010, the California NL for 1,4-dioxane was lowered from 3 μg/L to 1 μg/L; note the USEPA's (non-promulgated) Regional Screening Level (RSL published in November 2011) for this chemical in tapwater is 0.67 μg/L. The current CA NL for 1,4-dioxane is 3 times lower than the RBCG adopted in the ROD and thus protective within the same order of magnitude. Although the areal extent of groundwater with 1,4-dioxane concentrations that exceed 1 μg/L is approximately 3 times greater than the areal extent of groundwater with 1,4-dioxane concentrations exceeding 3 μg/L (refer to contours shown on Figure A.4-1), the overall distribution of this chemical is limited and unlikely to approach the CZ boundary. For these reasons, the USAF considers the existing RBCG adopted as a containment level to be protective; and no revision is recommended in response to the change in NL for this chemical. In practice, the analytical method used to monitor concentrations of 1,4-dioxane over the past 5 years has an RL of 1 μg/L, and figures showing the estimated distribution of 1,4-dioxane have included contours both at the RBCG of 3 μg/L and the RL of 1 μg/L.

In addition to containment levels discussed above, the ARARs identified in the ROD were reviewed as summarized in Appendix D; this evaluation concluded there were no changes affecting protectiveness of the remedies.

7.2.2.2 Changes in Toxicity Criteria Via Oral Exposure

Over the past 5 years, the USEPA has updated toxicity criteria for a number of chemicals in its IRIS database. Table 7.2-2 lists the groundwater COCs and the dates that toxicity criteria for the oral exposure route were adopted; the past 5 years have seen updates to toxicity criteria for cis-1,2-DCE, trans-1,2-DCE, methylene chloride, PCE, 1,1,1-TCA, TCE, and 1,4-dioxane (chemicals and dates listed in red). The oral reference doses (RfDs) (and their source) recommended for use by the California DTSC are listed in the right-hand columns of Table 7.2-2; except for three values (shown in purple) based on provisional peer-reviewed toxicity values, the source for these RfDs is the IRIS database. Because TCE is a primary COC and the new cancer and noncancer toxicity criteria may impact its drinking water MCL, the following discussion is limited to the potential impact of this revision:

- Anticipated Change in MCL for TCE. A lower federal MCL may be derived by the USEPA Office of Water within several years (and a lower State pMCL is expected sooner); the tapwater RSL has already been reduced by an order of magnitude to 0.44 μg/L (refer to Table 7.2-1). If/when a State or federal pMCL is adopted, it is recommended that the containment level for TCE be revised during the next FYR period. In the meantime, the change to the toxicity factor for TCE is not expected to impact the functionality and protectiveness of the groundwater remedy invoking a TI waiver inside the South AFRL CZ; the remedy already requires certain conditional actions (as listed in Section 4.3.2) should a COC be detected in a sentinel well outside the CZ boundary; and/or when breach of the CZ boundary is projected within the next 10 years. These conditional actions include preparation of a TEFA to determine the concentration of contaminants that can practicably be treated; and the design and implementation of a containment system to prevent breach of the CZ.

7.2.2.3 Changes in Risk Processes for Groundwater Exposure

The South AFRL ROD presented results from a preliminary screening-level HHRA for each of Sites 37, 133, 120 and 321 that calculated the ratio between the maximum concentration of each chemical detected in groundwater to a risk-based screening level for tapwater (multiplied by 10^{-6} for carcinogens); these ratios were summed to estimate the cumulative cancer risk and the noncancer HI. Because the groundwater at South AFRL is not used as a drinking water source, the residential exposure scenario is considered hypothetical. Results of these HHRAs (summarized in Section 2.7.1 of the ROD and Section 3.5.1 in this report) indicated that if groundwater at the South AFRL were to be used for drinking water purposes, such use would pose an unacceptable risk. VOCs and other

chemicals (e.g., 1,4-dioxane, NDMA and perchlorate) persistently detected at concentrations contributing to this risk were identified as COCs as listed in Table 3.5-1; note that drinking water standards for these chemicals are waived due to TI inside the CZ. The underlying risk assessment exposure assumptions used to select the COCs for the sites have not changed.

Because LUCs are in place to prevent exposures to South AFRL groundwater (including its use as a drinking water source), there are no currently complete exposure pathways. Risks/hazards associated with the hypothetical future use of South AFRL groundwater are expected to be similar to those presented in the conservative screening level HHRAs.

7.2.2.4 Progress Toward Meeting Groundwater RAOs

As listed in Section 4.2, two (of three) primary RAOs (presented in Section 2.8 of the ROD) address groundwater as follows:

- Protect human health by preventing (through LUCs) ingestion of groundwater contaminated by COCs at concentration levels exceeding their respective pMCLs or other RBCGs (for those COCs without pMCLs); and
- Prevent migration outside of the South AFRL CZ boundary of groundwater impacted by COCs at concentration levels exceeding their respective pMCLs or other RBCGs (for those COCs without pMCLs).

The data evaluation and other components of the FYR process presented in Section 6 of this report demonstrate that, through the implementation of LUCs and monitoring, adequate (i.e., expected) progress has been made in achieving these RAOs. These RAOs and the remedy implemented to address them are still applicable and appropriate. No changes to site conditions have occurred that would affect the remedy performance.

7.2.3 VAPOR INTRUSION

The technical assessment of Question B with respect to VI considered the following factors: VIP-related COCs; changes in toxicity criteria via inhalation exposure; changes in mitigation levels for VIP-related COCs; changes in risk processes for exposure via the VIP; and progress toward meeting VIP-related RAOs.

7.2.3.1 VIP-related COCs

Table 3.1-1 (adapted from Table 2.13-1 in the ROD) and Table 3.5-2 (adapted from Table 2.13-3 in the ROD) list the chemicals identified in the ROD as posing a potential risk via the VIP under residential and industrial exposure pathways. Four chemicals (benzene, cis-1,2-DCE, PCE, and TCE) were identified as VIP-related COCs for the residential pathway; while only PCE and TCE were identified as VIP-related COCs for the industrial exposure pathway. By contrast, Table 7.2-3 lists 25 chemicals (including m,p-xylenes and o-xylenes entered separately) identified as potentially VIP-related in the *South AFRL VI Report,* based on the pattern of their detection in sub-slab vapor samples collected below existing buildings in the South AFRL, and other lines of evidence as summarized in Appendix E.2 of the *South AFRL VI Report*. Included on this list are:

- 11 chemicals that are groundwater COCs;
- 11 chemicals detected in groundwater but not identified as groundwater COCs because detections were at low concentrations, sporadic and/or of limited extent; and
- 3 chemicals (4-ethyltoluene, dichlorodifluoromethane [DCDFM], and styrene) that have not been detected in groundwater but were identified as VIP-related based on their detection in sub-slab vapor samples.

Note that for most of these chemicals, the maximum concentration detected in any indoor air sample was at least 5 times lower than its IASL-ind designed to be protective at a cancer risk level of 10^{-6} or HI of 1. Only three chemicals were identified (under the current industrial land use; and using toxicity factors in the IRIS database) in at least one indoor air sample as potentially posing a cancer risk greater than or equal to 5×10^{-7}: benzene, ethylbenzene, and TCE; two additional chemicals (PCE and vinyl chloride) would be identified based on use of more protective OEHHA toxicity criteria. One chemical (trans-1,2-DCE) was identified (at two sampling locations) at a concentration posing an HQ greater than 0.5. Based on this evaluation of VI sampling results (that included analysis of a much longer VOCs list than COCs identified in the ROD), it is recommended that ethylbenzene, trans-1,2-DCE, and vinyl chloride be identified as chemicals of potential concern (COPCs) via the VIP under a residential exposure scenario; and benzene, cis-1,2-DCE, ethylbenzene, trans-1,2-DCE, and vinyl chloride be identified as COPCs via the VIP under an industrial exposure scenario. Note that this list of COPCs requiring further evaluation includes the anticipated daughter products from reductive dechlorination of

PCE and TCE (expected to occur locally in areas where petroleum products were co-released with solvent).

7.2.3.2 Changes in Toxicity Criteria Via Inhalation Exposure

As indicated in Section 7.2.2.2, the USEPA in the past 5 years has updated toxicity criteria for a number of chemicals in its IRIS database. Table 7.2-4 indicates the changes made to toxicity criteria for VIP-related chemicals listed in Table 7.2-3; note that updates were made to the toxicity criteria for trans-1,2-DCE and methylene chloride in addition to changes for PCE and TCE discussed below. Changes to the toxicity criteria for PCE and TCE via the inhalation exposure route can be summarized as follows:

- Based on the revised IRIS toxicity criteria for PCE, this chemical is a less potent carcinogen by a factor of approximately 23 and less toxic for noncancer effects by a factor of approximately 7. Note the California OEHHA toxicity criteria for PCE remain unchanged and DTSC prefers the use of these more protective OEHHA criteria.
- Based on the revised toxicity criteria for TCE, this chemical is a more potent carcinogen by a factor of approximately 2 and more toxic for noncancer effects by a factor of approximately 300.

To ensure protectiveness of the VI remedy, it is recommended that evaluation of PCE and TCE in indoor air take into consideration the changes in toxicity criteria for PCE and TCE, as further discussed in Section 7.2.3.3.

7.2.3.3 Changes in Mitigation Levels for VIP-Related COCs

For VIP-related COCs identified in the ROD, Tables 3.1-1 and 3.5-2 list the IAVMLs-res and IAVMLs-ind for indoor air concentrations meant to be protective at the 10^{-6} risk level and an HQ of 1. Per the *Basewide VI Protocol* (to be issued as draft final in late 2012), indoor air screening levels (IASLs) have been calculated using the standard exposure assumptions that USEPA Regions 3, 6, and 9 use to derive their RSLs; and toxicity criteria based on the most recent updates to IRIS and OEHHA databases or from other sources cited in the USEPA Region 9 RSLs. These IASLs (by comparison to IAVMLs as applicable) are listed for the VIP-related COCs and COPCs in Table 7.2-5. CA-IASLs (based on use of more protective OEHHA toxicity criteria as applicable) are also shown for comparison.

7.2.3.4 Changes in Risk Processes for Exposure via the VIP

The South AFRL ROD in Appendix B-1 presented a baseline risk assessment for the VIP; risks were calculated using the J&E model version 3.1 based on inputs using the 95 percent UCL of the mean for groundwater concentrations. The VIP-related COCs listed in Tables 3.1-1 and 3.5-2 were identified as an outcome of this risk assessment. As part of this FYR, revised GWVCLs were calculated as listed in Table 6.4-10 and discussed in Section 6.4.3.4.

Based on results of the VI evaluation conducted in 2009 through January 2011, Appendix E.3 of the *South AFRL VI Report* (and Appendix D of the *Building 8595 SVE Memo*) presents cumulative risks calculated for each indoor air sampling location inside Buildings 8354, 8595, 8403, 8404, 8406, 8408, and 8411 as summarized in Table 6.4-8. Cumulative risks and HIs are presented for: (1) all VOCs detected based both on IASLs-ind and CA-IASLs-ind; and (2) that subset of VIP-related VOCs (also based both on IASLs-ind and CA-IASLs-ind). Granting the potential data gaps listed in Table 6.4-9, the results for VIP-related chemicals nonetheless indicate that exposures under the current industrial scenario are unlikely to exceed the low end of the 10^{-6} to 10^{-4} risk management range for cancer or an HI of 1. As can be seen for minima and maxima summarized at the bottom of the table, cumulative risks for VIP-related VOCs ranged from 5.3×10^{-8} to 1.5×10^{-6} (2.5×10^{-7} to 4.4×10^{-6} using California toxicity criteria) and all HIs were below 1 (except at one sample location in Building 8595 where an anomalously high concentration of trans-1,2-DCE was detected in June 2009).

7.2.3.5 Progress Toward Meeting VIP-Related RAOs

As listed in Section 4.2, one of the three primary RAOs (presented in Section 2.8 of the ROD) addresses VI as follows:

> Protect human health by preventing (through LUCs and engineering controls) inhalation of vapor-phase COCs in indoor air that pose an unacceptable risk (greater than 1×10^{-6}) under a residential or industrial exposure scenario.

The data evaluation and other components of the FYR process presented in Section 6 of this report demonstrate that, through the implementation of LUCs and VI monitoring, adequate (i.e., expected) progress has been made in achieving this RAO. This RAO and the remedy implemented to address it are still applicable and appropriate. No changes to site conditions have occurred that would affect the remedy performance.

7.3 QUESTION C: HAS ANY OTHER INFORMATION COME TO LIGHT THAT COULD CALL INTO QUESTION THE PROTECTIVENESS OF THE REMEDY?

As applicable, the following sections assess the answer to Question C for LUCs, groundwater, and VI components of the remedy selected in the 2007 *South AFRL ROD*.

7.3.1 LAND USE CONTROLS

As recommended in Section 3.1 of the OSWER 9355.7-18 guidance document *Recommended Evaluation of Institutional Controls: Supplement to the "Comprehensive Five-Year Review Guidance"* (USEPA 2011), the technical assessment of Question C with respect to LUCs considered the following factors:

1. *Are there indications that land or other resource uses may be changing (e.g., due to redevelopment)?* **No**. As indicated in the answer to Question B, Section 7.2.1, land and resource uses in the South AFRL remain unchanged. No new ecological risks are anticipated.

2. *Have state or local land use laws changed in a way that could significantly impact LUCs at the site?* **No**.

3. *Do current conditions (e.g. a breach of the CZ or a breach of LUCs) warrant a change to LUCs?* **No**. There are no identified breaches to the LUCs.

7.3.2 GROUNDWATER

Has any other information come to light that could call into question the protectiveness of the remedy? **No** information has come to light that calls into question the protectiveness or appropriateness of the TI waiver remedy for groundwater; however, the following new information/new interpretation may impact (i.e., support acceleration of) the schedule for undertaking field investigations (e.g., subsurface geophysics, aquifer pump tests, and/or discrete zone monitoring wells to assess contaminant transport in the fractured bedrock and nature and location of the alluvial aquifer/fractured bedrock interface) to provide greater confidence in contaminant distribution and to evaluate the plumes' actual behavior against the site conceptual and computer groundwater models:

- The higher-than-anticipated TCE concentrations found in Wells 13-MW41, 13-MW42, and 13-MW43 near the leading edge of the Site 133 groundwater plume; and the disparity in depth to groundwater between Wells 13-MW38, 13-MW43 and 13-MW39 in the same area; and

- Output from the *2012 Groundwater Modeling Report for the South AFRL* that simulates a potential breach of the CZ boundary in 200 years versus simulations from the 2005 transport model (cited in the ROD) that showed no breach of the CZ within 1,000 years.

7.3.3 VAPOR INTRUSION

Has any other information come to light that could call into question the protectiveness of the remedy? **No** information has come to light that calls into question the protectiveness of remedy components selected to address the VIP; based on the monitoring conducted to date, the VIP does not appear to pose significant risk to current workers. Except in Building 8595, PCE and TCE concentrations in the indoor air of existing buildings are below IAVMLs-ind selected in the ROD; and cumulative risk due to VI-related compounds is generally below 1.5×10^{-6} (4.4×10^{-6} based on California toxicity criteria). To assess the impact of SVE operations on indoor air concentrations inside Building 8595, sampling events were conducted with the system operating and again when it was offline. PCE in the indoor air of Building 8595 was detected in two locations at concentrations slightly above its IAVML-ind when the SVE system located south of the building was not operating.

Note that IAVMLs selected in the ROD were developed using toxicity criteria published by OEHHA; subsequently (as discussed in Section 7.2.3.2), the USEPA's toxicity criteria for both chemicals were updated in IRIS (cumulative risk results are based on the updated IRIS toxicity criteria with results based on more protective toxicity criteria as preferred by California DTSC shown in parentheses). Using Tier 1 (IRIS) toxicity criteria updated with the latest available science and under CERCLA risk assessment guidance, risk of inhaling PCE is now calculated to be 23 times lower than when the ROD was signed in 2007. This further contributes to the finding of protectiveness in this FYR of the South AFRL remedy. However, because the guidance for evaluating the VIP has evolved over the past 5 years, the following optimizations are recommended:

- Additional evaluation to strengthen building-specific CSMs and improve confidence in existing results; and

- Development of a VI program in RAWP Version 2.0 that more clearly specifies criteria regarding the need for: (1) no further evaluation; (2) continued monitoring; and/or (3) mitigation to disrupt the VIP. Pending the development and implementation of these criteria, the USAF intends to continue operating the existing SVE system at Building 8595; however, the RAWP Version 2.0 will specify long-term plans for this system.

Further, ***if*** an ESD revision to the ROD is planned (to adopt the CA pMCL for perchlorate as its containment level in groundwater) ***then*** the following revisions to the VIP remedy are also recommended:

- Evaluate whether the COPCs identified in Section 7.2.3.1 should be identified as VI COCs; and
- Adopt the IASLs-res and IASLs-ind listed on Table 7.2-5 as mitigation levels to (1) replace outdated IAVMLs-res and IAVMLs-ind for TCE and PCE identified in the ROD with risk-based concentrations based on updated toxicity criteria; and (2) make use of standardized exposure assumptions.

7.4 TECHNICAL ASSESSMENT SUMMARY

According to the data review, site inspection and interviews, the remedy is functioning as intended by the ROD. There have been no changes in the physical conditions of the site that would affect the protectiveness of the remedy. Changes to pMCLs and RBCGs selected as groundwater containment levels are summarized in Table 7.2-1, and revisions to groundwater toxicity factors are summarized in Table 7.2-2. Revisions to inhalation toxicity factors for VI-related chemicals (listed in Table 7.2-3) are summarized in Table 7.2-4. Based on monitoring results, the VIP-related COCs for the South AFRL, and their associated IASLs (recommended for adoption as VI mitigation levels), are listed in Table 7.2-5. There is no information that calls into question the current protectiveness of the remedy.

In conclusion, the answers to Questions A, B, and C can be summarized as follows:

1. Question A: *Is the remedy functioning as intended*? **Yes** although a CPME scheduled in 2011 was postponed by approximately 9 months (to June and July 2012) due to contractual delays.
2. Question B: *Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid*? **No**. The exposure assumptions and RAOs are still valid; however, a State pMCL (ARAR) was established for perchlorate; and toxicity data were updated for the primary COCs TCE and PCE. These revisions do not impact current protectiveness but may impact future protectiveness of the remedy. Based on these revisions and to ensure the continuing protectiveness of the remedy, an ESD is recommended to update the:
    a. Containment level for perchlorate in groundwater. The ESD should revise the concentration to be contained inside the CZ to the State pMCL of 0.006 mg/L rather than the non-promulgated USEPA DWEL of 0.024 mg/L.

b. Mitigation level for TCE and PCE intruded into indoor air via the VIP. If an ESD is prepared, the IAVMLs selected for PCE and TCE in the ROD should be revised to incorporate toxicity criteria updated in IRIS in September 2011 and February 2012, respectively.

3. Question C: *Has any other information come to light that could call into question the protectiveness of the remedy*? **No**; there is no information that impacts protectiveness of the remedy. However, based on new information summarized in Sections 7.3.2 and 7.3.3, the remedy could be optimized by implementing the following actions:

   a. Accelerate hydrogeologic investigations near the downgradient (western and southern) CZ boundary:

   b. Evaluate whether to update the list of VIP-related COCs to include COPCs identified in Section 7.2.3.1;

   c. As needed, conduct further evaluation of risk via the VIP under the current industrial exposure scenario; and

   d. Specify more clearly the actions to be taken based on results of VIP monitoring.

8.0 ISSUES

Issues and opportunities for optimization identified during the course of this FYR are summarized in Tables 8.0-1 and 8.0-2, respectively; and briefly discussed below. On each table, issues or opportunities are sorted by remedy component, with citations to report sections providing more detail, and identification of the agency identifying each issue or suggested optimization.

8.1 ISSUES

Issues identified during this first FYR for the South AFRL remedy are summarized in Table 8.0-1; the far-right columns of this table include a determination of whether the issue affects current or future protectiveness of the remedy.

8.1.1 LUCs

No issues were identified for LUC components of the remedy.

8.1.2 GROUNDWATER ISSUES

Of the two issues identified for the groundwater remedy, neither is expected to affect current protectiveness because LUCs have been implemented to prevent exposures and the current LTM network confirms containment of impacted groundwater inside the CZ; however, see Section 6.4.2.2, Objective 1, Item (a) for USEPA reservations regarding this USAF conclusion. Issue 1 may affect future protectiveness because groundwater impacted by a concentration of perchlorate that exceeds the CA pMCL could be allowed to migrate outside the TI waiver zone. The second issue, involving a revised toxicity criterion (without a promulgated ARAR) for 1,4-dioxane, does not affect the future protectiveness of the South AFRL remedy because the distribution of 1,4-dioxane is limited and groundwater impacted by this chemical is not anticipated to breach the South AFRL CZ.

A recommendation to address each of these issues is provided in Table 9.0-1 cited in Section 9 of the report. No unresolved issues were raised by the public.

8.1.3 VI ISSUES

Of the two issues identified for the VI remedy, neither is expected to affect current protectiveness because LUCs have been implemented to prevent future residential exposure; engineering controls are required to disrupt the VIP if unacceptable under the current industrial exposure; and the VI monitoring performed to assess risk (using updated toxicity factors) under the existing industrial land use indicates that indoor air concentrations do not present a cumulative risk exceeding 1.5×10^{-6} (5×10^{-6} using CA toxicity criteria) for cancer or an HI in excess of 1. Neither issue is expected to affect future protectiveness:

1. Mitigation levels have already been established for the two primary COCs (PCE and TCE) under both the hypothetical residential and the current industrial exposure scenarios; and for benzene and cis-1,2-DCE under the residential scenario. In practice, concentrations of three additional chemicals (ethylbenzene, trans-1,2-DCE, and vinyl chloride) identified as COPCs based on VI monitoring were not detected individually at concentrations posing unacceptable cancer risk or noncancer hazard.

2. The 2007 ROD established IAVMLs for TCE prior to USEPA issuing more protective toxicity criteria in IRIS in September 2011; however, the change for the cancer criterion is only two-fold. Although the change in the non-cancer hazard criterion is 300-fold, the risk-based concentration based on the cancer factor remains lower than the risk-based concentration based on non-cancer effects.

A recommendation to address each issue is provided in Table 9.0-1 cited in Section 9.1 of the report.

No unresolved issues were raised by the public.

8.2 OPPORTUNITIES FOR OPTIMIZATION

Table 8.0-2 presents a list of suggested optimizations for remedy components selected in the ROD: three for continued LUCs implementation and monitoring; nine for LTM of groundwater; and two for VI monitoring and/or mitigation. Each item identified in Table 8.0-2 is entirely consistent with the remedy (involving LUCs and LTM) selected for groundwater and VI in the South AFRL ROD. A recommendation to address each of these suggested optimizations is provided in Table 9.0-2 cited in Section 9 of the report.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Recommendations to address each of the issues and opportunities for optimization identified in Section 8 are summarized in Tables 9.0-1 and 9.0-2, respectively. Each table also provides a suggested timeline.

9.1 REQUIRED/SUGGESTED ACTIONS TO ADDRESS IDENTIFIED ISSUES

Recommendations to address the issues identified in Table 8.0-1 are summarized in Table 9.0-1; and recommendations to optimize LUCs, LTM, and VI monitoring/mitigation are summarized in Table 9.0-2.

9.2 NOTE PARTIES RESPONSIBLE FOR ACTIONS

The USAF as lead agency is responsible for these actions.

9.3 NOTE AGENCY WITH OVERSIGHT AUTHORITY

The USEPA has oversight authority. The DTSC and Water Board as State agencies signatory to the FFA may concur with these actions.

9.4 SCHEDULE FOR COMPLETION OF ACTIONS RELATED TO RESOLUTION OF ISSUES

Each table provides a suggested timeline for implementation of actions; Table 9.0-3 summarizes milestone dates (quarter and year) for key deliverables to be prepared within the next 5 to 7 years. Note that some actions (e.g., groundwater monitoring and possibly the hydrogeologic investigations) are expected to take longer than 5 years but should be initiated within the next 5 years.

The target dates for milestone deliverables assume the parallel development of plans and reports to cover "short-term" (next 3 years) and longer-term (3-10 years) activities. The work plan/ sampling and analysis plan (WP/SAP) listed in Items 3-4, to be prepared in a format consistent with the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP), will govern the installation of wells to refine plume extent at Sites 37 and 133 (compatible with recommendations 1 and 2 for the groundwater medium in Table 9.0-2) and groundwater sampling through 2014; activities to be reported in deliverables 5-6 and 13-14.

In the meantime, the ESD (Items 7-9) will be developed to document the following revisions to South AFRL remedy selected in the 2007 ROD:

1. Adoption of CA pMCL as the level of perchlorate to be contained inside the CZ (see Recommendation 1 for the groundwater medium, Table 9.0-1).
2. Expanding the list of VIP COCs to include chemicals on Table 7.2-5 (Recommendation 1 for the vapor medium, Table 9.0-1); adoption of IASLs (including incorporation of post-ROD toxicity value changes) as IAVMLs (Recommendation 2 for the vapor medium, Table 9.0-1), and describing more specifically when further action (i.e., monitoring and/or mitigation) is required, with a decision tree for those actions.
3. Clarification of the role of predictive methods, specifically computer modeling, in the groundwater remedy (Recommendation 5 for the groundwater remedy, Table 9.0-2).

The RAWP Version 2.0 (Items 10-12) will be developed in parallel with the ESD, to govern groundwater monitoring in 2015 through 2019 (bracketing the period for the next FYR in 2017), including future hydrogeologic investigations to refine the leading edges of plumes and transition to an alluvial aquifer (Recommendation 3 for the groundwater remedy, Table 9.0-2). The RAWP Version 2.0 will also include the plan for further VIP evaluation to be completed by 2016 (Recommendation 1 for the vapor medium, Table 9.0-2); and long-term plans for the SVE system at Building 8595. Although Table 9.0-3 (lines 28-30) tentatively lists a RAWP Version 3.0, the USAF as lead agency will determine if this and future versions of the RAWP are necessary.

10.0 PROTECTIVENESS STATEMENTS

Protectiveness statements for the LUCs, groundwater and VI components of the remedy are presented in the subsections below.

10.1 LUCS

Although a LUC-specific protectiveness statement is generally not required, the USEPA 2011 guidance, *Recommended Evaluation of Institutional Controls: Supplement to the "Comprehensive Five-Year Review Guidance"* recommends that LUCS be mentioned specifically when long-term protectiveness hinges on compliance with LUCs. Such is the case with the South AFRL remedy. Because LUCs selected in the 2007 ROD have been implemented, are effective, and no exposures are occurring, the LUCs component of the remedial action for the South AFRL is protective.

10.2 GROUNDWATER

Based on the technical assessment presented in Section 7, the groundwater remedy at the South AFRL currently protects human health and the environment because LUCs and LTM are in place and effective to prevent exposures and verify containment. However, in order for the remedy to be protective in the long-term, the following actions should be taken to ensure long-term protectiveness:

- Prepare an ESD to revise the containment level for perchlorate to the State pMCL;
- Install additional monitoring wells to refine the distribution of TCE near the southern extent of the Site 133 plume and to refine the western extent of the Site 37 perchlorate plume; and
- Accelerate hydrogeologic investigations near the CZ boundary; possibly including the installation of boundary sentinel wells.

10.3 VAPOR

Based on the technical assessment presented in Section 7, the VI remedy at the South AFRL currently protects human health and the environment because LUCs and monitoring are in place and effective to prevent exposures and verify containment. To optimize the long-term protectiveness of the remedy, the following actions are recommended:

- If an ESD is prepared to revise the groundwater containment level for perchlorate (and TCE), evaluate whether to update the list of COCs to include COPCs listed in Table 7.2-5; and revise mitigation levels for PCE and TCE based on updated toxicity criteria in IRIS database;

- Continue to operate the SVE system at Building 8595 as a temporary mitigation to enhance the reduction of VIP risk inside Building 8595 pending development in RAWP Version 2.0 of a long-term plan for VIP monitoring and/or mitigation inside this building; and

- For other South AFRL buildings, conduct additional investigations to confirm acceptable risk to current workers.

11.0 NEXT REVIEW

The next FYR for South AFRL is required by 24 September 2017, 5 years from the finalization date of this review.

12.0 REFERENCES

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TABLE 2.0-1. CHRONOLOGY OF SITE EVENTS – SOUTH AFRL

	Event	Date	Reference
1	***Pre-NPL Activities.*** Installation Restoration Program (IRP) (now known as Environmental Restoration Program [ERP]) investigations were conducted at Edwards AFB throughout the 1980s at 21 sites in the Main Base, South Base, and AFRL areas. An initial preliminary assessment (Envirodyne Engineers, Inc. 1981) was conducted at the Base in 1980, which included an evaluation (but no sampling) of Sites 6 and 7 at the AFRL. Site 12 was investigated in 1986 (Engineering-Science 1988a) and 1991 (Dames & Moore 1991). Site 13 was investigated in beginning in 1985 (Engineering-Science 1988b). In February 1989, the USEPA used results obtained from IRP investigations at Sites 2, 3, 8, 15, 18, 19, and 21 (sites located at Main Base and South Base) to obtain an aggregate Hazard Ranking System score for Edwards AFB of 33.62, above the 28.5 cutoff for placement on the NPL. The Base was proposed for listing on the NPL in July 1989.	**1980**	*Assessment of the Potential for Groundwater Contamination, Edwards Air Force Base Hazardous Waste Disposal Sites Evaluation* (Envirodyne Engineers, Inc. 1981). *Installation Restoration Program, Phase II – Confirmation/Quantification, Stage 3B, for Edwards AFB, California, Final Report, Volumes 1-3* (Engineering-Science 1988a) *Report Environmental Geological/Geophysical Investigation, Phillips Laboratory Rocket Test Stand – Catchment Base, Edwards AFB, California (*Dames & Moore 1991) *Monitoring Well Resampling Program and Lysimeter Evaluation Report, Edwards Air Force Base, California, Volumes 1 and 2* (Engineering-Science 1988b)
2	***NPL Listing and Federal Facility Agreement***. Edwards AFB was formally listed on the National Priorities List (NPL) on 30 August 1990. The Base then entered into a Federal Facility Agreement (FFA) on 25 September 1990 with the United States Environmental Protection Agency Region 9 and two California (state) agencies: the California Environmental Protection Agency Department of Toxic Substances Control and the Regional Water Quality Control Board, Lahontan Region. The FFA is a cooperative agreement that assures that environmental impacts at Edwards AFB are investigated and appropriate response actions are taken to protect human health and the environment. The FFA also provides a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions. Preparation of a *Comprehensive Remedial Investigation/Feasibility Study Management Plan* was required under the FFA.	**1990**	Federal Facility Agreement dated September 1990 *Installation Restoration Program (IRP), Comprehensive Remedial Investigation/ Feasibility Study, Management Plan, Edwards Air Force Base, CA* (The Earth Technology Corporation 1991a)

TABLE 2.0-1. CHRONOLOGY OF SITE EVENTS – SOUTH AFRL

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	Event	Date	Reference
3	***Base-Wide Consolidated Planning Report*** - this document identified Site 37 as a Potential Release Location (PRL)	**1991**	*IRP Base-wide Consolidated Planning Report, Edwards AFB, California* (The Earth Technology Corporation 1991b)
4	***Expanded Source Investigation/RCRA Facility Assessment* (*ESI/RFA*)**. The *ESI/RFA* effort required under the FFA was undertaken between 1991 and 1993. The *ESI/RFA* identified 72 sites and areas of concern (AOCs) in OU4 (later split into OU4 and OU9) plus another 15 sites that contained underground storage tanks (USTs). The areas that later became Sites 37, 120, 133, and 321 were identified as PRLs requiring further investigation.	**1991 - 1993**	*Expanded Source Investigation/ RCRA Facility Assessment* (*ESI/RFA*, The Earth Technology Corporation 1993)
5	A ***Site Inspection*** (SI) was conducted in phases at 58 areas of concern (AOCs) and two sites in OU4 and OU9 between June 1993 and April 1996. The purpose of the SI was to identify which PRLs required further investigation (FI) in a remedial investigation/feasibility study (RI/FS); and which PRLs should be recommended for no further investigation (NFI). Site inspection summary reports (SISRs) were prepared for Sites 133, 120, and 321.	**1993 - 1996**	Site 37: No SISR Site 133 SISR (The Earth Technology Corporation 1994a) Site 120 SISR (The Earth Technology Corporation 1995b) Site 321 SISR (The Earth Technology Corporation 1994b)
6	***Restoration Advisory Board (RAB).*** The RAB was established in January 1995 to promote community awareness of Base cleanup efforts.	**1995**	*Community Relations Plan* (USAF 1996)
7	***Remedial Investigation/Feasibility Study*** (RI/FS). The *RI/FS Field Sampling Plan, Phillips Laboratory, Operable Unit 4* (*OU4 RI/FS FSP)* detailed RI field work to be performed at Sites 37, 133, and 120. The *RI/FS FSP, Operable Unit 7 – Base Wide Miscellaneous, Operable Unit 8 – Northwest Main Base, Operable Unit 9 – East Phillips Laboratory, Operable Unit 10 – North Base Miscellaneous (OU7/8/9/10 RI/FS FSP)* detailed RI field work for OU9 Site 321.	**1996**	*OU4 RI/FS FSP* (Earth Tech 1996a) *OU7/8/9/10 RI/FS FSP* (Earth Tech 1996b)
8	***Remedial investigation (RI)*** activities were conducted between 1996 and 2004 at Sites 37, 133, and 120 in OU4 and between 2001 and 2005 at Site 321 in OU9 (see Tables A.1-1 through A.1-4 for RI activities listed by site). The RI summary report (RISR) for each OU established the nature and extent of site contaminants and presented results of human health risk assessments (HHRAs) and ecological risk assessments (ERAs) at South AFRL Sites 37, 133, and 120 in OU4 and	**1996 - 2006**	*RI Summary Report OU4* (Earth Tech 2005a) *RI Summary Report OU9* (Earth Tech 2006a)

TABLE 2.0-1. CHRONOLOGY OF SITE EVENTS – SOUTH AFRL

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	Event	Date	Reference
	Site 321 in OU9.		
9	***Groundwater extraction and treatment system (GETS) operated at Site 37.*** A GETS was operated at Site 37 from January 1999 to November 2007. The system began operation with two extraction wells and was expanded over 9 years to include seven extraction wells. A total estimated 650 pounds of PCE were removed. The system ran at an average rate of 0.9-gallon per minute.	**1999 - 2007**	Annual operations reports (AORs) were prepared, the last covered calendar year 2007: *Site 37 GETS AOR for 2007* (Earth Tech 2008c)
10	***Soil vapor extraction system*** (SVE) operated at Site 172 south of Building 8595 in Site 37. The SVE system was installed in January 2000 and operated from April 2000 through present. - The system operated as an IRA for PCE-impacted soil underlying a former outdoor waste sump (identified as Site 172) located south of Building 8595. - Between April 2000 and September 2007, the SVE system was operated to reduce the concentration of PCE in the soil vapor underlying the sump. In 2008, no further action (NFA) was selected for Site 172 as part of the *ROD, AFRL Soil and Debris Sites*. - The system began operation with one vapor extraction well and was expanded over 7 years to include seven vapor extraction wells; an eighth vapor extraction well was installed in 2010. By 28 July 2006 when the system was shut-down for rebound monitoring it had removed approximately 7,500 pounds of VOCs and influent concentrations were nearly asymptotic at 22 ppm(v). - Although not required as part of the remedy selected for Site 37 in the South AFRL ROD, the USAF has continued to operate the SVE system on an intermittent and temporary basis while evaluating risks to workers potentially exposed to PCE and/or other VOCs in the indoor air of Building 8595 via the VIP.	**2000 to 2007 and intermittently over the past 4.5 years through the present**	Annual operations reports were prepared, the last report covering pre-ROD operation covered rebound monitoring through June 2007 as listed below: *Site 172 SVE System, AOR for January through July 2006 followed by Rebound Monitoring through June 2007, Air Force Research Laboratory, Operable Unit No. 4* (Earth Tech 2007a)
11	***Groundwater extraction and treatment system (GETS) operated at Site 133.*** A GETS was operated at Site 133 from April 2001 to November 2007. The system operated with four groundwater extraction wells and had an operational limit based on the volume of treated water that could be discharged via the AFRL STP. The system removed 530 pounds of TCE and ran at an average combined flow rate of 10 gallons per minute. Perchlorate was also treated at this GETS.	**2001 - 2007**	AORs were prepared, the last covered calendar year 2007: *Site 133 GETS AOR for 2007* (Earth Tech 2008d)
12	***Validation Study.*** As part of the ERA, a validation study was performed to evaluate the potential impact of PCE and TCE vapors (and their associated breakdown products) on the health and dynamics of small mammal and reptile populations. The results of this study showed very low concentrations of chlorinated solvent chemicals in soil gas samples from artificial burrows installed for the purposes of the study.	**2002**	*Validation Study, Environmental Restoration Program (ERP) Sites 25, 37, 133 and Corresponding Reference Sites, Biological Impact of TCE and PCE on Wild Rodent and Reptile Populations, Edwards AFB, California* (USGS 2002)

TABLE 2.0-1. CHRONOLOGY OF SITE EVENTS – SOUTH AFRL

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	Event	Date	Reference
13	***Pre-scoping ecological risk assessments*** were performed to identify whether habitat was present at each site. Based on a lack of habitat due to USAF development at Site 321, this site was not further evaluated in the ERA after the pre-scoping phase. The full ***scoping ecological risk assessments*** (SERAs) identified potentially complete pathways existing between site-related contaminants and potential ecological receptors at Sites 37, 120, and 133 through soil, vapor intrusion, and (at Site 120) surface water.	**2004**	*Pre-Scoping and Full Scoping Ecological Risk Assessments for OU4 and OU9* (USGS 2004a, 2004b, 2004c, and 2004d)
14	The ***Predictive Ecological Risk Assessment (PERA)*** for OU4 combined site-specific data into plant and animal exposure models that quantified the potential risk to ecological receptor groups.	**2004**	*Environmental Restoration Program, Predictive Ecological Risk Assessment (Sites 37, 120, and 133 PERA* [Tetra Tech 2004])
15	The ***OU4 HHRA*** for AFRL included an evaluation of the potential risk to human health associated with chemicals detected in the soil and/or groundwater at Sites 37, 120, and 133.	**2004**	*Environmental Restoration Program, HHRA (AFRL)* (Earth Tech 2004b)
16	The ***OU9 HHRA*** for East AFRL included an evaluation of the potential risk to human health associated with chemicals detected in the soil and/or groundwater at Site 321.	**2004**	*Environmental Restoration Program, HHRA (East AFRL)* (Earth Tech 2004c)
17	In ***risk management meetings*** among the Remedial Project Managers (RPMs) for Edwards AFB, the results of HHRAs and ERAs at Sites 37, 120, 133, and 321 were discussed; as an outcome of risk management decisions, COCs were identified at each site.	**2004 – 2005**	*OU4 and OU9 Risk Management Meetings* (Earth Tech 2004d and 2005d)
18	***Groundwater flow and transport modeling***. A report documenting the assumptions and predictive simulations of the 2005 groundwater flow and contaminant transport model for the South AFRL was finalized.	**2005**	*Groundwater Modeling Report, South AFRL Area, Sites 37, 133, 120, and 321* (Earth Tech 2005b)
19	***Focused Feasibility Study.*** The *Focused Feasibility Study to Support a Technical Impracticability Evaluation/Containment Zone Application for the South AFRL (Sites 37, 133, 120, and 321) (South AFRL FS)* was completed for Sites 37, 120, 133, and 321. The FS included an evaluation of the technical impracticability (TI) of groundwater restoration in the fractured granitic bedrock at the South AFRL, and evaluated remedial alternatives invoking a TI waiver of ARARs.	**2005**	*South AFRL FS* (Earth Tech 2005c)

TABLE 2.0-1. CHRONOLOGY OF SITE EVENTS – SOUTH AFRL

	Event	Date	Reference
20	***Proposed Plan.*** The *Final Proposed Plan for Cleanup of Groundwater at the South Air Force Research Laboratory – Sites 37, 120, 133 (OU4) and 321 (OU9) (South AFRL Proposed Plan)* was available for public comment between 7 April 2006 and 13 May 2006. A Report to Stakeholders mailed to 2,000 subscribers in March 2006 summarized the remedy proposed for the South AFRL Proposed Plan and also publicized public meetings that were held by the USAF on 12 April 2006 at the AFRL and in the community of Boron on 25 April 2006. The Proposed Plan presented the USAF's preferred alternative for Sites 37, 133, 120, and 321, which includes a TI Waiver of ARARs for groundwater inside the South AFRL Containment Zone (CZ).	**2006**	*South AFRL Proposed Plan* (USAF 2006b)
21	***Record of Decision.*** The *South AFRL ROD* was authorized by signatures of the Edwards Base Commander and USEPA Region 9 Branch Chief of Federal Facilities and Site Cleanup in September 2007. Representatives from the DTSC and the Water Board also signed their concurrence with the selected remedy. The selected remedy includes a TI waiver of cleanup to drinking water standards within the South AFRL CZ, and requires the Air Force to demonstrate containment of impacted groundwater by long-term monitoring (LTM) to detect chemicals of concern (COCs) at the leading edges of groundwater impact. The selected remedy also requires land use controls (LUCs) to protect human health by preventing inhalation of vapor-phase COCs in indoor air that pose an unacceptable risk under a residential or industrial exposure scenario.	**2007**	*Record of Decision, South Air Force Research Laboratory* (USAF 2007)
22	***Groundwater monitoring***. Groundwater samples were collected from wells at Site 321 in August 2007 (JT3/CH2M HILL [2010a]). Groundwater samples were collected from selected monitoring wells at Sites 37, 120, and 133 (Earth Tech [2009c]).	**2007**	*2007 Annual Groundwater Monitoring Report (AGMR)-OU9* (JT3/CH2M HILL 2010a) *2007 AGMR-OU4* (Earth Tech 2009c)
23	***SVE Operation***. On 30 October 2007, the SVE system south of Building 8595 was reactivated following 15 months of shutdown (beginning on 28 July 2006) for rebound monitoring.	**2007**	*Site 172 SVE System, AOR for October through December 2007* (Earth Tech 2008b)
24	***Deactivation of GETS.*** The GETSs at Site 37 and at Site 133 were deactivated.	**2007**	See Lines 9 and 11

TABLE 2.0-1. CHRONOLOGY OF SITE EVENTS – SOUTH AFRL

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	Event	Date	Reference
25	***SVE Operation*** The SVE system was operated throughout 2008.	**2008**	*Site 172 SVE System, AOR for 2008* (Earth Tech 2009b)
26	***Groundwater monitoring***. In June through August 2008, groundwater samples were collected from the majority of monitoring wells at Site 321 (JT3/CH2M HILL 2010b). In October 2008, groundwater samples were collected from the majority of monitoring wells at Sites 37, 120, and 133 (AECOM 2009b).	**2008**	*2008 AGMR-OU9* (JT3/CH2M HILL 2010b) *2008 AGMR-OU4* (AECOM 2009b)
27	***Remedial Action Work Plan.*** The *South AFRL Remedial Action Work Plan (RAWP)* Version 1.0 was finalized. This document implements remedy components selected for the South AFRL in the *2007 ROD*.	**2009**	*South AFRL RAWP Version 1.0* (Earth Tech 2009a)
28	***Remedy Implementation.*** The *South AFRL I-RAR* documents remedial actions completed for the South AFRL CZ through July 2009; including the installation and sampling of nine groundwater monitoring wells (includes nested wells) with video, acoustic, and optical televiewer logs of selected boreholes prior to well installation.	**2009**	*South AFRL Interim-Remedial Action Report* (AECOM 2009a)
29	***SVE Operation.*** In January through August the SVE system was operated. A vacuum influence test was conducted before the system was taken offline on 5 August 2009.	**2009**	*Site 172 SVE System, AOR for 2009* (AECOM 2010a)
30	***VIP Monitoring***. Between March and June 2009, initial surveys of buildings inside the VICB were conducted. A total 46 near-slab vapor monitoring wells associated with 18 buildings at Sites 37 and 133 were installed, and vapor samples collected. Based on results from the near-slab sampling, six sub-slab wells were installed in four buildings (Building 8354 at Site 37 and Buildings 8404, 8406, and 8408 at Site 133); four sub-slab wells were also installed inside Building 8595. Vapor samples from the sub-slab wells and indoor air samples inside six buildings (including Building 8411 where sub-slab wells could not be installed) were collected; at Building 8595, the SVE system was operating. Results are summarized in the *South AFRL Post-ROD Monitoring for Vapor Intrusion (South AFRL VI Report*.	**2009**	*South AFRL Post-ROD Monitoring for Vapor Intrusion* (AECOM 2012c)
31	***South AFRL VI Fact Sheet Notification.*** In May 2009, the Edwards AFB ERP released a Fact Sheet notifying the public of vapor assessment activities at the South AFRL.	**2009**	*ERP Fact Sheet* (USAF 2009c); included in Appendix C.3 of this report

TABLE 2.0-1. CHRONOLOGY OF SITE EVENTS – SOUTH AFRL

	Event	Date	Reference
32	***Groundwater monitoring***. In September and October 2009, groundwater samples were collected from the majority of monitoring wells at Site 321 (JT3/CH2M HILL 2011a). Groundwater samples were collected from selected monitoring wells at Sites 37, 120, and 133 in the South AFRL (AECOM 2011a).	**2009**	*2009 AGMR-OU9* (JT3/CH2M HILL 2011a) *2009 AGMR-OU4* (AECOM 2011a)
33	***VIP Monitoring.*** In December 2009 and January 2010, collected a second round of vapor samples from 13 near-slab vapor monitoring wells associated with nine buildings. Also collected vapor samples from sub-slab wells and indoor air samples inside Building 8354 at Site 37 and Buildings 8404, 8406, 8408, and 8411 at Site 133. In December 2009, collected sub-slab and indoor air samples inside Building 8595 following 4 months of SVE system shutdown.	**2010**	See line 30
34	***SVE Operation.*** On 2 February 2010, the SVE system was reactivated. Seven SVE extraction wells were sampled prior to reactivation. The vacuum influence test was repeated following reactivation.		No AOR was prepared for SVE operation between February 2010 and April 2011; however results at the time of reactivation are summarized in the report cited in Line 30.
35	***Groundwater monitoring***. In August and September 2010, groundwater samples were collected from the majority of monitoring wells at Site 321 (JT3/CH2M HILL 2011b). In October 2010, groundwater samples were collected from selected monitoring wells at Sites 37, 120, and 133 (AECOM 2012i).	**2010**	*2010 AGMR-OU9* (JT3/CH2M HILL 2011b) *2010 AGMR-OU4* (AECOM 2012i)
36	***Well installation***. Between April 2010 and April 2011: installed and sampled Monitoring Wells 13-MW39, 37-MW40, 120-MW17, and 321-MW10; conducted borehole visualization surveys and hydraulic conductivity testing in Borehole 13-MW39; installed and sampled Monitoring Wells 13-MW43, 13-MW44, and 37-MW47; installed and sampled Monitoring Wells 13-MW40, 13-MW41, and 13-MW42; conducted borehole visualization surveys and hydraulic conductivity testing in Borehole 13-MW41.	**2010**	*Well Installation Report for 2010 and 2011, South Air Force Research Laboratory* (Eco & Associates 2012)
37	***VIP Monitoring.*** In January 2011, sub-slab and indoor air samples were collected from Building 8595 at Site 37 (SVE system operating) and Building 8403 at Site 133.	**2011**	Results were added into Appendix J to the *South AFRL VI Report* (AECOM 2012c)

TABLE 2.0-1. CHRONOLOGY OF SITE EVENTS – SOUTH AFRL

	Event	Date	Reference
38	***SVE Offline.*** On 28 April 2011, the SVE system was taken offline.	**2011**	See lines 30 and 34
39	***VI sampling and SVE Operation.*** In January 2012, sub-slab and indoor air samples were collected inside Building 8595 at Site 37; confirmation samples were collected at one location (8595IA4) in February 2012, and the SVE system was reactivated in March 2012. Leak tests were conducted at all sub-slab wells in March 2012.	**2012**	*Results of Vapor Intrusion Sampling and Reactivation of SVE System at Building 8595* (AECOM 2012f)
40	***Five-Year Review Public Notifications.*** RAB members were notified of initiation of the FYR for the South AFRL via email on 22 February 2012 (refer to Appendix C.1); an update on the progress of the FYR was provided during a RAB meeting on 17 May 2012. A notification to the community was placed in the *Antelope Valley Press* newspaper on 16 May 2012 (refer to Appendix C.2).	**2012**	This FYR report
41	***Five-Year Review.*** Site interviews and a site inspection were conducted in April 2012 as part of the first FYR.	**2012**	This FYR report
42	***2012 Groundwater flow and transport modeling***. The draft report documenting assumptions and predictive simulations of a revised 2012 groundwater flow and contaminant transport model for the South AFRL is scheduled to be transmitted for RPM review in June 2012.	**2012**	*2012 Groundwater Modeling Report for the South AFRL* (AECOM 2012b)

TABLE 2.0-1. CHRONOLOGY OF SITE EVENTS – SOUTH AFRL

Notes:

AFB	Air Force Base
AFRL	Air Force Research Laboratory
AGMR	annual groundwater monitoring report
AOC	area of concern
AOR	annual operations report
ARAR	applicable or relevant and appropriate requirement
CA	California
COC	chemical of concern
CZ	Containment Zone
DTSC	Department of Toxic Substances Control
ERA	ecological risk assessment
ERP	Environmental Restoration Program
ESI/RFA	Expanded Source Investigation/RCRA Facility Assessment
FFA	Federal Facility Agreement
FI	further investigation
FS	feasibility study
FSP	Field Sampling Plan
FYR	five-year review
GETS	groundwater extraction and treatment system
HHRA	human health risk assessment
I-RAR	interim remedial action report
IRA	interim remedial action
IRP	Installation Restoration Program
LTM	long-term monitoring
LUC	land use control
NFA	no further action
NFI	no further investigation
No.	number
NPL	National Priorities List
OU	operable unit
PCE	tetrachloroethene
PERA	Predictive Ecological Risk Assessment
ppm(v)	parts per million by volume
PRL	potential release location
RAB	Restoration Advisory Board
RAWP	remedial action work plan
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RISR	remedial investigation summary report
ROD	Record of Decision
RPM	remedial project manager
SERA	scoping ecological risk assessment
SI	site inspection
SISR	site inspection summary report
STP	sewage treatment plant
SVE	soil vapor extraction
TCE	trichloroethene
TI	technical impracticability
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	underground storage tank
VI	vapor intrusion
VIP	vapor intrusion pathway
VICB	vapor intrusion compliance boundary
VOC	volatile organic compound

TABLE 3.0-1. COMPARISON OF CONTAMINANT CONCENTRATIONS IN WELL CLUSTERS INSTALLED TO MONITOR VERTICAL EXTENT – SOUTH AFRL

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Well Cluster Location	Well Number	Screen interval (feet bgs)	PCE (μg/L)	TCE (μg/L)	cis-1,2-DCE (μg/L)	Perchlorate (mg/L)
Site 37						
Within 30 feet of Building 8595	171-MW05	15-45	200,000	3,500	<1,000	0.010[a]
	37-EW07	37.4-57.4	5,000[a]	60 J[a]	<100[a]	0.0069[b]
	37-EW08	235-250	92,000[a]	1,200[a]	<500[a]	0.0012[b]
600 feet down slope of Building 8595	37-MW06	47.5-67.5	29,000[a]	220[a]	8.6 J[a]	0.00028 J[a]
	37-EW06	75-90	25,000[a]	260 J[a]	<500[a]	0.0032[b]
	37-OW02	140-155	2,100	4,700	4,500	NS
1,100 feet down slope of Building 8595 to south	37-OW06	53-73	5,300	120	68	0.0065[b]
	37-EW04	73-93	2,700[c]	72[c]	410[c]	0.0149 G[c]
	37-MW19	230-250	360	200	94	<0.00050
1,250 feet down slope of Building 8595 to southeast	37-EW02	56-76	4,300[a]	85 J[a]	<100[a]	0.0061[b]
	37-OW03	66-86	1,900[d]	33[d]	3.9 J[d]	0.0059 G[d]
	37-MW14	242-252	230	88	15	<0.00050[b]
3,250 feet down slope of Building 8595 to southwest	37-MW32	144-164	<1.0[e]	<1.0[e]	<1.0[e]	NS
	37-MW30	229.2-244.2	<1.0[e]	<1.0[e]	<1.0[e]	NS
6,150 feet down slope of Building 8595 to southwest	37-MW44	29.5-39.5	6.2[f]	<1.0[f]	<1.0[f]	0.013[f]
	37-MW45s	66.7-76.7	0.38 J[e]	<1.0[e]	<1.0[e]	0.0063[e]
	37-MW45d	204.7-234.7	<1.0[e]	<1.0[e]	<1.0[e]	<0.00050[e]
6,750 feet down slope of Building 8595 to southwest	37-MW46s	28.5-38.5	<1.0[f]	<1.0[f]	<1.0[f]	0.014[f]
	37-MW46d	73-93	<1.0[e]	<1.0[e]	<1.0[e]	<0.00050[e]
Site 133						
Next to former Dry Well E	153-MW01	34-49	<10	2,200	6.4 J	0.0078[a]
	153-MW08	157.5-167.5	<20	4,100	<20	0.011[b]
Next to former Dry Well F	153-MW04	29-39	16	3,600	<5.0	0.0038[c]
	133-OW05	127-147	32 J	62,000	270	0.00064[a]
	133-MW04	316.8-326.8	<200	72,000	51,000	<0.00050[b]
Just down gradient of removed USTs at Gas Station	186-MW01	18-28	2.7	1,700	2.1	<0.0040[g]
	133-MW02	23.5-33.5	5.0	2,200	11	0.0047[b]
	133-EW03	33-153	14[a]	3,600[a]	6.6[a]	0.0047[a]
	153-MW09	250.5-260.5	<1.0	22	6.6	<0.00050[b]
1,050 feet down gradient of Gas Station	133-OW01a	18-38	4.6 J	390	5.5	0.0051[b]
	133-OW01b	120-150	<5.0	15	340	<0.00050[b]
Down gradient of landfill	13-MW09	17-27	7.0 J[h]	2,700[h]	9.6 J[h]	0.0227 G[h]
	13-MW14	100-115	<20[i]	2,000[i]	6.1 J[i]	0.0091[i]
	13-MW21	178-198	<1.0[i]	2.8[i]	8.4[i]	<0.00050[i]

TABLE 3.0-1. COMPARISON OF CONTAMINANT CONCENTRATIONS IN WELL CLUSTERS INSTALLED TO MONITOR VERTICAL EXTENT – SOUTH AFRL

(Page 2 of 2)

Well Cluster Location	Well Number	Screen interval (feet bgs)	PCE (μg/L)	TCE (μg/L)	cis-1,2-DCE (μg/L)	Perchlorate (mg/L)
Site 133 (Continued)						
13,500 feet down gradient of landfill	13-MW42	78-88	<5.0 Q[i]	190[i]	2.5 JQ[i]	0.0063[i]
	13-MW39	178-193	<1.0[f]	<1.0[f]	<1.0[f]	<0.00050[f]
Site 120						
Just downgradient of Imhoff Tank	120-MW02	52-62	6,700	140	2,800	0.0016
	120-OW04	52.4-62.4	820[c]	57[c]	5,100[c]	0.0093[c]
	120-MW06	239-249	<1.0	<1.0	<1.0	<0.00050
2,000 feet southwest of Imhoff Tank	120-MW10	56-66	2.0[f]	3.6[f]	0.64 J[f]	0.019[f]
	120-MW15	328-338	<1.0	<1.0	<1.0	<0.00050
Site 321						
50 feet southwest of Building 9423	321-MW02	163.5-173.5	850 Q[f]	54[f]	300[f]	0.0021[f]
	321-MW09	303.3-313.3	190 Q[f]	140[f]	38[f]	<0.0040[c]
300 feet southwest of Building 9423	321-MW05b	205.7-225.7	0.86 J (J)[f]	0.86 J (J)[f]	0.91 J (J)[f]	<0.0040[c]
	321-MW05a	243.8-263.8	36[f]	3.1[f]	5.0[f]	<0.0040[c]
1,200 feet down slope and northwest of Building 9423	321-MW08b	162.8-172.8	<1.0 (U)[f]	<1.0 (U)[f]	<1.0 (U)[f]	<0.0040[c]
	321-MW08a	247.7-267.7	<1.0 (U)[f]	<1.0 (U)[f]	<1.0 (U)[f]	<0.0040[c]

Notes:

Well clusters are shown in order of increased distance from the source areas at each site. 2008 sampling results, unless otherwise noted.

[a] 2007 sampling result.
[b] 2006 sampling result.
[c] 2003 sampling result.
[d] 2005 sampling result.
[e] 2009 sampling result.
[f] 2010 sampling result.
[g] 2002 sampling result.
[h] 2001 sampling result.
[i] 2011 sampling result.

<	less than
μg/L	micrograms per liter
AFRL	Air Force Research Laboratory
bgs	below ground surface
DCE	dichloroethene
mg/L	milligrams per liter
NS	not sampled
PCE	tetrachloroethene
TCE	trichloroethene
UST	underground storage tank

Laboratory-Assigned Data Qualifiers:

J	Estimated result. Result is detected below the reporting limit.
G	Elevated reporting limit. The reporting limit is elevated due to matrix interference.
Q	Elevated reporting limit. The reporting limit is elevated due to high analyte levels.

Data Validation Qualifiers:

(J)	Analyte was present but reported value may not be accurate or precise.
(U)	Analyte was analyzed for but not detected at the specific detection limit.

TABLE 3.1-1. RISK-BASED GWVCLs-res AND IAVMLs-res FOR SOUTH AFRL PROTECTIVE FOR UNRESTRICTED USE*

Site	COC	GWVCLs-res (μg/L)	IAVMLs-res[(2)] (μg/m^3)
37	PCE	13.1[(1)]	0.4
37	TCE	60.7[(1)]	1.2
37	benzene	25.4	0.3
133	PCE	13[(1)]	0.4
133	TCE	57.3[(1)]	1.2
120	PCE	1.8	0.4
120	TCE	8.5	1.2
120	cis-1,2-DCE	672	36.5
321	PCE	19	0.4

Notes:

The GWVCL-res is the groundwater concentration that would result in a modeled IAVML-res that would cause a 1 x 10^{-6} cancer risk (or an HQ of 1 for cis-1,2-DCE at Site 120) for each COC via the indoor air vapor intrusion pathway under a residential exposure scenario. In all cases (where applicable), the GWVCL-res and IAVML-res based on a 1 x 10^{-6} indoor air cancer risk are lower than their respective concentration levels based on an HI = 1.0.

* As established in the South AFRL ROD (USAF 2007). Revised GWVCLs and IASLs have since been calculated based on toxicity values for PCE and TCE that were updated by USEPA as discussed in Section 7.2.3.

(1) See Table 6.4-10 for GWVCLs-res revised to incorporate toxicity values updated by USEPA IRIS since the 2007 ROD.

(2) See Table 7.2-5 for recommended IASLs-res that incorporate revisions to toxicity criteria published by USEPA IRIS subsequent to the 2007 ROD.

μg/L	micrograms per liter
μg/m^3	micrograms per cubic meter
AFRL	Air Force Research Laboratory
COC	chemical of concern
DCE	dichloroethene
GWVCLs-res	groundwater vapor compliance levels (residential exposure scenario)
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
IASLs-res	indoor air screening levels (residential exposure scenario)
IAVMLs-res	indoor air vapor mitigation levels (residential exposure scenario)
PCE	tetrachloroethene
ROD	Record of Decision
TCE	trichloroethene
USEPA	United States Environmental Protection Agency

TABLE 3.1-2. RISK-BASED GWVCLs-ind FOR DETERMINING WHERE TO INITIATE MONITORING TO ASSESS INDOOR AIR CONCENTRATIONS IN EXISTING BUILDINGS OVERLYING SOUTH AFRL PLUMES*

Site	COC	GWVCLs-ind** (μg/L)
37	PCE	607
37	TCE	2,990
133	TCE	2,340
120	PCE	32.4
321	PCE	451

Notes:

GWVCL-ind is the groundwater concentration that would result in a modeled IAVML-ind (Table 3.5-2) that would cause a 1 x 10^{-6} cancer risk for each COC via the indoor air vapor intrusion pathway under an industrial exposure scenario. In all cases, the GWVCL-ind based on a 1 x 10^{-6} cancer risk is lower than the RBCL based on an HI = 1.0.

*As established in the South AFRL ROD (USAF 2007); toxicity values for PCE and TCE were subsequently updated by USEPA IRIS as discussed in Section 7.2.
** See Section 6.4.3.4 for a discussion on GWVCLs-ind based on toxicity values updated by USEPA IRIS since the 2007 ROD.

μg/L	micrograms per liter
AFRL	Air Force Research Laboratory
COC	chemical of concern
GWVCL-ind	groundwater vapor compliance level (industrial exposure scenario)
HI	hazard index
IASL-ind	indoor air screening level (industrial exposure scenario)
IAVML-ind	indoor air vapor mitigation level (industrial exposure scenario)
IRIS	Integrated Risk Information System
PCE	tetrachloroethene
ROD	record of decision
RBCL	risk-based cleanup level
TCE	trichloroethene
USEPA	United States Environmental Protection Agency

TABLE 3.5-1. CHEMICALS OF CONCERN IN GROUNDWATER AT SOUTH AFRL

Contaminant	COC at Site(s)	Federal MCLGs[a] (μg/L)	Federal pMCL[a] (μg/L)	State of California pMCL[b] (μg/L)	RBCGs Selected in ROD (μg/L)	Cancer Causing?
1,1,1-trichloroethane	37	200	**200**	200	-	(c)
1,1-dichloroethane	37	-	-	**5**	-	Possible
1,2-dichloroethane	133	0	5	**0.5**	-	Probable
1,1-dichloroethene	37	7	7	**6**	-	Possible
1,4-dioxane	37, 133, 120	-	-	-	*3*[d]	Likely
benzene	37, 133	0	5	**1**	-	Known/likely
cis-1,2-dichloroethene	37, 133, 120, 321	70	70	**6**	-	(c)
trichlorofluoroethane (CFC 113)	37	-	-	**1,200**	-	(c)
methylene chloride (dichloromethane)	37	0	**5**	5	-	Likely
methyl tert butyl ether (MTBE)	133	-	-	**13**	-	(e)
N-nitrosodimethylamine (NDMA)	37, 133	-	-	-	*0.01*[d]	Probable
naphthalene	37	-	**-**	-	*17*[d]	Possible
tetrachloroethene (PCE)	37, 133, 120, 321	0	**5**	5	-	Likely
trans-1,2-dichloroethene	133, 120	100	100	**10**	-	(c)
trichloroethene (TCE)	37, 133, 120, 321	0	**5**	5	-	Known
vinyl chloride	37, 133, 120, 321	0	2	**0.5**	-	Known
perchlorate	37, 133, 120	-	-	-	*0.024 mg/L*[f]	Not likely
nitrate (as Nitrogen)	37, 133, 120, 321	10 mg/L	**10** mg/L	10 mg/L	-	(c)

Notes:

This table shows the chemicals of concern in the groundwater at the South AFRL and concentrations to be contained, as established in the South AFRL ROD (USAF 2007). Note that, subsequent to September 2007, the ROD-selected standards for two chemicals were revised as listed in Table 7.2-1; and toxicity criteria for several other chemicals have been revised, as listed in Table 7.2-3 (see discussion in Section 7.2.2).

Values in bold indicate ARARs to be waived within the South AFRL CZ. Values in italics indicate risk-based cleanup goals adopted for chemicals without MCLs. These chemicals will also be contained.

Descriptions under column heading "Cancer Causing ?" are from U.S.EPA Integrated Risk Information System, accessed July 2012.

[a] Source: USEPA 2006
[b] Source: California DHS 2007.
[c] No or inadequate information – generally regarded as non-carcinogenic.
[d] NL: Source: California DHS 2007.
[e] No data to adequately access – generally regarded as carcinogenic.
[f] Level of concern derived from an oral reference dose of 0.0007 mg/kg/day listed in the USEPA IRIS database.

-	none promulgated	CZ	containment zone	mg/L	milligrams per liter
μg/L	micrograms per liter	DHS	Department of Health Services	NL	notification level
AFRL	Air Force Research Laboratory	IRIS	Integrated Risk Information System	pMCL	primary maximum contaminant level
ARAR	applicable or relevant and appropriate requirement	MCL	maximum contaminant level	RBCG	risk-based cleanup goal
		MCLG	maximum contaminant level goal	ROD	Record of Decision
CFC	chlorofluorocarbon	mg/kg/day	milligrams per kilogram per day	USEPA	United States Environmental Protection Agency
COC	chemical of concern				

TABLE 3.5-2. RISK-BASED IAVMLs-ind FOR EXISTING INDUSTRIAL BUILDINGS LOCATED WITHIN THE VICB FOR SOUTH AFRL*

Site	COC	IAVMLs-ind** ($\mu g/m^3$)
37	PCE	1.7
37	TCE	5.1
133	TCE	5.1
120	PCE	1.7
321	PCE	1.7

Notes:

IAVML-ind corresponds to a 1 x 10^{-6} cancer risk for each COC under an industrial exposure scenario and these concentrations all exhibit an HI less than 1.0.

*As established in the South AFRL ROD (USAF 2007); toxicity values for PCE and TCE were subsequently updated by USEPA IRIS as discussed in Section 7.2.3.
** See Table 7.2-5 for recommended IASLs-ind that incorporate revisions to toxicity criteria published by USEPA IRIS subsequent to the 2007 ROD.

$\mu g/m^3$	micrograms per cubic meter
AFRL	Air Force Research Laboratory
HI	hazard index
IASL-ind	indoor air screening level (industrial exposure scenario)
IAVML-ind	indoor air vapor monitoring level (industrial exposure scenario)
IRIS	Integrated Risk Information System
PCE	tetrachloroethene
ROD	record of decision
TCE	trichloroethene
VICB	vapor intrusion compliance boundary
USEPA	United States Environmental Protection Agency

TABLE 4.3-1. LAND USE CONTROLS TO ADDRESS THE GROUNDWATER MEDIUM
(Page 1 of 2)

LUC Objective	Section providing details in *South AFRL RAWP*	LUC Activities/Prohibitions/Restrictions	Inspection/ Documentation
Protect receptors from exposure by ingestion or dermal contact with extracted groundwater at concentrations of COCs that exceed pMCLs or RBCGs.	2.4.1 (Appendix B.1.3, Section B.1.3.1 in this FYR report)	1. The drilling of new wells for the purpose of extracting groundwater to be used for municipal, industrial, or agricultural supply; or for freshwater replenishment is prohibited. 2. The use of existing wells to extract groundwater for use as municipal, industrial, or agricultural supply; or for freshwater replenishment is prohibited.	1. Document that prohibitions are maintained in the GIS database and tied to the South AFRL CZ boundary.
Prevent existing ERP wells from providing a conduit for further contamination of the groundwater.	2.4.2 (Appendix B.1.3, Section B.1.3.2 in this FYR report)	1. Existing and future wells installed for purposes of environmental monitoring will be equipped with padlocks (keyed alike) that shall be kept locked except during measurement of water levels, collection of groundwater samples, or for other environmental testing.	1. Annual inspection of monitoring well condition, and to verify that wells are locked. 2. Document annual monitoring well inspections.
Maintain integrity of monitoring well network.	2.4.2 and 2.4.3 (Appendix B.1.3, Sections B.1.3.2 and B.1.3.3 in this FYR report)	1. As needed, wells may require renovation by well redevelopment, water jet flushing, repairing of dedicated pumps, or well monument repainting. 2. “Mothballing” of wells not used for sampling will include pump removal and storage with in-well storage of well tubing, safety cable, and well cap assembly.	1. Annual inspection of monitoring wells to include water level and well depth measurements. 2. Document annual monitoring well inspections.
Maintain access to wells for sampling and routine maintenance.	2.4.3 (Appendix B.1.3, Section B.1.3.3 in this FYR report)	1. The immediate area surrounding each well shall be kept clear of brush, debris, and waste material. 2. A 15-foot wide driving pathway shall be maintained as an access route to each monitoring well.	1. Annual inspection of monitoring wells' access. Maintenance of access ways as required. 2. Document annual monitoring of well access.

TABLE 4.3-1. LAND USE CONTROLS TO ADDRESS THE GROUNDWATER MEDIUM
(Page 2 of 2)

LUC Objective	Section providing details in *South AFRL RAWP*	LUC Activities/Prohibitions/Restrictions	Inspection/ Documentation
Protect the integrity of existing or future remedy infrastructures and minimize accidental spills.	2.4.4 (Appendix B.1.3, Section B.1.3.4 in this FYR report)	1. Existing or future treatment of injection system compounds will be secured behind fences with locking gates (keyed alike) and access limited to O&M personnel. 2. Properly mark and provide signs delineating conveyance lines and for system compounds (where necessary). 3. Restrict excessive traffic and heavily weighted vehicles from driving over or parking above conveyance lines.	1. Annual inspection of system compound. 2. Document annual system inspection and store records in the Base GIS and/or BGP.

Notes:

AFRL	Air Force Research Laboratory
BGP	Base General Plan
COC	chemicals of concern
CZ	containment zone
ERP	Environmental Restoration Program
FYR	Five-Year Review
GIS	geographical information system
LUC	land use control
O&M	operation and maintenance
pMCL	primary maximum contaminant level
RAWP	remedial action work plan
RBCG	risk-based cleanup goal

TABLE 4.3-2. LAND USE CONTROLS TO ADDRESS EXPOSURE VIA THE VAPOR INTRUSION PATHWAY INTO INDOOR AIR

LUC Objective	Section providing details in *South AFRL RAWP*	LUC Activities/Prohibitions/Restrictions	Inspection/ Documentation
Protect receptors from indoor air exposure by inhalation of volatile COCs within the VICB.	2.5.1 (Appendix B.1.4, Section B.1.4.1 in this FYR report)	1. No development of any residential buildings within the VICB. 2. Any new building constructed within the VICB will include engineering controls to reduce risk via the VIP to less than 1 x 10^{-6} for the intended land use (industrial).	1. Document that prohibitions are maintained in the GIS database and tied to the VICB.
Protect worker safety in existing occupied buildings.	2.5.2 and 2.5.3 (Appendix B.1.4, Sections B.1.4.2 and B.1.4.3 in this FYR report)	1. Evaluate existing occupied buildings located where groundwater contains volatile COCs in excess of GWVCLs-ind to assess whether the VIP is complete. 2. Periodically monitor indoor air for volatile COCs in existing occupied buildings where VIP is complete. 3. Activate mitigation measures to reduce the risk via the VIP to less than 1 x 10^{-6} for industrial exposure.	1. Document that occupied buildings within the GWVCLs-ind have been evaluated for vapor intrusion and prohibitions are maintained in the GIS database and tied to the GWVCLs-ind boundary.
Revise the VICB periodically as groundwater contaminant plumes expand.	2.5.4 (Appendix B.1.4, Section B.1.4.4 in this FYR report)	1. Evaluate VICB using LTM and contaminant transport modeling results.	1. Incorporate revisions to the VICB in the GIS database. 2. Document any revisions to the VICB.

Notes:

AFRL	Air Force Research Laboratory
COC	chemicals of concern
FYR	Five-Year Review
GIS	geographic information system
GWVCLs-ind	groundwater vapor compliance levels (industrial exposure scenario)
LTM	long-term monitoring
LUC	land use control
RAWP	remedial action work plan
VICB	vapor intrusion compliance boundary
VIP	vapor intrusion pathway

TABLE 4.3-3. SPECIFICATIONS OF EXISTING STRUCTURES WITHIN THE GWVCL-ind AT THE SOUTH AFRL

Building ID	Floor Levels	Building Foot Print (ft^2)
Occupied		
Site 37		
8349	Single Story	2,754
8350	Two story	7,416
8351	Two story	11,900
8352	Two story	17,832
8353	Two story	13,589
8354	Single Story	9,770
8356	Single Story	8,753
8595	Single Story	22,863
Site 133		
8402	Single Story	1,022
8403	Single Story	1,022
8404	Single Story	1,214
8405	Single Story	1,087
8406	Single Story	3,770
8407	Single Story	11,299
8408	Single Story	3,873
8423*	Single Story	31,295
8424*	Single Story	39,914
8431*	Single Story	30,809
Not Occupied (and Not Designed for Occupancy)		
Site 37		
8380	NA	8,603
Site 133		
8401	Single Story	406
8409	Single Story	66
8410	Single Story	114
8411	Single Story	6,467
Site 120		
8120	Single Story	168
Site 321		
9423	Single Story	1,073

Notes:

Occupied buildings are those that are regularly occupied or identified to have at least one person who maintains an office in the building.
Not occupied buildings include numbered facilities that are not designed for occupancy such as storage pads and sheds.

* Building outside the GWVCL-ind but included in Phase I soil gas screening due to its proximity to a location where the past release of contaminants is suspected.

AFRL	Air Force Research Laboratory
ft^2	square feet
GWVCL-ind	groundwater vapor compliance level (industrial exposure scenario)
ID	identification
NA	not applicable

TABLE 4.3-4. IAVMLs-ind AND THEIR ASSOCIATED SOIL GAS SCREENING NUMBERS[1]

	IAVMLs-ind[2]		Soil Gas Screening Number (SNs)	
	($\mu g/m^3$)	(ppb[v])	($\mu g/m^3$)	(ppb[v])
PCE	1.7	0.25	1,700	250
TCE	5.1	0.95	5,100	950

Notes:
[1] Screening numbers established in the South AFRL RAWP based on the IAVMLs established in the South AFRL ROD; toxicity values for PCE and TCE were subsequently updated by USEPA IRIS as discussed in Section 7.2-3.
[2] See Table 7.2-5 for recommended IASLs-ind that incorporate revisions to toxicity criteria published by USEPA IRIS subsequent to the 2007 ROD.

$\mu g/m^3$	micrograms per cubic meters
AFRL	Air Force Research Laboratory
DTSC	Department of Toxic Substances Control
IASLs-ind	indoor air screening levels for industrial exposure
IAVMLs-ind	indoor air vapor mitigation levels for industrial exposure. Values above this concentration represent a risk greater than 10^{-6} for indoor air.
IRIS	Integrated Risk Information System
PCE	tetrachloroethene
ppb(v)	parts per billion (by volume)
RAWP	remedial action work plan
ROD	record of decision
TCE	trichloroethene
USEPA	United States Environmental Protection Agency

TABLE 4.4-1. PURPOSE AND RESULTS OF NEW WELLS INSTALLED AT SOUTH AFRL
(Page 1 of 4)

Well ID	Date	Referenced Documents	Total Depth (ft bgs)	Screen Interval (ft bgs)	Proposed Location	Rationale for Well Installation	Sampling Results and Conclusions for Use
Wells to Refine Plume Leading Edges[1]							
13-MW37	February 2009	Work Plan: *South AFRL RAWP* (Earth Tech 2009a) Well Installation Report: *South AFRL I-RAR* (AECOM 2009a)	169.75	158.75-168.75	Down gradient of 1 μg/L TCE contour at Site 133	Refine location of 1 μg/L TCE contour to within 500 ft; well is suitable for use as a 1° IS well (down gradient of 1 μg/L TCE contour)	TCE was not detected ($<$ 1 μg/L) in March 2009; this result was confirmed in October 2009. Well designated as a 1° IS well.
13-MW38	June 2009	Work Plan: *South AFRL RAWP* (Earth Tech 2009a) Well Installation Report: *South AFRL I-RAR* (AECOM 2009a)	117	105.5-115.5	Within 10 μg/L TCE contour at Site 133	Refine location of 1 μg/L TCE contour to within 500 ft	TCE was detected at a concentration of 36 μg/L in July 2009; the detection was confirmed in October 2009 (69 μg/L). Well not suitable as a 1° IS well.
13-MW40	March 2011	Work Plan: *South AFRL RAWP* (Earth Tech 2009a) and *2010 South AFRL WIWP* (Eco & Associates 2010) Well Installation Report: *2010/2011 South AFRL WIR* (Eco & Associates 2012)	264.7	242.3-262.3	Down gradient of 1 μg/L TCE contour; south of plume axis at Site 133	Potential 1° IS well (down gradient of 1 μg/L TCE contour)	TCE was detected at an estimated concentration of 0.53 J μg/L in April 2011. Well designated as a 1° IS well.
13-MW41	March 2011	Work Plan: *South AFRL RAWP* (Earth Tech 2009a) and *2010 South AFRL WIWP* (Eco & Associates 2010) Well Installation Report: *2010/2011 South AFRL WIR* (Eco & Associates 2012)	54.3	42.0-52.0	Down gradient of 1 μg/L TCE contour; north of plume axis ay Site 133	Potential 1° IS well (down gradient of 1 μg/L TCE contour)	TCE was detected at a concentration of 88 μg/L in April 2011. Well not suitable as a 1° IS well.
13-MW42 (originally planned as a vertical extent well)	March 2011	Work Plan: *South AFRL RAWP* (Earth Tech 2009a) and *2010 South AFRL WIWP* (Eco & Associates 2010) Well Installation Report: *2010/2011 South AFRL WIR* (Eco & Associates 2012)	90	78-88	Down gradient of 1 μg/L TCE contour along the axis of the Site 133 plume; companion well to Well 13-MW39 (based on analytical data)	Vertical extent down gradient of plume front AND potential 1° IS well (down gradient of 1 μg/L TCE contour)	TCE was detected at a concentration of 190 μg/L in April 2011. Groundwater encountered approximately 100 feet above 13-MW39, therefore, re-designated for use as a standard well. Well not suitable as a 1° IS well.

TABLE 4.4-1. PURPOSE AND RESULTS OF NEW WELLS INSTALLED AT SOUTH AFRL
(Page 2 of 4)

Well ID	Date	Referenced Documents	Total Depth (ft bgs)	Screen Interval (ft bgs)	Proposed Location	Rationale for Well Installation	Sampling Results and Conclusions for Use
Wells to Refine Plume Leading Edges *(Continued)*							
13-MW43	October 2010	Work Plan: *2010 South AFRL WIWP* (Eco & Associates 2010) Well Installation Report: *2010/2011 South AFRL WIR* (Eco & Associates 2012)	93.4	81.2-91.2	Install half-way between Wells 13-MW37 and 13-MW39 at Site 133	Refine location of 1 μg/L TCE contour; and potential IS well (down gradient of the 1 μg/L TCE contour)	TCE was detected at a concentration of 88 μg/L in December 2010. Well not suitable as a 1° IS well.
37-MW36	February 2009	Work Plan: *South AFRL RAWP* (Earth Tech 2009a) Well Installation Report: *South AFRL I-RAR* (AECOM 2009a)	63.3	40.5-60.5	Within the 1 μg/L PCE contour on the western lobe of the Site 37 plume	Refine location of 1 μg/L PCE contour to within 500 ft	PCE was detected at a concentration of 2.1 μg/L in March 2009; the detection was confirmed in October 2009 (3.4 μg/L). Well not suitable as a 1° IS well.
37-MW40	April 2010	Work Plan: *South AFRL RAWP* (Earth Tech 2009a) and *2010 South AFRL WIWP* (Eco & Associates 2010) Well Installation Report: *2010/2011 South AFRL WIR* (Eco & Associates 2012)	104	75-95	Down gradient of 1 μg/L PCE contour on western lobe of Site 37 plume, south of plume axis	Refine location of 1 μg/L PCE contour to within 1,000 ft or potential 1° IS well (down gradient of 1 μg/L PCE contour)	PCE was not detected ($<$ 1 μg/L) in May 2010; the result was confirmed in October 2010. Well designated as a 1° IS well for PCE.
37-MW44	March 2009	Work Plan: *South AFRL RAWP* (Earth Tech 2009a) Well Installation Report: *South AFRL I-RAR* (AECOM 2009a)	40.3	29-39	Within 1 μg/L PCE contour on the western lobe of Site 37 plume, east of the plume axis	Vertical extent down gradient of plume front and potential 1° IS well (down gradient of 1 μg/L PCE contour)	PCE was detected at a concentration of 3 μg/L in March 2009; the detection was confirmed in October 2009 and 2010 (4.6 μg/L and 6.2 μg/L, respectively). Well not suitable as a 1° IS well. Planned deeper water bearing zone wells installed as Wells 37-MW45s/d.
37-MW46s/d (two nested wells)	June 2009	Work Plan: *South AFRL RAWP* (Earth Tech 2009a)[2] Well Installation Report: *South AFRL I-RAR* (AECOM 2009a)	94	28.5-38.5 (shallow) 73-93 (deep)	Down gradient of 1 μg/L PCE contour along the axis of the Site 37 plume	Refine location of 1 μg/L PCE contour to within 500 ft and potential 1° IS well (down gradient of 1 μg/L PCE contour)	37-MW46s: PCE was not detected ($<$ 1 μg/L) in July 2009; the result was confirmed in October 2009. 37-MW46d: PCE was not detected ($<$ 1 μg/L) in July 2009; the result was confirmed in October 2009. Groundwater was encountered above the seal of Well 37-MW46d during well installation, therefore, a second, shallower zone was screened for Well 37-MW46s. Both wells designated as 1° IS wells for PCE.

TABLE 4.4-1. PURPOSE AND RESULTS OF NEW WELLS INSTALLED AT SOUTH AFRL
(Page 3 of 4)

Well ID	Date	Referenced Documents	Total Depth (ft bgs)	Screen Interval (ft bgs)	Proposed Location	Rationale for Well Installation	Sampling Results and Conclusions for Use
Wells to Monitor Plume Vertical Extent at Toe of Plume							
13-MW39 (originally planned as a standard shallow well)	April 2010	Work Plan: *South AFRL RAWP* (Earth Tech 2009a) and *2010 South AFRL WIWP* (Eco & Associates 2010) Well Installation Report: *2010/2011 South AFRL WIR* (Eco & Associates 2012)	194	178-193	Halfway between Wells 13-MW37 and 13-MW38 at Site 133	Refine location of 1 μg/L TCE contour to within 1,000 ft; and potential 1° IS well (down gradient of 1 μg/L TCE contour).	TCE was not detected (< 1 μg/L) in May 2010; the result was confirmed in October 2009. Groundwater encountered >100 feet below 13-MW42, therefore, the well was re-designated for use as a vertical extent well.
37-MW45s/d (two nested wells originally planned as nested within Well 37-MW44)	June 2009	Work Plan: *South AFRL RAWP* (Earth Tech 2009a) [(2)] Well Installation Report: *South AFRL I-RAR* (AECOM 2009a)	253	66.5-76.5 (shallow) 204.5-234.5 (deep)	Down gradient of 1 μg/L PCE contour along the axis of the Site 37 plume; PCE <1 μg/L based on samples collected from both wells in July 2009.	Vertical extent down gradient of plume front and potential 1° IS well (down gradient of 1 μg/L PCE contour).	37-MW45s: PCE was not detected (< 1 μg/L) in July 2009; the result was confirmed in October 2009 (0.47 J, estimated result below the reporting limit). 37-MW45d: PCE was not detected (< 1 μg/L) in July 2009; the result was confirmed in October 2009. Both wells designated as a 1° IS wells for PCE.
Wells to Fill Data Gap							
13-MW44	October 2010	Work Plan: *2010 South AFRL WIWP* (Eco & Associates 2010) Well Installation Report: *2010/2011 South AFRL WIR* (Eco & Associates 2012)	246.2	218.5-233.5	Site 133: Cross gradient of the plume axis at mid-plume; outside the eastern extent of the 1 μg/L TCE contour.	Refine the eastern extent of the 1 μg/L TCE contour at mid-plume.	TCE was not detected (< 1 μg/L) in December 2010. Use well as a mid-plume lateral extent well.
37-MW47	October 2010	Work Plan: *2010 South AFRL WIWP* (Eco & Associates 2010) Well Installation Report: *2010/2011 South AFRL WIR* (Eco & Associates 2012)	264.5	253.6-263.6	Site 37: Cross gradient of the plume axis at mid-plume; outside the western extent of the 1 μg/L PCE contour.	Refine the 1 μg/L PCE contour down gradient of Well 37-MW23.	PCE was not detected (< 1 μg/L) in December 2010. Use well as a mid-plume lateral extent well.
120-MW16	June 2009	Work Plan: *South AFRL RAWP* (Earth Tech 2009a) Well Installation Report: *South AFRL I-RAR* (AECOM 2009a)	101.4	88.5-98.5	Site 120: Down gradient of 1 μg/L TCE contour approximately 3,500 feet west and down gradient of Well 120-MW05.	Assess water quality in groundwater beneath the major drainage down gradient from former evaporation ponds at the AFRL sewage treatment plant; this well will also provide a monitoring point for measurement of groundwater elevation to confirm the groundwater flow direction in this area.	TCE was not detected (< 1 μg/L) in July 2009; the result was confirmed in October 2009. Well will be used to provide a monitoring point for measurement of groundwater elevation.

TABLE 4.4-1. PURPOSE AND RESULTS OF NEW WELLS INSTALLED AT SOUTH AFRL

(Page 4 of 4)

Well ID	Date	Referenced Documents	Total Depth (ft bgs)	Screen Interval (ft bgs)	Proposed Location	Rationale for Well Installation	Sampling Results and Conclusions for Use
Wells to Fill Data Gap *(Continued)*							
120-MW17	April 2010	Work Plan: *2010 South AFRL WIWP* (Eco & Associates 2010) Well Installation Report: *2010/2011 South AFRL WIR* (Eco & Associates 2012)	60	45-60	Site 120: Down gradient of the AFRL sewage treatment plant wastewater retention ponds, north of plume axis	Refine the 1 μg/L TCE contour down gradient of the AFRL sewage treatment plant.	TCE was detected at a concentration of 1.7 μg/L in May 2010; the detection was confirmed in October 2010 (1.1 μg/L). Well used to refine leading edge of Site 120 plume.
321-MW10[3]	April 2010	Work Plan: *2010 South AFRL WIWP* (Eco & Associates 2010) Well Installation Report: *2010/2011 South AFRL WIR* (Eco & Associates 2012)	224	203.5-223.5	Site 321: Cross gradient of the plume axis outside the southern extent of the 1 μg/L PCE contour	Refine the southern extent of the 1 μg/L PCE contour.	PCE was not detected (< 1 μg/L) in May 2010.

Notes:

[1] Except for Well 321-MW10, all wells shown in red on Figure 4.4-1.
[2] Wells 37-MW45s/d and 37-MW46s/d were not originally proposed in the *South AFRL RAWP* but were installed due to unexpected site conditions encountered during the installation of Wells 37-MW44 and 37-MW46, respectively.
[3] Well shown in red on Figure 4.4-2.

>	greater than
<	less than
μg/L	microgram per liter
1°	primary
AFRL	Air Force Research Laboratory
bgs	below ground surface
ft	feet
I-RAR	interim-remedial action report
ID	identification
IS	interim sentinel
J	laboratory qualifier indicating an estimated value
PCE	tetrachloroethene
RAWP	remedial action work plan
s/d	shallow/deep
TCE	trichloroethene
WIR	well installation report
WIWP	well installation work plan

TABLE 4.5-1. CHRONOLOGY OF GROUNDWATER MONITORING AT SOUTH AFRL
(Page 1 of 4)

Month and Year	Event	Description of Field Activities	Report
September 2007	LTM at Site 321	Nine wells were sampled for VOCs, NDMA, and/or nitrate (as N).	*2007 OU4/9 AGMR for Sites 6, 27, 39, 113, 115, 116, 125, 127, 178, 321, 333, and 338* and AOC 118 (JT3 CH2M HILL 2010a)
October 2007	Groundwater Level Measurements	Water levels measured from 182 wells; 6 wells were dry.	*2007 OU4/9 AGMR for Sites 37, 120, 133, 162, 177, 318, 325, and 461* (Earth Tech 2009c)
November 2007	Site 13 PCMMP GW Sampling	Nine wells were sampled for VOCs and/or perchlorate.	*2007 Site 13 ACMR* (Earth Tech 2008e)
	LTM at Sites 37, 133 and 120	26 wells were sampled for VOCs, perchlorate, NDMA, and/or 1,4-Dioxane.	Earth Tech 2009c
April 2008	Groundwater Level Measurements	Water levels measured from 179 wells; 5 wells were dry.	*2008 OU4/9 AGMR for Sites 37, 120, 133, 162, 177, 318, 325, and 461* (AECOM 2009b)
June – August 2008	LTM at Site 321	11 wells were sampled for VOCs, NDMA, alkalinity, common anions*, elements including metals, mercury, fluoride and/or TDS.	*2008 OU4/9 AGMR for Sites 6, 27, 39, 113, 115, 116, 125, 127, 178, 321, 333, and 338* and AOC 118 (JT3 CH2M HILL 2010b)
October 2008	Groundwater Level Measurements	Water levels measured from 183 wells; 8 wells were dry.	AECOM 2009b
	Site 13 PCMMP GW Sampling	Nine wells were sampled for VOCs, perchlorate, 1,4-Dioxane, alkalinity, common anions*, elements including metals, mercury and/or TDS.	*2008 Site 13 ACMR* (AECOM 2009c)
October/November 2008	CPME at Sites 37, 133 and 120	111 wells were sampled for VOCs, perchlorate, NDMA, 1,4-Dioxane, alkalinity, common anions*, elements including metals, mercury and/or TDS.	AECOM 2009b
January 2009	LTM Confirmation Samples	2 wells were re-sampled for VOCs to verify the unexpected detections of VOCs in GW.	AECOM 2009b

TABLE 4.5-1. CHRONOLOGY OF GROUNDWATER MONITORING AT SOUTH AFRL
(Page 2 of 4)

Month and Year	Event	Description of Field Activities	Report
March 2009	Initial Sampling of New Wells	3 wells were sampled for VOCs, perchlorate, common anions*, alkalinity, elements including metals, mercury and TDS.	*2009 South AFRL I-RAR* (AECOM 2009a)
April 2009	Groundwater Level Measurements	Water levels measured from 182 wells; 7 wells were dry.	*2009 OU4/9 AGMR for Sites 37, 120, 133, 162, 177, 318, 325, and 461* (AECOM 2011a)
	Site 13 PCMMP GW Sampling	Nine wells were sampled for VOCs and/or perchlorate.	*2009 Site 13 ACMR* (AECOM 2010b)
July 2009	Initial Sampling of New Wells	6 wells were sampled for VOCs, perchlorate, common anions*, elements including metals, mercury and TDS.	*2009 South AFRL I-RAR* (AECOM 2009a)
September 2009	LTM at Site 321	11 wells were sampled for VOCs, perchlorate, NDMA, and/or common anions*.	*2009 OU4/9 AGMR for Sites 6, 27, 39, 113, 115, 116, 125, 127, 178, 321, 333, and 338* and AOC 118 (JT3/CH2M HILL 2011a)
October 2009	Groundwater Level Measurements	Water levels measured from 192 wells; 9 wells were dry.	AECOM 2011a
	Site 13 PCMMP GW Sampling	Nine wells were sampled for VOCs, perchlorate, 1,4-Dioxane, common anions*, elements including metals, mercury, and/or TDS.	AECOM 2010b
October/November 2009	LTM at Sites 37, 133 and 120	23 wells were sampled for VOCs and/or perchlorate.	AECOM 2011a
April 2010	LTM Confirmation Samples	Three wells were re-sampled for VOCs following re-development to confirm unexpected detections of VOCs in GW in 2008.	AECOM 2011a
	Groundwater Level Measurements	Water levels measured from 196 wells; 11 wells were dry.	*2010 OU4/9 AGMR for Sites 37, 120, 133, 162, 177, 318, 325, and 461* (AECOM 2012i)

TABLE 4.5-1. CHRONOLOGY OF GROUNDWATER MONITORING AT SOUTH AFRL
(Page 3 of 4)

Month and Year	Event	Description of Field Activities	Report
April 2010 (*continued*)	Site 13 PCMMP GW Sampling	Nine wells were sampled for VOCs, perchlorate, 1,4-Dioxane, common anions*, elements including metals, mercury, and/or TDS.	*2010 Site 13 ACMR* (AECOM 2011b)
May 2010	Initial Sampling of New Wells	Four wells were sampled for VOCs, perchlorate, alkalinity, common anions*, elements including metals, mercury and TDS.	*2010/2011 South AFRL Well Installation Report* (Eco & Associates 2012)
August - September 2010	LTM at Site 321	11 wells were sampled for VOCs, perchlorate, NDMA, and/or common anions*.	*2010 OU4/9 AGMR for Sites 6, 27, 39, 113, 115, 116, 125, 127, 178, 321, 333, and 338* and AOC 118 (JT3/CH2M HILL 2011b)
October 2010	Groundwater Level Measurements	Water levels measured from 179 wells; 7 wells were dry.	AECOM 2012i
	Site 13 PCMMP GW Sampling	Nine wells were sampled for VOCs, perchlorate, 1,4-Dioxane, common anions*, elements including metals, mercury, and/or TDS.	AECOM 2011b
October/November 2010	LTM at Sites 37, 133 and 120	Eight wells were sampled for VOCs, perchlorate and/or nitrate (as N).	AECOM 2012i
December 2010	Initial Sampling of New Wells	Three wells were sampled for VOCs, perchlorate, alkalinity, common anions*, elements including metals, mercury and TDS.	*2010/2011 South AFRL Well Installation Report* (Eco & Associates 2012)
April 2011	Initial Sampling of New Wells	Three wells were sampled for VOCs, perchlorate, alkalinity, common anions*, elements including metals, mercury and TDS.	*2010/2011 South AFRL Well Installation Report* (Eco & Associates 2012)
	Groundwater Level Measurements	Water levels measured from 201 wells; 7 wells were dry.	*2010/2011 South AFRL Well Installation Report* (Eco & Associates 2012)

TABLE 4.5-1. CHRONOLOGY OF GROUNDWATER MONITORING AT SOUTH AFRL

(Page 4 of 4)

Month and Year	Event	Description of Field Activities	Report
April 2011 (*continued*)	Site 13 PCMMP GW Sampling	Nine wells were sampled for VOCs, perchlorate, 1,4-Dioxane, common anions*, elements including metals, mercury, and/or TDS.	*2011 Site 13 ACMR* (AECOM 2012j)
October 2011	Groundwater Level Measurements	Water levels measured from 203 wells.	South AFRL Annual Groundwater Level Measurements Memorandum (JT3/CH2M HILL 2011c) – refer to Appendix B.5
June and July 2012[1]	CPME at Sites 37, 133, 120, and 321	104 wells were sampled for VOCs; selected wells also sampled for perchlorate, nitrate, 1,4-dioxane, and/or NDMA	NA[2]

Notes:

Gray shaded rows document compliance monitoring at the Site 13 landfill, this monitoring was discontinued as of October 2011 as described in Section 1.7.

* Common anions include: chloride, nitrate (as N), and sulfate.

[1] Per the RAWP Version 1.0, this CPME was supposed to take place in October 2011 but moved to June 2012 due to contractual delays.

[2] Results to be reported in the *Annual Groundwater Monitoring Report for 2012, Sites 37, 120, 133, and 321 (South AFRL) and Sites 177, 318 and 325 (Northeast AFRL), Operable Units 4 and 9, Edwards AFB* (targeted for submittal as a draft in January 2013).

AFRL Air Force Research Laboratory
ACMR annual compliance monitoring report
AGMR annual groundwater monitoring report
AOC area of concern
CPME comprehensive plume monitoring event
GW groundwater
I-RAR interim-remedial action report
LTM long-term monitoring
N nitrogen
NA not available
NDMA N-nitrosodimethylamine
OU Operable Unit
PCMMP post-compliance maintenance and monitoring plan
TDS total dissolved solids
VOC volatile organic compound

TABLE 4.5-2. LEADING EDGE AND SENTINEL WELLS SAMPLED IN 2007 AND 2009 THROUGH 2011

Well	2007	2009	2010	2011[a]
Site 37				
13-MW26	-	A	A	-
37-MW12	-	A	-	-
37-MW13	A	A	-	-
37-MW22	A	A	-	-
37-MW23	-	-[b]	-[b]	-
37-MW30	-	-[c]	-	-
37-MW32	A	A	-	-
37-MW36	B	A	-	-
37-MW40	B	B	A	-
37-MW43	B	B	B	-
37-MW44	B	A	A	-
37-MW45s	B	A	-	-
37-MW45d	B	A	-	-
37-MW46s	B	A	A	-
37-MW46d	B	A	-	-
37-MW47	B	B	A	-
271-MW01	-	-	A[d]	-
Site 133				
13-MW16	-	-	-	-
13-MW25	-	-	-	-
13-MW28	A	-	-	-
13-MW29	A	A	-	-
13-MW30	A	A	-	-
13-MW31	-	A	-	-
13-MW32	A	A[e]	A	-
13-MW33	A	A	-	-
13-MW34	A	A	-	-
13-MW35	A	A[f]	-[f]	-
13-MW36	A	A	-	-
13-MW37	B	A	-	-
13-MW38	B	A	-	-
13-MW39	B	B	A	-
13-MW40	B	B	B	A
13-MW41	B	B	B	A
13-MW42	B	B	B	A
13-MW43	B	B	A	-
13-MW44	B	B	A	-
266-MW02	A	-	-	-

Notes:

The 2007 sampling event was performed in accordance with the 2004/2005 LTM Strategy (Earth Tech 2004 revised 2005); the 2009 and 2010 sampling events were sampled in accordance with their respective Sampling Plans (AECOM 2009d and AECOM 2010c, respectively).

(a) A sampling event was not held in 2011. Samples listed indicate first time sampling at new wells.

(b) Prompted by the unexpected detection of VOCs in Well 37-MW23, confirmation samples were collected in January 2009; samples were also collected in April 2010 following re-development of this well.

(c) Prompted by the unexpected detection of VOCs in Well 37-MW23, samples were collected from downgradient Well 37-MW30 in January 2009.

(d) Samples were collected for nitrate (as N) and perchlorate only.

(e) Prompted by the unexpected detection of VOCs in Well 13-MW32, confirmation samples were collected in January 2009; samples were also collected in July 2010 following extended purging of this well.

(f) Prompted by the unexpected trace detection of PCE in this well, confirmation samples were collected in January 2009; samples were also collected in July 2010 following re-development of this well.

- Well was not sampled.

A Well was sampled as planned.

B Well was not yet installed.

LTM long-term monitoring

TABLE 4.5-3. MONITORING WELLS WITH ISSUES
(Page 1 of 3)

	Date Issues Were Noted						
Well ID	October 2007/ April 2008	October 2008/ April 2009	October 2009/ April 2010	October 2010/ April 2011	October 2011	April 2012	Repairs made in April 2012
120-MW01	-	-	-	A	-	-	
120-MW03	B	C	C	A, B	C	B	
120-MW04	-	-	-	A	-	-	
120-MW07	-	-	-	A	-	-	
120-MW10	-	-	-	A	-	-	
120-MW12	-	C	C	-	C	-	
120-MW13	-	D	D	-	-	-	
120-MW15	-	-	-	A	-	-	
120-OW01	-	-	-	A	-	-	
120-OW03	-	-	-	A	-	-	
120-OW05	-	-	-	E	-	-	
133-EW03	-	-	-	-	-	B, E	
133-EW04	-	-	-	-	-	B	
133-IW01	-	-	B	B	B	B, H	
133-IW02	B	-	-	-	-	H	
133-IW03	B	-	-	-	-	C	
133-MW01	-	-	-	-	D	A	
133-MW02	-	-	-	-	-	I	
133-MW03	-	-	-	-	-	J	
133-OW02	-	-	-	A	-	-	added sand
133-OW06	-	-	-	-	-	H	
133-OW07	B	-	-	-	-	-	
133-OW08	-	-	-	-	-	C	
133-OW10	B	-	-	-	-	-	
13-MW05	-	-	-	-	-	A, H	
13-MW09	-	-	-	-	-	F	added sand
13-MW10	-	D	D	-	D	-	
13-MW12	-	-	-	A	-	-	
13-MW14	-	-	-	-	-	A	
13-MW15	-	B	B	A	B	-	
13-MW18	-	-	-	A	-	-	
13-MW20	-	-	-	A	-	-	
13-MW23	-	-	-	F, G	-	-	
13-MW24	-	-	-	-	-	H	
13-MW27	-	-	-	A	-	-	
13-MW28	-	-	-	A	-	-	
13-MW29	-	-	-	A	-	-	
13-MW30	-	-	-	A	-	-	
13-MW32	-	-	-	A	-	-	
13-MW33	-	-	-	A	-	-	
13-MW35	-	B	B	A	B	B	
13-MW36	-	-	-	-	-	H	
13-MW40	-	-	-	E	-	-	
145-MW01	-	B	-	-	-	-	
150-MW04	-	-	C	-	C	E	

TABLE 4.5-3. MONITORING WELLS WITH ISSUES
(Page 2 of 3)

	Date Issues Were Noted						
Well ID	October 2007/ April 2008	October 2008/ April 2009	October 2009/ April 2010	October 2010/ April 2011	October 2011	April 2012	Repairs made in April 2012
151-MW01	-	-	-	-	-	E	
153-MW06	-	C	C	-	C	C	
153-MW07	-	-	-	C	-	C, E	
153-MW10	-	-	-	C	-	I	
171-MW05	-	-	-	F	-	G	
186-MW01	-	-	-	-	-	I	
26-MW08	-	-	-	G	-	G, H	
271-MW01	-	-	-	-	-	H	
321-MW02	-	-	-	A	-	-	
37-EW01	-	-	-	A	-	-	
37-EW09	-	-	-	E	-	E, H	
37-EW10	-	-	-	E	-	E, H	
37-MW01	-	-	-	A	-	A	
37-MW02	-	A	A	-	A	-	
37-MW04	-	C	C	-	C	-	
37-MW05	-	C	C	C	C	C, H	
37-MW06	-	-	-	-	-	-	added sand
37-MW07	-	-	-	A	-	A	
37-MW08	-	A	A	A	A	A	
37-MW09	-	A	A	A	A	A	
37-MW10	-	A	A	A	A	-	
37-MW11	-	A	A	A	A	A	
37-MW16	-	-	-	-	-	H	
37-MW17	-	-	-	-	-	A	
37-MW19	-	C	C	-	C	C, H	
37-MW22	-	-	-	F	-	A	
37-MW23	-	-	-	-	-	A, E, H	
37-MW24	-	-	-	-	-	H	
37-MW25	-	-	-	B	-	B	added label
37-MW26	-	A	A	A	A	A	
37-MW29	-	-	-	-	-	C	
37-MW31	-	A	A	A	A	G	added sand
37-MW32	-	-	-	A	-	-	
37-MW33	-	C	C	-	C	C	
37-MW34	-	-	-	-	-	E, H	
37-MW35	-	-	-	-	-	E, H	
37-MW37	-	C	A, C	C	A, C	C, E, H	
37-MW38	-	-	-	-	-	E, H	
37-MW39	-	-	-	-	-	E, H	
37-MW41	-	-	-	E	-	E, H	
37-MW42	-	-	-	E	-	E, H	
37-MW45s/d	-	-	-	-	-	H	
37-OW01	-	-	-	A	-	-	added sand
37-OW03	-	A	A	-	A	A, H	
37-OW05	-	A	A	A	A	A, H	
396-MW02	-	D	-	-	-	-	
442/1-MW01	-	-	-	A	-	-	
442/2-MW01	-	-	-	A	-	-	
443-MW01	-	-	-	E	-	-	

TABLE 4.5-3. MONITORING WELLS WITH ISSUES
(Page 3 of 3)

	Date Issues Were Noted						
Well ID	October 2007/ April 2008	October 2008/ April 2009	October 2009/ April 2010	October 2010/ April 2011	October 2011	April 2012	Repairs made in April 2012
OB/OD-MW01	-	B	B	B	B	B	
P059-MW01	-	C	C	C	C	C, I	
P059-VMW01	-	C	C	C	-	-	

Notes:

A: Requires more sand to be added within casing to allow for retrieval of equipment if dropped in annular space inside well monument

B: Protective casing lid/hinge damaged or broken

C: Broken or cracked concrete pad

D: Observed to have plant roots in well

E: Well casing needs Well ID exterior stencil

F: Pad not visible/buried

G: Overgrown brush needs clearing

H: Wells/ballards need yellow paint

I: Standing water in flush mount

J: Flush mount casing is caving in

- no issue identified

ID identification

TABLE 4.5-4. SUMMARY OF REMEDIAL ACTION OPERATIONAL COSTS FOR GROUNDWATER

	Non-Discounted Costs Estimated in South AFRL ROD			Actual Cost			
Year - FY	LTM[a]	Well Installation[b]	Total	LTM	Well Installation	Total	Cost Difference (proposed - actual)
1 - FY2008	$425,000	$0	$425,000	$385,000	$0	$385,000	$40,000
2 - FY2009	$181,000	$0	$181,000	$165,000	$257,000	$422,000	-$241,000
3 - FY2010	$181,000	$0	$181,000	$208,000	$0	$208,000	-$27,000
4 - FY2011	$181,000	$0	$181,000	$70,000[c]	$324,000[d]	$394,000	-$213,000
Total	$968,000	$0	$968,000	$828,000	$581,000	$1,409,000	-$441,000

Notes:

[a] Estimated costs for LTM are presented in Table 2.13-4 of the *South AFRL ROD* (USAF 2007). Costs are based on an average of 36 wells sampled annually and 121 wells sampled every CPME. See Table 4.5-5 for a comparison of total number of wells assumed for sampling in the South AFRL ROD and the actual number of samples collected from 2008 to 2011.

[b] The *South AFRL ROD* did not include costs for additional well installation.

[c] Based on sampling costs at Site 321 only. Sampling was not conducted in 2011 at Sites 37, 133, or 120; a CPME similar to 2008 is planned for 2012 at these sites.

[d] Includes wells installed in FY2010 and FY2011.

AFRL	Air Force Research Laboratory
CPME	comprehensive plume monitoring event
FY	fiscal year
LTM	long-term monitoring
ROD	record of decision
USAF	United States Air Force

TABLE 4.5-5. COMPARISON OF WELLS PROPOSED FOR SAMPLING IN THE SOUTH AFRL ROD AND ACTUAL WELLS SAMPLED

Year	Proposed Number of Wells Scheduled for Sampling in the *South AFRL ROD*	Number of Wells Actually Sampled[a]	Difference (Proposed – Actual)
2008	121	131	-10
2009	36	43	-7
2010	36	30	6
2011	36	6[b]	30
Total	229	210	19

Notes:

[a] Number of wells actually sampled in 2009 and 2010 was consistent with the sampling strategy in the approved RAWP.

[b] Based on sampling at Site 321 only. Sampling was not conducted in 2011 at Sites 37, 133, or 120; a CPME similar to 2008 is planned for 2012 at these sites.

AFRL Air Force Research Laboratory
CPME comprehensive plume monitoring event
RAWP remedial action work plan
ROD record of decision

TABLE 4.5-6. SUMMARY OF REMEDIAL ACTION OPERATIONAL COSTS FOR VAPOR

	Non-Discounted Costs Estimated in South AFRL ROD[a]				Actual Cost				
Year - FY	SVE O&M	Sampling and AOR	SVE Well Installation	Total	SVE O&M	Sampling and AOR	SVE Well Installation[b]	Total	Difference (proposed - actual)
1 - FY2008	$11,000	$158,000	$94,000	$263,000	$119,000	$54,000	$0	$173,000	$90,000
2 - FY2009	$69,000	$158,000	$0	$227,000	$135,000	$57,000	$0	$192,000	$35,000
3 - FY2010	$68,000	$158,000	$0	$226,000	$143,000	$59,000	$0	$202,000	$24,000
4 - FY2011	$87,000	$158,000	$0	$245,000	$64,000	$49,000	$0	$113,000	$132,000
Total	$235,000	$632,000	$94,000	$961,000	$461,000	$219,000	$0	$680,000	$281,000

Notes:

[a] 12 months operation of the SVE per Scenario 3 presented in Appendix B-2 of the South AFRL ROD (USAF 2007).

[b] One additional existing soil gas well was tied in to the SVE system at Site 172. No additional well installation costs were incurred.

AFRL Air Force Research Laboratory
AOR annual operations report
FY fiscal year
O&M operations and maintenance
ROD record of decision
SVE soil vapor extraction
USAF United States Air Force

TABLE 6.1-1. SUBMITTAL DATES FOR SOUTH AFRL FYR REPORT

Deliverable	Submittal By:	Submittal To:	Due Date
Draft FYR Report	USAF	RPMs	30 May 2012
Review Comments on Draft	RPMs	USAF	29 Jun 2012
Draft Final	USAF	RPMs	25 July 2012
Review Comments	RPMs	USAF	9 August 2012
Final*	USAF	RPMs	24 August 2012

Notes:

*The USEPA will provide this document version to Headquarters for review to meet statutory deadline of 24 September 2012 for completion of the South AFRL FYR.

AFRL Air Force Research Laboratory
FYR five-year review
RPM Remedial Project Manager
USAF United States Air Force
USEPA United States Environmental Protection Agency

TABLE 6.4-1. SITE 37 LEADING EDGE SAMPLING RESULTS, COMPARISON TO SITE COCs
(Page 1 of 3)

Chemical of Concern	ROD Selected Standard for Site 37[a]	13-MW26			37-MW12	37-MW13			37-MW22			37-MW23		
Volatile Organics (in µg/L)		10/22/2008	10/29/2009	10/26/2010	10/30/2009	11/9/2007	10/21/2008[b]	10/28/2009	11/8/2007	10/22/2008	10/29/2009	10/28/2008	1/14/2009	4/15/2010
1,1,1-trichloroethane (1,1,1-TCA)	200	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1	<1.0
1,1,2-trichlorotrifluoroethane (CFC 113)	1,200	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0 / <2.0	<2.0	<2.0	<2.0	<2.0	0.49 J	0.37 J	<2.0
1,1-dichloroethane (1,1-DCA)	5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1	<1.0
1,1-dichloroethene (1,1-DCE)	6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1	<1.0
cis-1,2-dichloroethene (cis-1,2-DCE)	6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / 0.36 J	<1.0	<1.0	<1.0	<1.0	0.99 J	1.2	0.42 J
methylene chloride	5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1	<1.0
naphthalene	17	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1	<1.0
tetrachloroethene (PCE)	5	<1.0	<1.0	<1.0	<1.0	**41**	**48 / 46**	**60**	<1.0	<1.0	<1.0	**28**	**20**	2.1
trichloroethene (TCE)	5	<1.0	<1.0	<1.0	<1.0	1.2	1.5 / 2.2	1.8	<1.0	<1.0	<1.0	0.97 J	0.98 J	<1.0
vinyl chloride	0.5	<1.0	<1.0	<0.50	<1.0	<1.0	<1.0 / <1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1	<1.0
Semivolatile Organics (in µg/L)														
1,4-dioxane	3[c]	-	-	-	-	-	-	-	-	-	-	-	-	-
N-nitrosodimethylamine (NDMA)	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-
Inorganics (in mg/L)														
nitrate (as N)	10	5.6	-	-	-	-	8.7 MHA	-	-	<0.50 RL1	-	<0.20 RL3	-	-
perchlorate	0.024[d]	-	-	-	-	-	-	*0.0092*	-	-	-	-	-	-

TABLE 6.4-1. SITE 37 LEADING EDGE SAMPLING RESULTS, COMPARISON TO SITE COCs
(Page 2 of 3)

Chemical of Concern	ROD Selected Standard for Site 37[a]	37-MW30[e]		37-MW31	37-MW32			37-MW36		37-MW40		37-MW44		
Volatile Organics (in μg/L)		1/15/2009	10/30/2009	10/28/2008	11/9/2007	10/22/2008	10/30/2009	3/30/2009	10/28/2009	5/19/2010	10/26/2010[b]	3/30/2009	10/29/2009[b]	10/26/2010[b]
1,1,1-trichloroethane (1,1,1-TCA)	200	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0 / <1.0
1,1,2-trichlorotrifluoroethane (CFC 113)	1,200	<2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0 / <2.0	<2.0 / <2.0
1,1-dichloroethane (1,1-DCA)	5	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0 / <1.0
1,1-dichloroethene (1,1-DCE)	6	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0 / <1.0
cis-1,2-dichloroethene (cis-1,2-DCE)	6	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0 / <1.0
methylene chloride	5	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0 / <1.0
naphthalene	17	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0 / <1.0
tetrachloroethene (PCE)	5	<1	<1.0	<1.0	<1.0	<1.0	<1.0	2.1	3.4	<1.0	<1.0	3.0	4.5 / 4.6	**6.0** / **6.2**
trichloroethene (TCE)	5	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0 / <1.0
vinyl chloride	0.5	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.50	<1.0	<1.0 / <1.0	<0.5 / <0.5
Semivolatile Organics (in μg/L)														
1,4-dioxane	3[c]	-	-	-	-	-	-	-	-	-	-	-	-	-
N-nitrosodimethylamine (NDMA)	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-
Inorganics (in mg/L)														
nitrate (as N)	10	-	-	<0.10	-	<0.20 RL3	-	9.3	-	**16.7** Q	0.18 / 0.15	**12**	-	-
perchlorate	0.024[d]	-	-	-	-	-	-	*0.017*	0.0049	*0.024*	**0.030**	*0.011*	*0.011 / 0.011*	*0.013 / 0.012*

TABLE 6.4-1. SITE 37 LEADING EDGE SAMPLING RESULTS, COMPARISON TO SITE COCs

(Page 3 of 3)

Chemical of Concern	ROD Selected Standard for Site 37[a]	37-MW45s[e]		37-MW45d[e]		37-MW46s			37-MW46d[e]		37-MW47	271-MW01	
Volatile Organics (in μg/L)		7/22/2009	10/29/2009	7/22/2009	10/29/2009	7/22/2009	10/29/2009	10/28/2010	7/27/2009	10/29/2009	12/28/2010	11/19/2008	10/27/2010
1,1,1-trichloroethane (1,1,1-TCA)	200	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 (UJ-4L)	-
1,1,2-trichlorotrifluoroethane (CFC 113)	1,200	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0 (UJ-4L)	-
1,1-dichloroethane (1,1-DCA)	5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 (UJ-4L)	-
1,1-dichloroethene (1,1-DCE)	6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 (UJ-4L)	-
cis-1,2-dichloroethene (cis-1,2-DCE)	6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 (UJ-4L)	-
methylene chloride	5	0.80 J (J1)	<1.0	0.83 J (J1)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 (UJ-4L)	-
naphthalene	17	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 (UJ-4L)	-
tetrachloroethene (PCE)	5	<1.0	0.38 J	<1.0	<1.0	0.47 J	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 (UJ-4L)	-
trichloroethene (TCE)	5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 (UJ-4L)	-
vinyl chloride	0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.50	<1.0	<1.0	<1.0	<1.0 (UJ-4L)	-
Semivolatile Organics (in μg/L)													
1,4-dioxane	3[c]	-	-	-	-	-	-	-	-	-	-	-	-
N-nitrosodimethylamine (NDMA)	0.01	-	-	-	-	-	-	-	-	-	-	-	-
Inorganics (in mg/L)													
nitrate (as N)	10	**11**	-	<0.20 RL1	-	**28**	-	-	2.1	-	<0.50 G	-	<0.10
perchlorate	0.024[d]	*0.01*	*0.0063*	<0.0005	<0.00050	*0.015*	*0.012*	*0.014*	0.0005	<0.00050	<0.00050	-	*0.0090*

Notes:

Analytical results shown in bold exceed the ROD selected standard. Perchlorate results shown in italics exceed the CA pMCL but are less than the ROD selected standard.

[a] All standards are CA pMCLs unless otherwise noted.

[b] Second value is the result of the duplicate sample.

[c] Existing NL at the time of the signing of the South AFRL ROD. The NL has since been dropped to 1 μg/L.

[d] Standard derived as the DoD level of concern from an oral reference dose of 0.0007 mg/kg/day listed in the USEPA's IRIS database. A CA pMCL of 0.006 mg/L has since been developed.

[e] Well screened across a deeper water-bearing zone.

-	not sampled
<	less than
μg/L	micrograms per liter
AFRL	Air Force Research Laboratory
CA	California
CDPH	California Department of Public Health
COC	chemical of concern
DoD	Department of Defense
IRIS	Integrated Risk Information System
mg/kg/day	milligrams per kilogram per day
mg/L	milligrams per liter
MS/MSD	matrix spike/matrix spike duplicate
N	nitrogen
NL	notification level (CDPH 2010)
pMCL	primary maximum contaminant level (CDPH 2011)
QC	quality control
ROD	record of decision
USEPA	United States Environmental Protection Agency

Laboratory-Assigned Data Qualifiers:

J	Estimated result. Result is less than the reporting limit.
G	Elevated reporting limit. The reporting limit is elevated due to matrix interference.
MHA	Due to high levels of analyte in the sample, the MS/MSD calculation does not provide useful spike recovery information.
Q	Elevated reporting limit. The reporting limit is elevated due to high analyte levels.
RL1	Reporting limit raised due to sample matrix effects.
RL3	Reporting limit raised due to high concentrations of non-target analytes.

Data Validation Qualifiers:

(J1)	Estimated value. Blank contamination: indicates possible high bias and/or false positives.
(UJ-4L)	Reporting limit estimated. Recoveries for one or more surrogates are below the QC limits. Indicates possible low bias.

TABLE 6.4-2. SITE 133 LEADING EDGE SAMPLING RESULTS, COMPARISON TO SITE COCs

(Page 1 of 4)

Chemical of Concern	ROD Selected Standard for Site 133 [a]	13-MW16	13-MW25	13-MW28		13-MW29			13-MW30			13-MW31	
Volatile Organics (in μg/L)		10/20/2008	10/15/2008	11/6/2007	10/14/2008	11/7/2007	10/14/2008	10/27/2009	11/7/2007	10/14/2008	10/30/2009	10/16/2008	11/9/2009
1,2-dichloroethane (1,2-DCA)	0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0	<1.0
benzene	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0	<1.0
cis-1,2-dichloroethene (cis-1,2-DCE)	6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	**10**	**8.7**	**7.4 / 7.1**	<1.0	<1.0
methyl tert-butyl ether (MTBE)	13	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0 / <2.0	<2.0	<2.0
tetrachloroethene (PCE)	5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0	<1.0
trichloroethene (TCE)	5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	**90**	**110**	**110 / 110**	<1.0	<1.0
vinyl chloride	0.5	<1.0	<1.0	<1.0 L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0	<1.0
Semivolatile Organics (in μg/L)													
1,4-dioxane	3[b]	-	-	-	-	-	-	-	-	-	-	-	-
N-nitrosodimethylamine (NDMA)	0.01	-	-	-	-	-	-	-	-	-	-	-	-
Inorganics (in mg/L)													
nitrate (as N)	10	<0.50 RL1	<0.10	-	<0.10	-	<0.10	-	-	<0.50 RL3	-	<0.10	-
perchlorate	0.024[c]	<0.00050	<0.00050	<0.00050	-	-	-	-	-	-	-	-	-

TABLE 6.4-2. SITE 133 LEADING EDGE SAMPLING RESULTS, COMPARISON TO SITE COCs

(Page 2 of 4)

Chemical of Concern	ROD Selected Standard for Site 133 [a]	13-MW32						13-MW33			13-MW34		
Volatile Organics (in μg/L)		11/6/2007	10/16/2008[d]	1/14/2009	7/15/2009	11/9/2009	4/28/2010	11/7/2007	10/16/2008[d]	7/14/2009	11/6/2007	10/13/2008	10/27/2009
1,2-dichloroethane (1,2-DCA)	0.5	<1.0	<1.0 / <1.0	<1	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0	<1.0	<1.0	<1.0
benzene	1	<1.0	<1.0 / <1.0	<1	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0	<1.0	<1.0	<1.0
cis-1,2-dichloroethene (cis-1,2-DCE)	6	<1.0	<1.0 / <1.0	<1	<1.0	<1.0	<1.0	5.7	**6.0** / **6.1**	5.4	<1.0	<1.0	<1.0
methyl tert-butyl ether (MTBE)	13	<2.0	<2.0 / <2.0	<2	<2.0	<2.0	<2.0	<2.0	<2.0 / <2.0	<2.0	<2.0	<2.0	<2.0
tetrachloroethene (PCE)	5	<1.0	<1.0 / <1.0	<1	<1.0	<1.0	<1.0	4.5	4.6 / 4.9	4.4	<1.0	<1.0	<1.0
trichloroethene (TCE)	5	0.63 J	3.6 / 2.9	0.54 J	<1.0	<1.0	<1.0	4.1	3.9 / 4.2	3.8	<1.0	<1.0	<1.0
vinyl chloride	0.5	<1.0	<1.0 / <1.0	<1	<1.0	<1.0	<1.0	<1.0	<1.0 / <1.0	<1.0	<1.0	<1.0	<1.0
Semivolatile Organics (in μg/L)													
1,4-dioxane	3[b]	-	-	-	-	-	-	-	-	-	-	-	-
N-nitrosodimethylamine (NDMA)	0.01	-	-	-	-	-	-	-	-	-	-	-	-
Inorganics (in mg/L)													
nitrate (as N)	10	-	<0.10 / <0.10	-	-	-	-	-	1.8 / 1.8	-	-	<0.10	-
perchlorate	0.024[c]	-	-	-	-	-	-	-	-	-	-	-	<0.00050

TABLE 6.4-2. SITE 133 LEADING EDGE SAMPLING RESULTS, COMPARISON TO SITE COCs

(Page 3 of 4)

Chemical of Concern	ROD Selected Standard for Site 133 [a]	13-MW35						13-MW36			13-MW37	
Volatile Organics (in μg/L)		11/6/2007	10/13/2008	1/14/2009	7/15/2009	11/9/2009	4/15/2010	11/6/2007	10/13/2008	10/27/2009	3/31/2009	10/27/2009
1,2-dichloroethane (1,2-DCA)	0.5	<1.0	<1.0	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
benzene	1	<1.0	<1.0	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-1,2-dichloroethene (cis-1,2-DCE)	6	<1.0	<1.0	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
methyl tert-butyl ether (MTBE)	13	<2.0	<2.0	<2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
tetrachloroethene (PCE)	5	<1.0	0.88 J	0.84 J	<1.0	0.36 J	0.38 J	<1.0	<1.0	<1.0	<1.0	<1.0
trichloroethene (TCE)	5	<1.0	<1.0	<1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
vinyl chloride	0.5	<1.0	<1.0	0.38 J	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Semivolatile Organics (in μg/L)												
1,4-dioxane	3[b]	-	-	-	-	-	-	-	-	-	-	-
N-nitrosodimethylamine (NDMA)	0.01	-	-	-	-	-	-	-	-	-	-	-
Inorganics (in mg/L)												
nitrate (as N)	10	-	3.8	-	-	-	-	-	<0.10	-	0.30	-
perchlorate	0.024[c]	-	-	-	-	0.0010	-	-	-	<0.00050	0.00016 J	<0.00050

TABLE 6.4-2. SITE 133 LEADING EDGE SAMPLING RESULTS, COMPARISON TO SITE COCs

(Page 4 of 4)

Chemical of Concern	ROD Selected Standard for Site 133 [a]	13-MW38		13-MW39[e]		13-MW40	13-MW41	13-MW42	13-MW43	13-MW44	266-MW02	
Volatile Organics (in μg/L)		7/23/2009[d]	10/29/2009	5/19/2010	10/27/2010	4/18/2011	4/18/2011	4/18/2011	12/28/2010	12/28/2010	11/7/2007	10/14/2008[d]
1,2-dichloroethane (1,2-DCA)	0.5	<1.0 / <1.0	<1.0	<1.0	<0.50	<1.0	<2.0 Q	<5.0 Q	<2.0 Q	<1.0	<1.0	<1.0 / <1.0
benzene	1	<1.0 / <1.0	<1.0	<1.0	<1.0	<1.0	<2.0 Q	<5.0 Q	<2.0 Q	<1.0	<1.0	<1.0 / <1.0
cis-1,2-dichloroethene (cis-1,2-DCE)	6	0.3 J / 0.3 J	0.63 J	<1.0	<1.0	<1.0	0.83 J Q	2.5 J Q	0.91 J Q	<1.0	<1.0	<2.0 / <2.0
methyl tert-butyl ether (MTBE)	13	<2.0 / <2.0	<2.0	<2.0	<2.0	<2.0	<4.0 Q	<10 Q	<4.0 Q	<2.0	<2.0	<1.0 / <1.0
tetrachloroethene (PCE)	5	<1.0 / <1.0	<1.0	<1.0	<1.0	<1.0	<2.0 Q	<5.0 Q	<2.0 Q	<1.0	<1.0	<1.0 / <1.0
trichloroethene (TCE)	5	**33 / 36**	**69**	<1.0	<1.0	0.53 J	**88** (J-)	**190**	**88**	<1.0	<1.0	<1.0 / <1.0
vinyl chloride	0.5	<1.0 / <1.0	<1.0	<1.0	<0.50	<1.0	<2.0 Q	<5.0 Q	<2.0 Q	<1.0	<1.0	<1.0 / <1.0
Semivolatile Organics (in μg/L)												
1,4-dioxane	3[b]	-	-	-	-	-	-	-	-	-	-	-
N-nitrosodimethylamine (NDMA)	0.01	-	-	-	-	-	-	-	-	-	-	-
Inorganics (in mg/L)												
nitrate (as N)	10	3.9 / 3.8	-	<0.10	-	<0.50 G	5.9 G	1.6 G	2.1 G	9.1 G	-	1.2 / 1.2
perchlorate	0.024[c]	0.0057 / 0.0058	0.0058	<0.00050	<0.00050	<0.00050	*0.010*	*0.0063*	*0.0070*	*0.0071*	-	-

Notes:

Analytical results shown in bold exceed the ROD selected standard. Perchlorate results shown in italics exceed the CA pMCL but are less than the ROD selected standard.

[a] All standards are CA pMCLs unless otherwise noted.
[b] Existing NL at the time of the signing of the South AFRL ROD. The NL has since been dropped to 1 μg/L.
[c] Standard derived as the DoD level of concern from an oral reference dose of 0.0007 mg/kg/day listed in the USEPA's IRIS database. A CA pMCL of 0.006 mg/L has since been developed.
[d] Second value is the result of the duplicate sample.
[e] Well screened across a deeper water-bearing zone.

-	not sampled
<	less than
μg/L	micrograms per liter
AFRL	Air Force Research Laboratory
CA	California
CDPH	California Department of Public Health
COC	chemical on concern
DoD	Department of Defense
IRIS	Integrated Risk Information System
mg/kg/day	milligrams per kilogram per day
mg/L	milligrams per liter
N	nitrogen
NL	notification level (CDPH 2010)
pMCL	primary maximum contaminant level (CDPH 2011)
ROD	record of decision
USEPA	United States Environmental Protection Agency

Laboratory-Assigned Data Qualifiers:

J	Estimated result. Result is less than the reporting limit.
G	Elevated reporting limit. The reporting limit is elevated due to matrix interference.
Q	Elevated reporting limit. The reporting limit is elevated due to high analyte levels.
RL1	Reporting limit raised due to sample matrix effects.
RL3	Reporting limit raised due to high concentrations of non-target analytes.

Data Validation Qualifiers:

TABLE 6.4-3. SITE 120 LEADING EDGE SAMPLING RESULTS, COMPARISON TO SITE COCs

Chemical of Concern	ROD Selected Standard for Site 120[a]	120-MW10			120-MW15[b]		120-MW16		120-MW17	
Volatile Organics (in μg/L)		11/6/2007	10/30/2008	10/26/2010[c]	11/6/2007	10/30/2008	7/23/2009	10/29/2009	5/19/2010	10/26/2010
cis-1,2-dichloroethene (cis-1,2-DCE)	6	1.2	0.78	0.62 J / 0.64 J	<1.0	<1.0	<1.0	<1.0	1.7	1.3
tetrachloroethene (PCE)	5	2.3	2.1	2.0 / 1.9	<1.0	<1.0	<1.0	<1.0	1.6	1.0
trans-1,2-dichloroethene (trans-1,2-DCE)	10	<1.0	<1.0	<1.0 / <1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
trichloroethene (TCE)	5	4.5	3.6	3.5 / 3.6	<1.0	<1.0	<1.0	<1.0	1.7	1.1
vinyl chloride	0.5	<1.0	<1.0	<0.50 / <0.50	<1.0	<1.0	<1.0	<1.0	<1.0	<0.50
Semivolatile Organics (in μg/L)										
1,4-dioxane	3[d]	0.174 J	<1.0	-	0.208 J	-	-	-	-	-
Inorganics (in mg/L)										
nitrate (as N)	10	-	13	-	-	<0.10	6.8	-	0.79 G	-
perchlorate	0.024[e]	0.016	0.018	0.019 / 0.019	<0.00050	<0.00050	0.0034	<0.00050	0.0016	0.0014

Notes:
Analytical results shown in bold exceed the ROD selected standard.
[a] All standards are CA pMCLs unless otherwise noted.
[b] Well screened across a deeper water-bearing zone.
[c] Second value is the result of the duplicate sample.
[d] Existing NL at the time of the signing of the South AFRL ROD. The NL has since been dropped to 1 μg/L.
[e] Standard derived as the DoD level of concern from an oral reference dose of 0.0007 mg/kg/day listed in the USEPA's IRIS database. A CA pMCL of 0.006 mg/L has since been developed.

<	less than
-	not sampled
μg/L	micrograms per liter
AFRL	Air Force Research Laboratory
CA	California
CDPH	California Department of Public Health
COC	chemical of concern
DoD	Department of Defense
IRIS	Integrated Risk Information System
mg/kg/day	milligrams per kilogram per day
mg/L	milligrams per liter
N	nitrogen
NL	notification level (CDPH 2010)
pMCL	primary maximum contaminant level (CDPH 2011)
ROD	record of decision
USEPA	United States Environemtal Protection Agency

Laboratory-Assigned Data Qualifiers:

J	Estimated result. Result is less than the reporting limit.
G	Elevated reporting limit. The reporting limit is elevated due to matrix interference.

TABLE 6.4-4. SITE 321 LEADING EDGE SAMPLING RESULTS, COMPARISON TO SITE COCs
(Page 1 of 2)

Chemical of Concern	ROD Selected Standard for Site 321[a]	321-MW05a[b]				321-MW05b				321-MW06			321-MW07					
Volatile Organics (in µg/L)		8/23/2007	6/26/2008	9/28/2009	9/29/2010	8/23/2007	6/23/2008	9/28/2009	9/29/2010	6/26/2008	9/28/2009	8/23/2010	8/27/2007	6/25/2008	7/28/2008	9/29/2009	8/24/2010	9/29/2010
cis-1,2-dichloroethene (cis-1,2-DCE)	6	0.9 J (U)	<1.0 (U)	0.94 J (J)	0.91 J (J)	2.9	4.3	5.0 (J)	5.0	1.1	1.1	0.73 J (J)	<1.0	<1.0 (U)	-	<1.0 (U)	<1.0 (U)	-
tetrachloroethene (PCE)	5	0.75 J	0.39 J (J)	1.2 (J)	0.89 J (J)	**17**	**17**	**37** (J)	**36**	<1.0 (U)	<1.0 (U)	<1.0 (U)	<1.0	0.060 J (J)	-	<1.0 (U)	<1.0 (U)	-
trichloroethene (TCE)	5	0.22 J	0.15 J (J)	0.62 J (J)	0.86 J (J)	**5.6**	4.7	3.8 (J)	3.1	3.4	4.0	3.0	<1.0	0.12 J (J)	-	<1.0 (U)	<1.0 (U)	-
vinyl chloride	0.5	<1.0 (U)	<1.0 (U)	<1.0 (UJ)	<1.0 (U)	<1.0	<1.0 (U)	<1.0 (UJ)	<1.0 (U)	<1.0 (U)	<1.0 (U)	<1.0 (U)	<1.0	<1.0 (U)	-	<1.0 (U)	<1.0 (U)	-
Inorganics (in mg/L)																		
nitrate (as N)	10	<0.11 (U)	<0.11 (U)	<0.55 RL1 (U)	-	<0.11	<0.11 (U)	<0.55 RL1 (U)	-	-	<0.22 RL1 (U)	<0.25 G (U)	1.4	1.5	1.5	1.5	1.7 G	1.8 G

TABLE 6.4-4. SITE 321 LEADING EDGE SAMPLING RESULTS, COMPARISON TO SITE COCs
(Page 2 of 2)

Chemical of Concern	ROD Selected Standard for Site 321[a]	321-MW08a[b]					321-MW08b					321-MW10
Volatile Organics (in µg/L)		8/27/2007	6/26/2008	9/29/2009	8/24/2010	9/29/2010	8/27/2007	6/26/2008	9/29/2009	8/24/2010	9/29/2010	5/19/2010
cis-1,2-dichloroethene (cis-1,2-DCE)	6	<1.0	-	<1.0 (U)	<1.0 (U)	-	<1.0	-	-	<1.0 (U)	-	<1.0
tetrachloroethene (PCE)	5	<1.0	-	<1.0 (U)	<1.0 (U)	-	<1.0	-	-	<1.0 (U)	-	<1.0
trichloroethene (TCE)	5	<1.0	-	<1.0 (U)	<1.0 (U)	-	<1.0	-	-	<1.0 (U)	-	0.18 J
vinyl chloride	0.5	<1.0	-	<1.0 (U)	<1.0 (U)	-	<1.0	-	-	<1.0 (U)	-	<1.0
Inorganics (in mg/L)												
nitrate (as N)	10	0.80	2.4	2.2	2.1 G	2.2 G	2.3	1.2	1.3	1.2 G	1.1 G	0.19

Notes:
Analytical results shown in bold exceed the ROD selected standard.

[a] All standards are CA pMCLs.
[b] Well screened across a deeper water-bearing zone.

<	less than
-	not sampled
µg/L	micrograms per liter
CA	California
CDPH	California Department of Public Health
COC	chemical of concern
mg/L	milligrams per liter
N	nitrogen
pMCL	primary maximum contaminant level (CDPH 2011)
ROD	record of decision

Laboratory-Assigned Data Qualifiers:

J	Estimated result. Result is less than the reporting limit.
G	Elevated reporting limit. The reporting limit is elevated due to matrix interference.
RL1	Reporting limit raised due to sample matrix effects.

Data Validation Qualifiers:

(J)	Indicates an estimated value with a negative bias.
(U)	Indicates the compound or analyte was analyzed for but not detected at or above the stated limit.
(UJ)	Indicates the compound or analyte was analyzed for but not detected. The sample detection limit is an estimated value.

TABLE 6.4-5. RESULTS OF SCREENING EVALUATION BASED ON SOIL GAS RESULTS FROM VAPOR MONITORING WELLS AT SITE 37

(Page 1 of 2)

Sample ID	Date	PCE	TCE	Comments	Summary of Other Results	Outcome of Screening Evaluation
8349-SG1	3/24/2009	< 15	< 19			Bldg 8349 - no further sampling
8349-SG2	3/26/2009	< 15	< 19			
8349-SG2-FD	3/26/2009	< 15	< 19	Field Duplicate		
8350-SG1s	3/24/2009	< 15	< 19			
8350-SG1d	3/24/2009	< 15	< 19		TCFM at 48 ppb v/v	
8350-SG2	3/25/2009	28	< 19			conduct 2nd round of sampling
8351-SG1s	3/26/2009	< 15	< 19		toluene at 42.5 (J-10) ppb v/v	Bldg 8351 - no further sampling
8351-SG1s-FD	3/26/2009	< 15	< 19	Field Duplicate		
8351-SG1d	3/26/2009	< 15	< 19			
8351-SG2	3/26/2009	< 15	< 19		TCFM at 720 ppb v/v	
8352-SG1	3/24/2009	120	< 19		TCFM at 77 ppb v/v	conduct 2nd round of sampling
8352-SG2	3/25/2009	< 15	< 19			
8352-SG3	3/27/2009	< 15	< 19			
8353-SG1	3/24/2009	< 15	< 19		TCFM at 630 ppb v/v	
8353-SG2	3/27/2009	55	< 19			conduct 2nd round of sampling
8354-SG1	3/24/2009	< 15	26			
8354-SG2	3/24/2009	< 15	33			
8354-SG2-FD	3/24/2009	< 15	< 19	Field Duplicate		
8354-SG3	3/25/2009	< 15	< 19			
8354-SG3-FD	3/25/2009	< 15	< 19	Field Duplicate		
8354-SG4	3/25/2009	50	< 19			Bldg 8354 - slated for Phase II monitoring[1]
8354-SG5	3/25/2009	< 15 (R9)	< 19 (R9)			
8354-SG6	3/25/2009	**300**	< 19			**conduct sub-slab sampling**
8354-SG7s	3/27/2009	< 15	< 19	adjacent to Well 37-EW03		
8354-SG7d	3/27/2009	38	< 19	adjacent to Well 37-EW03		not next to a building[2]
8356-SG1	3/24/2009	< 15	< 19			Bldg 8356 - no further sampling
8356-SG1-FD	3/24/2009	< 15	< 19	Field Duplicate		
8356-SG2	3/24/2009	< 15	< 19			

TABLE 6.4-5. RESULTS OF SCREENING EVALUATION BASED ON SOIL GAS RESULTS FROM VAPOR MONITORING WELLS AT SITE 37

(Page 2 of 2)

Notes:

Samples were analyzed on-site by EST using Modified USEPA Method 8260B. All concentrations are in ppb v/v.

Sample IDs and numbers in blue identify locations where PCE concentrations exceed 25 ppb v/v; i.e., 10% of the SN (250) for PCE.

Sample IDs and numbers in bold blue identify locations where PCE concentrations exceed the SN for PCE, 250 ppb v/v.

None of the samples had TCE concentrations that exceeded 95 ppb v/v, which is 10% of the SN (950) for TCE.

(1) Because the sampling result for 37-8354SG6 exceeded the SN for PCE, triggering installation of Phase II sub-slab wells inside Building 8354, a 2nd round of sampling in Well 37-8354SG4 was not conducted.

(2) Because sampling point 37-8354SG7 was installed adjacent to Well 37-EW03 and is not associated with a building, a 2nd round of sampling was not conducted.

%	percent
<	less than
Bldg	building
EST	Environmental Support Technologies, Inc.
FD	field duplicate
ID	identification
ppb v/v	parts per billion volume by volume
PCE	tetrachloroethene
QC	quality control
SN	screening number
TCE	trichloroethene
TCFM	trichlorofluoromethane
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

Data Validation Data Qualifiers:

J-10	Estimated value. Value reported by laboratory is below reporting limit and was not qualified by the laboratory.
R9	Rejected data. Sample identity uncertain.

TABLE 6.4-6. RESULTS OF SCREENING EVALUATION BASED ON SOIL GAS RESULTS FROM VAPOR MONITORING WELLS AT SITE 133

(Page 1 of 2)

Sample ID	Date	PCE	TCE	Comments	Summary of Other Results	Outcome of Screening Evaluation
8402-SG1s	3/23/2009	< 15	71		VC at 86 (J-8) ppb v/v	
8402-SG1d	3/23/2009	< 15	160		VC at 47 (J-8) ppb v/v	conduct 2nd round of sampling
8403-SG1	3/23/2009	< 15	650		VC at 63 (J-8) ppb v/v	conduct 2nd round of sampling
8403-SG2	3/24/2009	< 15	140			conduct 2nd round of sampling
8404-SG1	3/23/2009	< 15	**960**			**conduct sub-slab sampling**
8405-SG1	3/25/2009	< 15	170			conduct 2nd round of sampling
8405-SG1-FD	3/25/2009	< 15	160	Field Duplicate		conduct 2nd round of sampling
8406-SG1	3/23/2009	< 15	33		CF at 160 ppb v/v	
8406-SG1-FD	3/23/2009	< 15	29.8	Field Duplicate	4 other VOCs detected; CF at 160 ppb v/v	
8406-SG2	3/23/2009	100	**4,700**			**conduct sub-slab sampling**
8406-SG2-FD	3/23/2009	97.3	**4,570**	Field Duplicate	3 other VOCs detected	**conduct sub-slab sampling**
8406-SG3	3/23/2009	37	**2,300**		DCDFM at 32 ppb v/v; VC at 51 (J-8) ppb v/v	**conduct sub-slab sampling**
8406-SG4	3/25/2009	< 15	< 19			
8407-SG1	3/24/2009	< 15	380			conduct 2nd round of sampling
8407-SG1-FD	3/24/2009	< 15	411	Field Duplicate		conduct 2nd round of sampling
8407-SG2	3/24/2009	24	< 19			
8408-SG1	3/24/2009	< 15	**2,000**			**conduct sub-slab sampling**
8408-SG2	3/23/2009	< 15	**1,400**			**conduct sub-slab sampling**
8411-SG1	3/26/2009	< 15	**1,600**			**conduct sub-slab sampling**[(1)]
8411-SG2	3/27/2009	< 15	850			conduct 2nd round of sampling
8411-SG2-FD	3/27/2009	< 15	882	Field Duplicate		conduct 2nd round of sampling
8423-SG1	3/24/2009	< 15	35			Bldg 8423 - no further sampling
8423-SG2	3/25/2009	< 15	< 19			
8423-SG3	3/27/2009	55	**1,800**	Adjacent to (former) Dry Well F		**not next to a building**[(2)]
8424-SG1	3/25/2009	< 15	< 19			Bldg 8424 - no further sampling
8424-SG2	3/26/2009	< 15	< 19			
8431-SG1	3/27/2009	34	84	Adjacent to (former) Dry Well E		not next to a building[(2)]
8431-SG2	3/27/2009	< 15	37			Bldg 8431 - no further sampling
8431-SG2-FD	3/27/2009	< 15	40.9	Field Duplicate		

TABLE 6.4-6. RESULTS OF SCREENING EVALUATION BASED ON SOIL GAS RESULTS FROM VAPOR MONITORING WELLS AT SITE 133

(Page 2 of 2)

Notes:

Samples were analyzed on site by EST using Modified USEPA Method 8260B. All concentrations are in ppb v/v.

Sample IDs and numbers in red identify locations where TCE concentrations exceed 95 ppb v/v; i.e., 10% of the SN (950) for TCE.

Sample IDs and numbers in bold red identify locations where TCE concentrations exceed the SN for TCE, 950 ppb v/v.

Sample IDs and numbers in blue identify locations where PCE concentrations exceed 25 ppb v/v; i.e., 10% of the SN (250) for PCE.

(1) A metal plate underlying Building 8411 precluded the installation of sub-slab wells; therefore, two more rounds of samples were collected from near-slab wells in conjunction with indoor air sampling.

(2) Because sampling points 133-8423SG3 and 133-8431SG1 were installed adjacent to former Dry Wells F and E, respectively, and are not associated with a building, a 2nd round of sampling was not conducted.

%	percent
<	less than
CF	chloroform
DCDFM	dichlorodifluoromethane
EST	Environmental Support Technologies, Inc.
FD	field duplicate
ID	identification
LCS	laboratory control sample
PCE	tetrachloroethene
ppb v/v	parts per billion volume by volume
QC	quality control
SN	screening number
TCE	trichloroethene
USEPA	United States Environmental Protection Agency
VC	vinyl chloride

Data Validation Data Qualifier:

J-8 Estimated value. Recovery for the affected analyte in the LCS is below the QC limit and the analyte is present in the sample. Indicates possible low bias.

TABLE 6.4-7. SUMMARY OF RESULTS FROM SUB-SLAB WELLS AND INDOOR/OUTDOOR SAMPLING LOCATIONS ASSOCIATED WITH SITES 37 AND 133 EXCLUDING BUILDING 8595

(Page 1 of 2)

		Summer (June 2009)			Winter (December 2009, Jan 2010, or Jan 2011)		
Sample ID	Method	PCE	TCE	Other Results	PCE	TCE	Other Results
8354-SS1	TO-14A	65	<4.8	5 other VOCs	68	<5.1	9 other VOCs
8354-SS2	TO-14A	450	1.5 J	8 other VOCs	260	0.93 J	5 other VOCs
8354-IA1	TO-15	<0.2	<0.2	20 other VOCs	0.18 J	0.35	15 other VOCs
8354-IA2	TO-15	0.034 J	<0.2	19 other VOCs	0.18 J	<0.2	11 other VOCs
8354-IA3	TO-15	<0.2	<0.2	15 other VOCs	0.047 J	<0.2	14 other VOCs
8354-OA1	TO-15	<0.2	<0.2	11 other VOCs	<0.2	<0.2	16 other VOCs
8403-IA1	TO-15 SIM	-	-	-	0.41 J	0.59	16 other VOCs
8403-IA2	TO-15 SIM	-	-	-	0.31 J	0.70	17 other VOCs
8403-IA3	TO-15 SIM	-	-	-	0.27 J	0.38	18 other VOCs
8403-OA1	TO-15 SIM	-	-	-	0.23 J	0.09	16 other VOCs
8404-SS1	TO-14A	<4.0	50	7 other VOCs	<4.0	35	11 other VOCs
8404-IA1	TO-15	<0.2	<0.2	11 other VOCs	<0.2	0.16 J	21 other VOCs
8404-IA2	TO-15	<0.2	<0.2	13 other VOCs	<0.2	<0.2	16 other VOCs
8404-OA1	TO-15	<0.2	<0.2	21 other VOCs	3.9	<0.2	12 other VOCs
8406-SS1	TO-14A	130	2,000	5 other VOCs	88	2,000	15 other VOCs
8406-SS1-fd	TO-14A	65	2,100	5 other VOCs	110	2,000	9 other VOCs
8406-SS2	TO-14A	23	630	10 other VOCs	37	740	8 other VOCs
8406-IA1	TO-15	<0.2	<0.2	19 other VOCs	<0.2	0.16 J	16 other VOCs
8406-IA1	TO-15	<0.2	<0.2	17 other VOCs	<0.2	0.17 J	18 other VOCs
8406-IA2	TO-15	<0.2	<0.2	13 other VOCs	<0.2	0.11 J	18 other VOCs
8406-IA3	TO-15	<0.37	<0.37	14 other VOCs	0.045 J	0.24	20 other VOCs
8406-IA3-fd	TO-15	<0.33	<0.33	15 other VOCs	-	-	-
8408-SS1	TO-14A	6.0 J	710	10 other VOCs	53	570	9 other VOCs
8408-IA1	TO-15	<0.2	0.17 J	19 other VOCs	<0.2	0.50	22 other VOCs
8408-IA2	TO-15	<0.2	0.30	15 other VOCs	<0.2	0.44	17 other VOCs
8408-IA2-fd	TO-15	-	-	-	<0.2	0.44	17 other VOCs
8408-IA3	TO-15	<0.5	<0.5	19 other VOCs	0.086 J	0.22	14 other VOCs
8408-IA3-fd	TO-15	<0.23	0.11 J	19 other VOCs	-	-	-
8411-IA1	TO-15	<0.2	<0.2	18 other VOCs	<0.2	0.062 J	19 other VOCs
8411-IA2	TO-15	0.061 J	0.026 J	21 other VOCs	<0.2	0.038 J	19 other VOCs
8411-OA1	TO-15	0.089 J	0.023 J	17 other VOCs	<0.2	<0.2	13 other VOCs

TABLE 6.4-7. SUMMARY OF RESULTS FROM SUB-SLAB WELLS AND INDOOR/OUTDOOR SAMPLING LOCATIONS ASSOCIATED WITH SITES 37 AND 133 EXCLUDING BUILDING 8595

Notes:
All concentrations are in ppb v/v.

%	percent
<	less than
fd	field duplicate
ID	identification
Jan	January
MDL	method detection limit
PCE	tetrachloroethene
ppb v/v	parts per billion by volume
RL	reporting limit
SN	screening number
TCE	trichloroethene
VOC	volatile organic compound

Laboratory-Assigned Data Qualifier:

J	Estimated value. Analyte detected at a level less than the RL and greater than or equal to the MDL. The user of these data should be aware that these data are of limited reliability.

TABLE 6.4-8. SUMMARY OF CUMULATIVE RISK AND HAZARD - SOUTH AFRL INDOOR AIR SAMPLING 2009 AND 2011

Site	Building ID	Location	Sampling Event	Cumulative Risk (USAF)	Cumulative Risk (CA)	VI Cumulative Risk (USAF)	VI Cumulative Risk (CA)	Hazard	VI Hazard
37	8354	IA1	Jun-09	7.3E-07	2.9E-06	-	-	<0.1	<0.1
			Dec-09	1.1E-06	3.0E-06	6.9E-07	**1.3E-06**	0.2	0.2
	8354	IA2	Jun-09	6.9E-07	3.1E-06	1.8E-07	2.9E-07	<0.1	<0.1
			Dec-09	6.1E-07	2.7E-06	2.1E-07	7.7E-07	<0.1	<0.1
	8354	IA3	Jun-09	4.1E-07	2.4E-06	-	-	<0.1	<0.1
			Dec-09	5.7E-07	2.8E-06	5.3E-08	2.5E-07	<0.1	<0.1
	8595	IA1	Jun-09	2.2E-06	6.2E-06	**1.4E-06**	**4.0E-06**	0.9	0.8
			Dec-09	5.2E-07	4.0E-06	1.7E-07	**1.6E-06**	0.1	<0.1
			Jan-11	1.1E-06	3.6E-06	3.2E-07	**1.1E-06**	<0.1	<0.1
			Jan-12	1.0E-06	3.8E-06	4.8E-07	**1.5E-06**	<0.1	<0.1
	8595	IA2	Jun-09	7.5E-07	2.6E-06	4.8E-07	9.1E-07	0.7	0.7
			Dec-09	5.5E-05	5.8E-05	4.0E-07	**2.2E-06**	<0.1	<0.1
			Jan-11	8.2E-07	3.0E-06	4.1E-07	**1.1E-06**	<0.1	<0.1
			Jan-12	9.0E-07	4.6E-06	4.2E-07	**2.3E-06**	<0.1	<0.1
	8595	IA3	Jun-09	1.5E-06	3.9E-06	**1.5E-06**	**3.9E-06**	2.0	**2.0**
			Dec-09	1.9E-06	5.6E-06	**1.0E-06**	**2.8E-06**	<0.1	<0.1
			Jan-11	2.8E-06	5.3E-06	3.7E-07	**1.1E-06**	<0.1	<0.1
			Jan-12	1.2E-06	6.0E-06	6.9E-07	**3.4E-06**	<0.1	<0.1
	8595	IA4	Jun-09	4.4E-07	2.3E-06	2.0E-07	6.2E-07	0.1	<0.1
			Dec-09	6.9E-07	3.4E-06	3.9E-07	**1.4E-06**	<0.1	<0.1
			Jan-11	8.6E-07	3.2E-06	2.8E-07	9.6E-07	<0.1	<0.1
			Feb-12*	1.3E-06	5.0E-06	4.2E-07	**1.5E-06**	<0.1	<0.1
	8595	IA6	Jan-11	1.3E-06	3.7E-06	2.9E-07	9.6E-07	<0.1	<0.1
133	8403	IA1	Jan-11	1.5E-06	4.5E-06	9.8E-07	**2.1E-06**	<0.1	<0.1
		IA2	Jan-11	1.6E-06	4.8E-06	**1.1E-06**	**2.2E-06**	<0.1	<0.1
		IA3	Jan-11	1.6E-06	4.8E-06	9.9E-07	**2.4E-06**	<0.1	<0.1
	8404	IA1	Jun-09	2.1E-06	4.0E-06	7.0E-08	2.6E-07	<0.1	<0.1
			Dec-09	1.4E-05	1.6E-05	8.6E-07	**1.7E-06**	0.1	0.1
	8404	IA2	Jun-09	3.6E-06	5.5E-06	8.9E-08	3.3E-07	<0.1	<0.1
			Dec-09	1.3E-05	1.6E-05	4.4E-07	**1.3E-06**	<0.1	<0.1
	8406	IA1	Jun-09	5.9E-07	2.5E-06	1.4E-07	5.2E-07	<0.1	<0.1
			Jun-09	9.1E-07	2.7E-06	1.6E-07	5.9E-07	<0.1	<0.1
			Dec-09	1.4E-06	5.9E-06	9.6E-07	**3.7E-06**	0.1	0.1
	8406	IA2	Jun-09	3.9E-07	2.4E-06	8.9E-08	3.3E-07	<0.1	<0.1
			Dec-09	1.4E-06	6.5E-06	8.3E-07	**4.4E-06**	0.4	0.4
	8406	IA3	Jun-09	5.1E-07	2.4E-06	1.6E-07	5.9E-07	<0.1	<0.1
			Dec-09	1.5E-06	4.1E-06	**1.1E-06**	**2.1E-06**	0.2	0.2
	8408	IA1	Jun-09	2.3E-06	6.0E-06	9.2E-07	**2.6E-06**	0.2	0.1
			Dec-09	2.8E-06	7.1E-06	**1.4E-06**	**2.7E-06**	0.8	0.3
	8408	IA2	Jun-09	1.4E-06	4.7E-06	9.9E-07	**2.2E-06**	0.2	0.2
			Dec-09	1.5E-06	4.0E-06	**1.1E-06**	**2.0E-06**	0.3	0.3
	8408	IA3	Jun-09	7.4E-06	9.7E-06	5.1E-07	**1.3E-06**	0.2	<0.1
			Dec-09	9.7E-07	3.6E-06	6.8E-07	**1.7E-06**	0.2	0.1
	8411	IA1	Jun-09	1.9E-06	4.9E-06	6.3E-07	**2.3E-06**	<0.1	<0.1
			Dec-09	1.5E-06	4.4E-06	6.4E-07	**2.0E-06**	<0.1	<0.1
	8411	IA2	Jun-09	7.1E-07	3.2E-06	4.2E-07	**1.6E-06**	<0.1	<0.1
			Dec-09	1.1E-06	3.8E-06	4.8E-07	**1.6E-06**	<0.1	<0.1
Maximum risk or hazard for all buildings				5.5E-05	5.8E-05	**1.5E-06**	**4.4E-06**	2.0E+00	**2.0E+00**
Minimum risk or hazard for all buildings				3.9E-07	2.3E-06	5.3E-08	2.5E-07	<0.1	<0.1

Notes:

Cancer risks and HQ values shown in blue font are based on the approach recommended by Cal EPA, using the more health protective toxicity criterion between OEHHA and USEPA/IRIS.

Cancer risks and HQ values shown in blue font are based on the approach recommended by Cal EPA, using the more health protective toxicity criterion between OEHHA and USEPA/IRIS

Chemicals shown in bold are those with high to moderate evidence of having originated in the subsurface and intruded into indoor air via the VIP.

*Note that the anomalously high reading of PCE (60 $\mu g/m^3$) detected at this location in January 2012 is not shown; duplicate samples collected in February 2012 did not confirm this result.

$\mu g/m^3$	micrograms per cubic meter
<	less than
AFRL	Air Force Research Laboratory
CA	California
EPA	Environmental Protection Agency
HQ	hazard quotient
ID	identification
IRIS	Integrated Risk Information System
OEHHA	Office of Environmental Health Hazard Assessment
PCE	tetrachloroethene
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
VI	vapor intrusion
VIP	vapor intrusion pathway

TABLE 6.4-9. SAMPLING PROTOCOL USED AT SOUTH AFRL COMPARED TO PROTOCOL DEVELOPED FOR AFRL AND OTHER AREAS AT EDWARDS AFB

Item	Protocol Used for South AFRL	Protocol to be Used for other AFRL Areas at Edwards AFB	Protocol to be Used at Edwards AFB Outside the AFRL	Potential Impact to South AFRL Evaluation	Recommendations
Areas to be Studied	All occupied* buildings overlying groundwater concentrations exceeding GWVCLs-ind identified in ROD.	All occupied* buildings overlying groundwater plumes or suspected as upgradient sources.	All occupied* buildings overlying groundwater concentrations exceeding GWVSLs-ind.	Buildings outside the GWVCLS-ind that overlie lower concentrations of groundwater VOCs were not investigated.	Evaluate whether a VIP investigation needs to be conducted for Building 8451 at Site 133, or any other buildings associated with groundwater plumes in the South AFRL.
Conceptual Site Model	Investigation focused on VI via volatilization of chemicals from groundwater.	Conduct records search to identify potential shallow sources above the groundwater.	Conduct records search to identify potential shallow sources above the groundwater.	If shallow sources exist, additional sampling may be required to evaluate contribution to VIP.	Conduct records search and prepare building-specific CSMs similar to those done for Arroyos, NE AFRL, and Mars Blvd.
Near-Slab Wells (Outside Vapor Monitoring Wells)					
a. Objective	Screen vapor results versus industrial SNs to decide whether sub-slab well installation and indoor/sub-slab sampling is required; use as a line of evidence to assess whether chemicals have a subsurface source.	Same as for South AFRL.	In general, outside soil vapor sampling points will NOT be used for screening purposes.	Based on all factors listed below, some buildings screened from further evaluation based on Phase I soil gas sampling results may require further investigation.	Evaluate whether further investigation is required for any of the 11 buildings (8349, 8350, 8351, 8352, 8353, 8356, 8402, 8407, 8423, 8424, or 8431) that did not proceed past Phase I sampling.
b. Sampling Design	Sampling locations selected by USAF contractor; see rationales summarized in Tables 3.0-2, 3.0-3 in South AFRL VI Report.	A consensus was reached with the RPMs on sampling design for each building, which took into account shallow potential sources, building size, and coverage.	See above.	See above.	See above.
c. Number	One per building smaller than 1,300 sq ft; two (one each on opposite ends) per building larger than 1,300 sq ft; additional probes at Bldgs 8354 and 8406.	Generally DTSC prefers a spacing of one per 25-50 ft and coverage on each side (where accessible).	See above.	See above.	See above.
d. Placement	As close as possible to the building's exterior wall, up to 10 ft away. A small number were also placed next to suspected sources (e.g., former dry wells) and adjacent to groundwater well containing a high concentration of VOCs in groundwater.	Same unless objective is to evaluate a shallow VI source.	See above.	See above.	See above.
e. Depth	Goal was to install nested wells at depths of 5.5 ft and 12-15 ft; if borehole was not able to reach 12 ft, a shallow well was set at 5.5 ft.	Install well if borehole reaches 5.5 ft and nested well if borehole reaches 12 ft. Wells to be used for screening only if they reach a minimum depth of 12 ft bgs.	See above.	At most locations, the minimum depth of 12 ft was not achieved.	The 12-foot minimum depth is likely not achievable at many locations based on field results (refer to Table 2.3-1 in South AFRL VI Report).
f. Analytical Method	Mobile lab used Method 8260B; collected confirmation samples (at 10 percent of locations) for off-site analysis by Method TO 14A.	Mobile lab will use Method 8260B or TO 15; collect confirmation samples at 10 percent of locations for analysis by method TO 14A or TO 15 mod.	See above.	See above.	For any further subsurface sampling at sites in the South AFRL, TO-17 samples will be collected at the next event to confirm TO-15 sampling results at a frequency of five percent of the field samples. If sub-slab or indoor air samples are collected, then naphthalene will be added to the analyte list for TO-15 (sub-slab) and TO-15 SIM (indoor air) for the next event.

TABLE 6.4-9. SAMPLING PROTOCOL USED AT SOUTH AFRL COMPARED TO PROTOCOL DEVELOPED FOR AFRL AND OTHER AREAS AT EDWARDS AFB

Item	Protocol Used for South AFRL	Protocol to be Used for other AFRL Areas at Edwards AFB	Protocol to be Used at Edwards AFB Outside the AFRL	Potential Impact to South AFRL Evaluation	Recommendations
Sub-Slab Wells (Inside Vapor Monitoring Wells)					
a. Objective	Use as a line of evidence to evaluate whether the VI pathway exists.	Same.	Same. BW VI Protocol revised to specify that sub-slab wells should be collected first (before indoor air samples) to assess whether a VI pathway exists and identify VI COCs.	Not expected to have an impact.	None.
b. Sampling Design	Sampling quantities were presented in the RAWP; final locations were selected by USAF's contractor taking into account building coverage and occupancy patterns; see rationales summarized in Tables 3.0-2, 3.0-3, 3.0-4 in South AFRL VI Report.	A consensus was reached with the RPMs on sampling design for each bldg, which took into account potential conduits, proximity to potential sources, size of the bldg, coverage, and occupancy patterns.	Same as for future AFRL investigations.	USAF contractor selected placement of sub-slab wells using similar considerations as described for consensus approach; also considered inputs from facility manager.	Based on all factors listed below, evaluate the need to install additional sub-slab wells in buildings where a Phase II investigation was conducted; and/or the need for sub-slab wells in buildings screened from further evaluation based on Phase I soil gas sampling results.
c. Number	Generally, one to two per building; four in the larger building 8595.	A consensus was reached with the RPMs on the number of sub-slab wells to be installed inside each bldg; generally not fewer than two (see below).	See above.	RPMS may request additional sub-slab wells in some buildings investigated during Phase II.	Evaluate the need for (and implementability of installing) additional sub-slab wells inside Buildings 8354, 8402, 8403**, 8404, 8405, and 8408 (not possible to install in 8411).
d. Depth	3 to 6 inches below building.	3 inches below building	3 inches below building	No impact.	No impact.
e. Sampling Methodology	Sub-slab samples were collected over an 8-hr period concurrent with indoor air samples; however, a USEPA reviewer expressed concern that the concurrent 8-hour sampling may have depleted VOC concentrations leading to low bias in indoor air sampling results.	Grab samples from sub-slab wells will be collected within 24 hours after indoor air sampling.	Same as for future AFRL investigations.	Based on results for samples collected subsequently from Bldg. 8595, there is likely little to no impact. The South AFRL VI Report recommends collecting a 3rd round of indoor air samples from Buildings 8354, 8402, 8404, 8405, 8406, and 8408 to assess impact.	Conduct the sampling recommended in the South AFRL VI Report (additional round of sub-slab samples taken within 24 hours after indoor air sampling at Building 8403).
f. Analytical Method	Mobile lab used Method 8260B (screening data and leak test); TO 14A used for fixed lab analyses.	Mobile lab will use Method 8260B or TO 15 (screening data and leak test); TO 14A or TO 15 mod for fixed lab analyses.	For future sampling, use the analytical method that achieves project action limits specified by the site-specific work plan (to obtain RLs below SVSLs-ind for chemicals of interest).	Not expected to have an impact; RLs were generally lower than screening levels	For future sampling, use the analytical method that achieves RLs at project action limits specified by the site-specific work plan.

TABLE 6.4-9. SAMPLING PROTOCOL USED AT SOUTH AFRL COMPARED TO PROTOCOL DEVELOPED FOR AFRL AND OTHER AREAS AT EDWARDS AFB

Item	Protocol Used for South AFRL	Protocol to be Used for other AFRL Areas at Edwards AFB	Protocol to be Used at Edwards AFB Outside the AFRL	Potential Impact to South AFRL Evaluation	Recommendations
Indoor Air Samples					
a. Objective	Compare PCE and TCE concentrations against IAVMLs-ind established in South AFRL ROD; use results to calculate cumulative risk attributable to the VIP.	Compare results for all chemicals to IASLs-ind and use to calculate cumulative risk attributable to the VIP.	Same as for future AFRL investigations.	Not expected to have an impact.	Evaluate whether IAVMLs-ind remain valid (see Section 7.2 of this FYR report).
b. Sampling Design	Sampling quantities were presented in the RAWP; final locations were selected by USAF's contractor taking into account building coverage and occupancy patterns; see rationales summarized in Tables 3.0-2, 3.0-3, 3.0-4 in South AFRL VI Report	A consensus was reached with the RPMs on sampling design for each bldg, and took into account potential conduits, proximity to potential sources, size of the bldg, coverage, and occupancy patterns.	Same as for future AFRL investigations.	USAF contractor selected placement of indoor air samplers using similar considerations as described for consensus approach; also considered inputs from facility manager.	Collect a 3rd round of indoor air samples from Buildings 8354, 8402, 8404, 8405, and 8408 and a 2nd round from Building 8403 all with sub-slab sampling conducted after indoor air sampling is complete. Evaluate the need for indoor air samples in buildings screened from further evaluation based on Phase I soil gas sampling results.
c. Number	Generally, one to three per building; up to six in the larger building, Bldg 8595.	A consensus was reached with the RPMs on the number of indoor air samples to be collected inside each bldg; generally one collocated with each sub-slab well.	Same as for future AFRL investigations.	RPMs may request additional indoor air sample locations in some buildings investigated during Phase II.	Evaluate the need for collection of indoor air samples from additional locations inside Buildings 8354, 8402, 8403, 8404, 8405, 8408, and 8411.
d. Height of Sample Collection	1 to 5 ft from floor	Same	Same	No impact.	For future sampling events, samples will be collected at a height of 3 to 5 feet from the floor.
e. Sampling Methodology	Collected over an 8-hr period under ventilation conditions normal for the building during the season.	If possible, sampling will be conducted with windows and doors closed as preferred by DTSC.	Same as for future AFRL investigations.	No impact. Samples were collected with door and windows closed.	If additional sampling is required, confirm sampling is conducted with windows and doors closed where possible.
f. Analytical Method	TO 15 Low Level (individually certified clean summa canisters).	TO 15 SIM (individually certified clean summa canisters).	TO 15 Low Level or SIM (individually certified clean summa canisters).	Impact if RLs achieved by TO 15 low level exceeded IASLs-ind for chemicals of concern.	For future sampling, use the analytical method that achieves project action limits specified by the site-specific work plan (to obtain RLs below IASLs-ind for chemicals of interest).

TABLE 6.4-9. SAMPLING PROTOCOL USED AT SOUTH AFRL COMPARED TO PROTOCOL DEVELOPED FOR AFRL AND OTHER AREAS AT EDWARDS AFB

Item	Protocol Used for South AFRL	Protocol to be Used for other AFRL Areas at Edwards AFB	Protocol to be Used at Edwards AFB Outside the AFRL	Potential Impact to South AFRL Evaluation	Recommendations
Outdoor Air Samples					
a. Objective	Use to assess background concentrations of VOCs in ambient outdoor air.	Same.	Same.	No impact.	None.
b. Sampling Design	Sampling quantities were presented in the RAWP; final sampling locations were selected by USAF's contractor upwind of buildings.	New DTSC guidance indicates a minimum of three outdoor air samples should be collected per event, at a distance twice the height of the building.	Per DTSC guidance to the extent practical.	Not expected to have an impact.	For future indoor air sampling events, align strategy for outdoor air sample collection with DTSC guidance.
c. Number	One sampling location per isolated building or two per group of buildings, upwind of buildings.	One sampling location per isolated building or two per group of buildings, upwind of buildings.	Per DTSC guidance to the extent practical.	Additional samples may help with data interpretation.	See above.
d. Height of Sample Collection	1 to 5 ft from ground	5 to 6 ft from ground	5 to 6 ft from ground	No impact.	For future indoor air sampling events, samples will be collected at a height of 6 feet off of the ground.
e. Sampling Methodology	Collected over the same 8-hr period as indoor air samples.	Same.	Same.	No impact.	None.
f. Analytical Method	TO 15 Low Level	TO 15 SIM (individually certified clean summa canisters)	TO 15 Low Level or SIM (individually certified clean summa canisters)	Impact if RLs achieved by TO 15 low level exceeded IASLs-ind for chemicals of concern	For future sampling, use same analytical method that is used for indoor air; and individually certified canisters.

Notes:

* Includes buildings designed for occupancy even though they may not be currently occupied.
** No sub-slab wells have been installed inside Building 8403 to date.

AFB	Air Force Base
AFRL	Air Force Research Laboratory
bgs	below ground surface
Blvd	boulevard
BW	base-wide
COC	chemical of concern
CSM	conceptual site model
DTSC	Department of Toxic Substances Control
ft	feet or foot
FYR	Five-Year Review
GWVSL-ind	groundwater vapor screening level for industrial exposure
hr	hour
IASL-ind	indoor air screening level for industrial exposure
IAVML-ind	indoor air vapor mitigation level for industrial exposure
NE	northeast
PCE	tetrachloroethene
RAWP	remedial action work plan
RL	reporting limit
ROD	Record of Decision
RPM	remedial project manager
SN	soil gas screening number
sq ft	square feet
SVSL-ind	screening level for industrial exposure
TCE	trichloroethene
USAF	United States Air Force
VI	vapor intrusion
VIP	vapor intrusion pathway
VOC	volatile organic compound

further

RPMs may request additional indoor air sample locations in some buildings investigated during Phase II.

Impact if RLs achieved by TO 15 low level exceeded IASLs-ind for chemicals of concern.

Impact if RLs achieved by TO 15 low level exceeded IASLs-ind for chemicals of concern

TABLE 6.4-10. COMPARISON OF GWVCLs-res AND GWVCLs-ind ESTABLISHED IN THE 2007 SOUTH AFRL ROD TO VALUES UPDATED PER USEPA TOXICITY VALUES PUBLISHED IN IRIS

Site	COC	2007 ROD GWVCLs-res (μg/L)	2007 ROD GWVCLs-ind (μg/L)	Updated GWVCLs-res[1] (μg/L)	Updated GWVCLs-ind[1] (μg/L)
37	PCE	13.1	607	297 (13.1)[2]	5,510 (243)[2]
133	TCE	57.3	2,340	27.9	457

Notes:

GWVCL-res and GWVCL-ind are the groundwater concentrations, based on J&E modeling, that result in an indoor air concentration presenting a 1 x 10^{-6} cancer risk via the indoor air vapor intrusion pathway under the residential (-res) and industrial (-ind) exposure scenarios.

[1]Updated GWVCLs-res and –ind included in this table have been revised from the values established in the South AFRL ROD (USAF 2007) to include toxicity values for TCE and PCE updated by USEPA IRIS in September 2011 and February 2012, respectively; and an industrial exposure duration of 25 years (rather than 10 years used for J&E modeling in the 2007 South AFRL ROD).

[2] Values shown in parentheses represent the GWVCL-res and GWVCL-ind established using California DTSC preferred toxicity criteria.

μg/L	micrograms per liter
AFRL	Air Force Research Laboratory
COC	chemical of concern
DTSC	Department of Toxic Substances Control
GWVCL-ind	groundwater vapor compliance level (industrial exposure scenario)
GWVCL-res	groundwater vapor compliance level (residential exposure scenario)
HI	hazard index
IAVML-ind	indoor air vapor mitigation level (industrial exposure scenario)
IAVML-res	indoor air vapor mitigation level (residential exposure scenario)
IRIS	Integrated Risk Information System
J&E	Johnson and Ettinger
PCE	tetrachloroethene
ROD	record of decision
RBCL	risk-based cleanup level
TCE	trichloroethene
USEPA	United States Environmental Protection Agency

TABLE 6.4-11. SUMMARY OF SAMPLING RESULTS FROM UTILITY VAULTS

Sample ID	Date	PCE	TCE	Comments	Summary of Other Results	Outcome of Screening Evaluation
37-8350-VL1	3/27/2009	0.47	<4.8	results are J12 qualified	3 other VOCs detected	
37-8351-VL1	3/27/2009	<4.6	<4.6	same as above	4 VOCs detected	
37-8352-VL1	3/27/2009	<4.3	<4.3	same as above	4 VOCs detected	
37-8356-VL1	3/26/2009	4.4 J	<4.4	same as above	4 other VOCs detected	Detection at RL and no detections in near-slab wells adjacent to Building 8356 (Table 2.5-1); therefore, Building 8356 not slated for Phase II monitoring.
37-8595-VL1	12/23/2009	<2.0	<2.0		2 VOCs detected	
133-8406-VL1	3/27/2009	7.5			3 other VOCs detected	Phase II monitoring already triggered by results for near-slab Wells 133-8406SG2 and 133-8406SG3 (see Table 2.5-2)
133-8407-VL1	3/27/2009	<4.8	0.83 J		12 other VOCs detected	
133-8407-VL1-FD	3/27/2009	1.0 J	0.65 J	Field Duplicate	4 other VOCs detected	
133-8423-VL1	3/27/2009	0.80 J	<4.0		5 other VOCs detected	

Notes:

Concentrations in blue identify locations where PCE concentrations exceed 2.5 ppb v/v; i.e., 1% of the SN (250) for PCE.
None of the samples had TCE concentrations that exceeded 9.5 ppb v/v, which is 1% of the SN (950) for TCE.

<	less than
%	percent
ID	identification
ppb v/v	parts per billion volume by volume
PCE	tetrachloroethene
RL	reporting limit
SN	screening number
TCE	trichloroethene
VOC	volatile organic compound

Laboratory-Assigned Data Qualifier:

J Estimated value. Value is below the reporting limit but above the method detection limit.

Data Validation Qualifier:

J12 Estimated value; chain of custody forms switched between coolers.

TABLE 6.4-12. CALCULATED BUILDING-SPECIFIC ATTENUATION FACTORS FOR BUILDINGS 8354, 8404, 8406, 8408, AND 8595

		Building 8354						Building 8404			Building 8406						Building 8408		
Month*	Chemical	SS1	IA1	α-1	SS2	IA2	α-2	SS1	IA1	α-1	SS1	IA1	α-1	SS2	IA2	α-2	SS1	IA1	α-1
June	PCE	65	<0.2	–	450	0.034 J	7.6E-05	<4.0	<0.2	–	130	<0.2	–	23	<0.2	–	6 J	<0.2	–
December	PCE	68	0.18 J	2.6E-03	260	0.18 J	6.9E-04	<4.0	<0.2	–	110	<0.2	–	37	<0.2	–	53	<0.2	–
June	TCE	<19	<0.2	–	1.5 J	<0.2	–	50	<0.2	–	2,100	<0.2	–	630	<0.2	–	710	0.17 J	2.4E-04
December	TCE	<4.8	0.35	–	0.93 J	<0.2	–	35	0.16 J	4.6E-03	2,000	0.17 J	8.5E-05	740	0.11 J	1.5E-04	570	0.5	8.8E-04

		Building 8595											
Month*	Chemical	SS1	IA1	α-1	SS2	IA2	α-2	SS3	IA3	α-3	SS4	IA4	α-4
June	PCE	1.2 J	<0.25	–	5,900	<0.2	–	20	<1.8	–	1 J	<0.2	–
December	PCE	4.7	0.035 J	0.007447	7,800	0.31	3.97E-05	6,900	0.28	4.1E-05	2.1 J	0.055 J	0.02619
June	TCE	<3.7	<0.25	–	11 J	0.11 J	0.01	<4.8	<1.8	–	–	<0.2	–
December	TCE	<4.5	0.046 J	–	82 J	<0.2	–	26 J	<0.2	–	–	<0.2	–
June	trans-1,2-DCE	51	50	0.980392	1,300	38	0.029231	120	130	1.08333	1.3	3.8	2.92308
December	trans-1,2-DCE	<0.2	<4.5	–	440	<0.2	–	45	0.12	0.00267	<4.1	0.11	–

Notes:

All vapor concentratons are in units of ppb v/v; the alpha values are unitless.

The full sampling location identification for each sampling point is 37-8595SS# or 37-8595IA#.

* All samples were collected in 2009.

–	not calculated.
<	less than
α	attenuation factor
IA	indoor air sample
PCE	tetrachloroethene
SS	sub-slab sample
TCE	trichloroethene
trans-1,2-DCE	trans-1,2-dichloroethene

Laboratory-Assigned Data Qualifier:

J Estimated value. Value is below the reporting limit but above the method detection limit.

TABLE 6.6-1. LIST OF INTERVIEWEES – SOUTH AFRL FYR
(Page 1 of 2)

Interviewee Name	Title/Position	Organization	Date of Interview
USAF			
Colonel Michael Platt	Site Commander	AFRL, DET7	5 April 2012
Ai Duong	Chief, Environmental Restoration	412 TW/CEVR	5 April 2012
Patrice Hallman	Restoration Program Manager	412 TW/CEVR	16 April 2012
Stephan Watts	Restoration Program Manager	412 TW/CEVR	3 April 2012
Ranney Adams	AFRL Environmental Manager	DET7 AFRL/SE	3 April 2012
Debra Fuller	Chief of ESOH (AFRL)	DET7 AFRL/SE	5 April 2012
Gregory Hogan	AFRL CE Project Manager	412 TW/CEOFR/AFRL	5 April 2012
Ken Hansing	Range OPS	412 RAN	5 April 2012
Julio Barrios	GIS Manager	412 TW/CEVR	5 April 2012
Wesley E. King	Geospatial Information Specialist	412 TW/CEPT	5 April 2012
Robert Edwards	Facility Planner	AFRL/RZS	5 April 2012
Samuel Cox	Environmental Manager	412 TW/CEVN	2 April 2012
Regulatory Agencies			
Joseph Healy	Environmental Engineer	USEPA, Region 9	4 April 2012
Kevin Depies	Engineering Geologist	California EPA-DTSC	3 April 2012
Tim Post	Engineering Geologist	California Regional Water Quality Control Board – Lahontan Region	5 April 2012
RAB			
Bruce Davies	RAB Co-Chair	North Edwards RAB Representative	9 April 2012
Milton McKay	RAB Representative for AFRL	AFRL/RZSP	5 April 2012
USAF O&M Contractors			
Sarah Grossi	Project Manager	AECOM	16 April 2012
Mark Henkes	Project Geologist	AECOM	18 April 2012
Josefa Silva	Environmental Scientist II	JT3/CH2M HILL	5 April 2012
Jun Kumazawa	Scientist I	JT3/CH2M HILL	6 April 2012

TABLE 6.6-1. LIST OF INTERVIEWEES – SOUTH AFRL FYR
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Notes:

95 ABW was reorganized as 412 TW as of 13 July 2012.

95 ABW	95th Air Base Wing
412 RANS	412th Range Squadron
412 TW	412th Test Wing
AECOM	AECOM Technical Services, Inc.
AFRL	Air Force Research Laboratory
CA	California
CE	Civil Engineering
CEOFR	Civil Engineering Operations Facilities Research
CEPT	Civil Engineer Division, Technical Support Section
CEVN	Environmental Restoration Branch, Conservation Section
CEVR	Environmental Restoration Branch
DET 7	Detachment 7
EPA-DTSC	Environmental Protection Agency- Department of Toxic Substances Control
ESOH	Environment, Safety, and Occupational Health
FYR	Five-Year Review
GIS	Geographic Information Systems
OPS	Operations
RAB	Restoration Advisory Board
RZS	Space and Missile Propulsion Division
RZSP	Space and Missile Propulsion Division, Propellants
SE	Safety
USAF	United States Air Force
USAF O&M	United States Air Force Operation and Maintenance
USEPA	United States Environmental Protection Agency

TABLE 7.2-1. GROUNDWATER CONTAINMENT LEVELS AND UPDATES TO STANDARDS ON WHICH THEY ARE BASED

Chemical of Concern	ROD Selected Standard[a]	Revised Standard During this FYR Period	Tapwater RSLs for Comparison Purposes[b]
Volatile Organics (in μg/L)			
benzene	1	-	0.39
1,1-dichloroethane (1,1-DCA)	5	-	2.4
1,2-dichloroethane (1,2-DCA)	0.5	-	0.15
1,1-dichloroethene (1,1-DCE)	6	-	260
cis-1,2-dichloroethene (cis-1,2-DCE)	6	-	28
trans-1,2-dichloroethene (trans-1,2-DCE)	10	-	86
methyl tert butyl ether (MTBE)	13	-	12
methylene chloride	5	-	4.7
naphthalene	17[c]	-	0.14
tetrachloroethene (PCE)	5	-	0.072
1,1,1-trichloroethane (1,1,1-TCA)	200	-	7,500
trichloroethene (TCE)	5	-	0.44
1,1,2-trichlorotrifluoroethane (CFC 113)	1,200	-	53,000
vinyl chloride	0.5	-	0.015
Semivolatile Organics (in μg/L)			
1,4-dioxane	3[c]	1[c][d]	0.67
N-nitrosodimethylamine (NDMA)	0.01[c]	-	0.00042
Inorganics (in mg/L)			
perchlorate	0.024[e]	0.006[f]	11
nitrate (as N)	10	-	25,000

Notes:

[a] Standards listed are California pMCLs (selected in the 2007 ROD and still current based on CDPH 2011), unless otherwise noted.
[b] USEPA revised in May 2012
[c] Notification Level
[d] The state of California revised the NL in November 2010.
[e] Drinking water equivalent level derived as the DOD level of concern.
[f] The state of California promulgated a pMCL of 0.006 mg/L for perchlorate in October 2007.

μg/L	micrograms per liter	mg/L	milligrams per liter
AFRL	Air Force Research Laboratory	MCL	maximum contaminant level
CDPH	California Department of Public Health	N	nitrogen
CZ	containment zone	pMCL	primary maximum contaminant level
DOD	Department of Defense	ROD	record of decision
FYR	Five-Year Review	RSL	regional screening level
mg/kg	milligrams per kilogram		

TABLE 7.2-2. CHANGES IN TOXICITY CRITERIA FOR GROUNDWATER COCS IDENTIFIED IN ROD

Chemical of Concern	IRIS Cancer			IRIS Noncancer		DTSC-Recommended*	
	DWUR $(\mu g/L)^{-1}$	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Date Adopted or Last Reviewed	RfD (mg/kg-day)	Date Adopted or Last Reviewed	RfD (mg/kg-day)	Source
Volatile Organics							
benzene	1.6×10^{-6}	0.055	1/19/2000	0.004	4/17/2003	0.004	IRIS
1,1-dichloroethane (1,1-DCA)	-	-	12/1/1996	-	-	0.2	PPRTV
1,2-dichloroethane (1,2-DCA)	2.6×10^{-6}	0.091	1/1/1991	-		0.006	PPRTV
1,1-dichloroethene (1,1-DCE)	-	-	8/13/2002	0.05	8/13/2002	0.05	IRIS
cis-1,2-dichloroethene (cis-1,2-DCE)	-	-	9/30/2010	0.002	9/30/2010	0.002	IRIS
trans-1,2-dichloroethene (trans-1,2-DCE)	-	-	9/30/2010	0.02	9/30/2010	0.02	IRIS
methyl tert-butyl ether (MTBE)	-	-	-	-	3/1/1993	-	
methylene chloride	-	0.002	11/18/2011	0.006	11/18/2011	0.006	IRIS
naphthalene	-	-	9/17/1998	0.02	9/17/1998	0.02	IRIS
tetrachloroethene (PCE)	6.1×10^{-8}	0.0021	2/10/2012	0.006	2/10/2012	0.006	IRIS
1,1,1-trichloroethane (1,1,1-TCA)	-	-	9/28/2007	2	9/28/2007	2	IRIS
trichloroethene (TCE)	-	0.046	9/28/2011	0.0005	9/28/2011	0.0005	IRIS
1,1,2-trichlorotrifluoroethane (CFC 113)	-	-	-	30	2/1/1996	30	IRIS
vinyl chloride	4.2×10^{-5}	1.5	8/7/2000	0.003	8/7/2000	0.003	IRIS
Semivolatile Organics							
1,4-dioxane	2.9×10^{-6}	0.1	8/11/2010	0.03	8/11/2010	0.03	IRIS
N-nitrosodimethylamine (NDMA)	0.0014	51	7/1/1993	-	-	0.000008	PPRTV
Inorganics							
perchlorate	-	-	2/18/2005	0.0007	2/18/2005	0.0007	IRIS
nitrate (as N)	-	-	-	1.6	10/1/1991	1.6	IRIS

Notes:

COCs and dates shown in red indicate IRIS toxicity criteria have been updated in the past 5 years; RfDs in purple are not based on IRIS values.
*Personal communication from Kimberly Day with DTSC HERO to Ray Kaminsky with AECOM.

COC	chemical of concern	kg	kilogram
DTSC	Department of Toxic Substances Control	mg	milligram
DWUR	drinking water unit risk	PPRTV	provisional peer-reviewed toxicity value
HERO	Human and Ecological Risk Office	RfD	reference dose
IRIS	integrated risk information system	ROD	Record of Decision
$\mu g/L$	micrograms per liter		

TABLE 7.2-3. VI-RELATED CHEMICALS IDENTIFIED USING POST-ROD VI SAMPLING RESULTS AND GROUNDWATER SAMPLING RESULTS

VI related chemical[1,2,3]	Common Uses	IASL-ind[4]	CA-IASL-ind[4]	Max Risk or Hazard in Indoor Air of South AFRL Building Based on IASL-ind[5]	Max Risk or Hazard in South AFRL Building Based on CA-IASL-ind[5]	Occurrence in Groundwater	No. of Detections/Total Number of Sub-slab Samples	No. of Detections/Total Number of Indoor Air Samples
acetone	solvent	1.3E+05	-	<0.1	-	low/infrequent	27/29	41/44
benzene[6]	fuels	1.6E+00	4.2E-01	**9.5E-07**	**3.5E-06**	groundwater COC	16/36	48/49
carbon disulfide	organosulfur product	3.1E+03	-	<0.1	-	low/infrequent	23/39	41/44
chloroform	solvent	5.3E-01	-	4.5E-07	-	low/infrequent	13/39	16/49
chloromethane	motor vehicles	3.9E+02	-	<0.1	-	not detected	13/35	48/49
dichlorodifluoromethane	refrigerant	8.8E+02	-	<0.1	-	not detected	7/39	27/49
1,1-dichloroethane	solvent	7.7E+00	-	9.7E-10	-	groundwater COC	Not Detected	2/49
cis-1,2-dichloroethene[6]	solvent	2.6E+02	3.1E+01	<0.1	<0.1	groundwater COC	3/39	6/49
trans-1,2-dichloroethene	solvent	2.6E+02	-	**1.9**	-	groundwater COC	12/39	11/49
ethylbenzene	solvent	4.9E+00	-	**6.3E-07**	-	low/infrequent	10/39	33/49
4-ethyltoluene	motor vehicles	4.4E+02	-	<0.1	-	not detected	3/29	19/44
methyl tert-butyl ether (MTBE)	gasoline additive	4.7E+01	-	2.1E-08	-	groundwater COC	Not Detected	3/44
methylene chloride	solvent	2.6E+01	1.2E+01	8.1E-08	1.7E-07	groundwater COC	1/39	27/51
styrene	rubber/plastic/fiberglass	4.4E+03	3.9E+03	<0.1	<0.1	not detected	4/39	29/51
tetrachloroethene (PCE)	solvent	4.7E+01	2.1E+00	4.5E-08	**1.0E-06**	groundwater COC	32/39	23/49
toluene	motor vehicles/solvent	2.2E+04	1.3E+03	<0.1	<0.1	low/infrequent	15/39	42/51
1,1,1-trichloroethane	solvent	2.2E+04	4.4E+03	<0.1	<0.1	groundwater COC	3/39	4/49
trichloroethene (TCE)	solvent	3.0E+00	-	**9.0E-07**	-	groundwater COC	22/39	24/51
trichlorofluoromethane	refrigerant	3.1E+03	-	<0.1	-	low/infrequent	8/39	51/51
1,1,2-trichlorotrifluoroethane	refrigerant/solvent	1.3E+05	-	<0.1	-	groundwater COC	13/39	36/49
1,2,4-trimethylbenzene	constituent of petroleum	3.1E+01	-	0.3	-	low/infrequent	6/34	34/46
1,3,5-trimethylbenzene	constituent of petroleum	1.5E+02	-	<0.1	-	low/infrequent	4/39	18/46
vinyl chloride	plastics	2.8E+00	1.6E-01	1.4E-07	**2.4E-06**	groundwater COC	1/39	3/44
m- & p-xylene	motor vehicles/solvent	4.4E+02	-	<0.1	-	low/infrequent	19/39	49/51
o-xylene	motor vehicles/solvent	4.4E+02	-	<0.1	-	low/infrequent	11/39	48/51

Notes:

(1) Chemicals shown in bold are identified as COCs in South AFRL groundwater.

(2) Chemicals shown in italics were identified as VIP-related in the South AFRL VI Report (refer to tables in Appendix E.2 of the South AFRL VI Report, AECOM 2012e).

(3) Chemicals shown in red are the VI COCs identified in the ROD; chemicals shown in blue are identified as COPCs in this FYR.

(4) IASLs-ind are protective for the industrial exposure scenario at a risk level of 10^{-6} and an HQ of 1; CA-IASLs-ind use more conservative OEHHA toxicity criteria when available.

(5) Risk levels shown in bold exceed 5 x 10^{-7}; hazard quotients shown in bold exceed 0.5. These levels are highlighted to facilitate identification of chemicals potentially contributing to a cumulative risk exceeding 10^{6} or an HI exceeding 1.

(6) Identified as a VI COC in the ROD for residential exposure; and a VI COPC in this FYR report for industrial exposure.

AFRL	Air Force Research Laboratory
CA-IASL-ind	indoor air screening levels based on use of OEHHA toxicity criterion more conservative than IRIS value
COC	chemical of concern
COPC	chemical of potential concern
DTSC	Department of Toxic Substances Control
FYR	five-year review
HQ	hazard quotient
IASL-ind	indoor air screening level for 10^{-6} risk based on IRIS toxicity criteria when available
IRIS	Integrated Risk Information System (USEPA database)
No.	number
OEHHA	Office of Human Health Hazard Assessment (California DTSC risk database)
ROD	record of decision
USEPA	United States Environmental Protection Agency
VI	vapor intrusion
VIP	vapor intrusion pathway

TABLE 7.2-4. TOXICITY CRITERIA FOR VIP-RELATED CHEMICALs IDENTIFIED IN TABLE 7.2-3
(Page 1 of 2)

Chemical of Concern	IRIS Cancer URF $(\mu g/m^3)^{-1}$	Date Revised	IRIS Noncancer RfC (mg/m^3)	Date Revised	Current OEHHA URF $(\mu g/m^3)^{-1}$	Current OEHHA RfC (mg/m^3)
Volatile Organics (in μg/L)						
acetone	-	-	-	-	-	-
benzene	7.8E-06	1/19/2000	0.03	4/17/2003	2.9E-05	0.06[1]
carbon disulfide	-	-	0.7	8/1/1995	-	0.8[1]
chloroform	2.3E-05	10/19/2001	-	-	5.3E-06[1]	0.3
chloromethane	-	-	0.09	7/17/2001	-	-
dichlorodifluoromethane	-	-	-	-	-	0.1[2]
1,1-dichloroethane	-	-	-	-	1.6E-06	-
cis-1,2-dichloroethene	-	-	-	-	-	0.035[3]
trans-1,2-dichloroethene	-	-	-	-	-	0.06[2]
ethylbenzene	-	-	1	3/1/1991	2.5E-06	2[1]
4-ethyltoluene	-	-	-	-	-	-
methyl tert butyl ether (MTBE)	-	-	3	9/1/1993	2.6E-07	8
methylene chloride	1.0E-08	**11/18/2011**	0.6	**11/18/2011**	1.0E-06	0.4
naphthalene	-		3E-03[4]	8/17/1998	3.4E-05	9E-03
styrene	-	-	1	7/1/1993	-	0.9
tetrachloroethene (PCE)	2.6E-07	**2/10/2012**	0.04	**2/10/2012**	5.9E-06	0.035[3]
toluene	-	-	5	9/23/2005	-	0.3
1,1,1-trichloroethane	-	-	5	9/28/2007	-	-
trichloroethene (TCE)	4.1E-06	**9/28/2011**	0.002	**9/28/2011**	2.0E-06[1]	0.6[1]
trichlorofluoromethane	-	-	-	-	-	0.7[5]
1,1,2-trichlorotrifluoroethane	-	-	-	-	-	30[5]
1,2,4-trimethylbenzene	-	-	-	-	-	7E-03[2]
1,3,5-trimethylbenzene	-	-	-	-	-	6E-03[6]
vinyl chloride	4.4E-06	8/7/2000	0.1	8/7/2000	7.80E-05	-
m- & p-xylene	-	-	0.1	2/21/2003	-	0.7[1]
o-xylene	-	-	0.1	2/21/2003	-	0.7[1]

TABLE 7.2-4. TOXICITY CRITERIA FOR VIP-RELATED CHEMICALs IDENTIFIED IN TABLE 7.2-3

(Page 2 of 2)

Notes:

Dates for criteria adopted since *South AFRL ROD* signing (September 2007) are shown in bold.

For trichlorofluoromethane, 1,1,2-trichlorotrifluoroethane and 1,2,4-trimethylbenzene, USEPA recommends the HEAST toxicity criteria for the first two chemicals and the PPRTV toxicity criteria for the third chemical as listed in the May 2012 USEPA RSL table.

(1) HERO recommends use of IRIS values in lieu of the OEHHA toxicity criteria.

(2) PPRTV toxicity criteria

(3) Value recommended by HERO

(4) Not identified as a VIP-related chemical based on sampling to date, which has not consistently included naphthalene on the analyte list for fixed-laboratory analytical methods.

(5) HEAST toxicity criteria

(6) 2011 DTSC J&E Model

-	not applicable
$(\mu g/m^3)^{-1}$	per micrograms per cubic meter
AFRL	Air Force Research Laboratory
COC	chemical of concern
DTSC	Department of Toxic Substances Control
IRIS	Integrated Risk Information System
OEHHA	Office of Health Hazard Assessment
mg/m^3	milligrams per cubic meter
RfC	reference concentration
ROD	record of decision
URF	cancer unit risk factor
VIP	vapor intrusion pathway

TABLE 7.2-5. SOUTH AFRL VI COCs, COPCs AND POTENTIAL MITIGATION STANDARDS FOR INDOOR AIR

Chemical of Concern	IAVML-res ($\mu g/m^3$)	IAVML-ind ($\mu g/m^3$)	IASL-res ($\mu g/m^3$)	IASL-ind ($\mu g/m^3$)	CA-IASL-res ($\mu g/m^3$)	CA-IASL-ind ($\mu g/m^3$)
Volatile Organics						
benzene[1]	0.3	-	**0.31**	**1.6**	0.084	0.42
cis-1,2-dichloroethene[1]	36.5	-	**63**	**260**	37	31
ethylbenzene[2]	-	-	**0.97**	**4.9**	-	-
tetrachloroethene (PCE)	0.4	1.7	**9.4**	**47**	0.41	2.1
trans-1,2-dichloroethene[2]	-	-	**63**	**260**	-	-
trichloroethene (TCE)	1.2	5.1	**0.43**	**3**	-	-
vinyl chloride[2]	-	-	**0.16**	**2.8**	0.031	0.16

Notes:

[1] VI COPC for industrial exposure (refer to Section 7.2.3.1).
[2] VI COPC for residential and industrial exposure.
Bold values indicate suggested mitigation levels for residential and industrial exposure.

$\mu g/m^3$	micrograms per cubic meters
AFRL	Air Force Research Laboratory
CA-IASL-res	California Indoor Air Screening Level for residential exposure
CA-IASL-ind	California Indoor Air Screening Level for industrial exposure
COPC	chemicals of potential concern
IASL-res	USAF Indoor Air Screening Level for residential exposure
IASL-ind	USAF Indoor Air Screening Level for industrial exposure
IAVML-res	Indoor Air Vapor Mitigation Level for residential exposure
IAVML-ind	Indoor Air Vapor Mitigation Level for industrial exposure
VI	vapor intrusion
USAF	United States Air Force

TABLE 8.0-1. ISSUES IDENTIFIED DURING FIRST FYR FOR SOUTH AFRL, EDWARDS AFB, CA

Remedy Component	Report Citations	Issue	Identified By	Affects Protectiveness[1] (Yes/No) Current[2]	Future[3]
Groundwater					
1. Change in ARAR	7.2.2.1 and Table 7.2-1	1. CA pMCL for perchlorate adopted in October 2007; 4 times lower than the RBCG selected in ROD	USAF	No	**Yes**
2. Change in TBC Used to Select an RBCG	7.2.2.1 and Table 7.2-1	2. Revised CA NL for 1,4-dioxane; 3 times lower than the RBCG selected in ROD	USAF	No	No
Vapor Intrusion					
1. Identification of Additional COPCs via the VIP	7.2.3.1 and Table 7.2-3	1. Additional VI-related chemicals have been identified as a result of sub-slab and indoor air monitoring.	USAF	No	No
2. Changes in Toxicity Criteria	7.2.3.2 and Table 7.2-4	2. Based on recent updates to the IRIS database, TCE is more toxic and PCE is less toxic than criteria listed in OEHHA database used to develop IAVMLs selected in ROD.	USAF	No	No

Notes:

[1] Refer to Section 10 for a fuller discussion on Protectiveness Determinations.

[2] No issue was found to affect current protectiveness because LUCs are in place to prevent exposures; the groundwater monitoring well network is adequate to confirm containment inside the CZ; results of VI monitoring indicate that risks to current workers are at the low end of risk management range and considered acceptable.

[3] Where the determination of an effect on future protectiveness is No, the basis is the same as for Current Exposures.
Where the determination is **Yes**, although this potential future issue was identified, the remedy currently remains protective and is expected to do so for 30 years.

AFB	Air Force Base	NL	Notification Level (CDPH 2010)
AFRL	Air Force Research Laboratory	OEHHA	Office of Environmental Health Hazard Assessment
ARAR	applicable and relevant and appropriate requirement	PCE	tetrachloroethene
CA	California	pMCL	primary maximum contaminant level
CDPH	California Department of Public Health	RBCG	risk-based cleanup goal
COPC	chemical of potential concern	ROD	record of decision
CZ	containment zone	TBC	to-be-considered
FYR	five-year review	TCE	trichloroethene
IAVML	indoor air vapor mitigation level	VI	vapor intrusion
IRIS	Integrated Risk Information System	VIP	vapor intrusion pathway
LUC	land use control	USAF	United States Air Force

TABLE 8.0-2. OPPORTUNITES FOR OPTIMIZATION OF SOUTH AFRL REMEDY, EDWARDS AFB, CA
(Page 1 of 2)

	Remedy Component	Report Citations		Item	Identified By
LUCs					
1.	Condition of Monitoring Wells	6.5.2 and Table 4.5-3 (see also Appendices B.5, B.6)	1.	Minor repairs needed as listed in Section 6.5.2 and/or Table 4.5-3.	USAF (JT3 and AECOM Contractors)
2.	Access to Monitoring Wells	6.5.2 and Table 4.5-3	2.	Minor issues as listed in Table 4.5-3.	Same as above
3.	Optimize Well Field	6.4.2.2, Objective 7; 7.1.2, Item 4 (a) (iii)	3.	Identify wells for re-development, replacement, and/or destruction.	USAF
Groundwater					
1.	Plume Extent – Site 133	6.4.2.2 Objective 1, Item (a); 7.1.2, Item 4 (a) (i)	1.	Initially, need additional well to better monitor TCE extent at the toe of Site 133 groundwater plume; and additional investigation of water table disparity between Well 13-MW39 and nearby Wells 13-MW38 and 13-MW43 near the toe of the plume. Additional wells supplemented by techniques to be identified in RAWP Version 2.0 may be needed for adequate delineation of this plume front.	USAF, USEPA (comment on 2010/2011 WIR and comments on draft FYR report) Water Board (interview)
2.	Plume Extent – Site 37	6.4.2.2 Objective 1, Item (b); 7.1.2, Item 4 (ii)	2.	Need additional wells to better delineate perchlorate extent at the leading edge of the Site 37 plume.	USAF, DTSC (comment on 2010/2011 WIR and in interview)
3.	Hydrogeologic Investigations	6.4.2.2, Objective 5, Item a (i); 7.1.2, Item 4 (b) (ii); 7.3.2	3.	Develop a plan to initiate these investigations using techniques to be identified in RAWP Version 2.0. The RAWP will include DQOs and a detailed discussion of empirical data to be collected.	USAF, USEPA (in comment on 2010/2011 WIR)
4.	Estimated Plume Distributions	6.4.2.2, Objective 5, Item (b)	4.	Update CSM to evaluate whether plume shapes should be contoured in a more "fingered" or channelized distribution.	USEPA (comment on 2010/2011 WIR and in interview)
5.	Performance (Protectiveness) Indicator	6.4.2.2, Objective 5, Item a; 7.1.2, Item 4 (b) (i)	5.	Given the change in 2012 model predictions relative to 2005 model simulations, the groundwater model has less value as the primary predictive protectiveness indicator, suggesting the need to collect empirical data to provide sufficient lines of evidence regarding protectiveness for next FYR.	USAF

TABLE 8.0-2. OPPORTUNITES FOR OPTIMIZATION OF SOUTH AFRL REMEDY, EDWARDS AFB, CA
(Page 2 of 2)

Remedy Component	Report Citations	Item	Identified By
6. Assess Distribution of 1,4-Dioxane	7.1.2, Item 4(a)(iv)	6. During comprehensive plume monitoring to be conducted during the next FYR period, sampling for 1,4-dioxane should be conducted in a sufficient number of wells at key locations both current and future, to update the distribution of this chemical particularly with respect to downgradient extent.	DTSC (comment on draft FYR report)
7. LTM Strategy	6.4.2.2, Objective 7, 7.1.2, Item 4 (a) (iii), 4 (b) (ii)	7. Update LTM strategy presented in the RAWP. Use flowchart to guide decisions on frequency of sampling in each well.	USAF, DTSC (comment on LTM WP for 2012 sampling)
8. LTM Reporting	7.1.2, Item 6 (a)	8. Provide sampling results for South AFRL in a single report.	DTSC (comments on 2010 AGMR)
9. Timeliness of Reporting	7.1.2, Item 6 (b)	9. Submit draft report within 6 months of data collection and final within 12 months.	DTSC (comment on LTM WP for 2012 sampling)
Vapor Intrusion			
1. Protocol Used for VI Evaluation	6.4.3.2 and Table 6.4-9	1. Conduct additional sampling as required for consistency with recent guidance and protocols developed for AFRL sites at Edwards AFB.	USAF
2. Update of VICB	6.4.3.4	2. Based on an evaluation of potential updates to the VICB, no revision is needed at this time.	USAF

Notes:

AFB	Air Force Base
AFRL	Air Force Research Laboratory
AGMR	Annual Groundwater Monitoring Report
BW	Basewide
CA	California
CSM	conceptual site model
DTSC	Department of Toxic Substances Control
FYR	five-year review
GWVCL	groundwater vapor compliance level
IASL	indoor air screening level
IRIS	Integrated Risk Information System
LTM	long-term monitoring
LUC	land use control
OEHHA	Office of Environmental Health Hazard Assessment
RAWP	remedial action work plan
TCE	trichloroethene
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
VI	vapor intrusion
VICB	vapor intrusion compliance boundary
WIR	well installation report
WP	work plan

TABLE 9.0-1. RECOMMENDATIONS TO ADDRESS ISSUES IDENTIFIED IN SECTION 8, TABLE 8.0-1
(Page 1 of 2)

Remedy Component	Issue[1]	Recommendation[2]	Timeframe
Groundwater			
1. Change in ARAR	1. CA pMCL for perchlorate adopted in October 2007; 4 times lower than the RBCG selected in ROD.	1. Prepare an ESD to adopt the CA pMCL as the perchlorate level to be contained inside the CZ.	Before next FYR in 2017[3]
2. Change in TBC Used to Select an RBCG	2. Revised CA NL for 1,4-dioxane; 3 times lower than the RBCG selected in ROD	2. No action needed.	The USAF considers the existing level for containment of this chemical to be sufficiently protective (refer to Section 7.2.2.1).
Vapor Intrusion			
1. Identification of Additional COPCs via the VIP	1. Additional VI-related chemicals have been identified as a result of sub-slab and indoor air monitoring.	1. No action necessary; however, if an ESD is prepared as recommended for Groundwater Issue 1, evaluate whether the list of VI-related COCs (both residential and industrial) should be updated to include the seven chemicals listed in Tables 7.2-5. These are the VI-related chemicals that have been detected in the indoor air of existing South AFRL buildings at concentrations that individually pose a risk to current workers greater than 5 $x10^{-7}$, a HQ greater than 0.5, OR are the potential reductive dechlorination products of parent solvents PCE and TCE.	Before next FYR in 2017[3]
2. Changes in Toxicity Criteria	2. Based on recent updates to the IRIS database, TCE is more toxic and PCE is less toxic than criteria listed in OEHHA database used to develop IAVMLs selected in ROD.	2. If an ESD is prepared as recommended for Groundwater Issue 1, update the list of IAVMLs (both residential and industrial) to incorporate use of the updated toxicity criteria. Consider adopting the approach used to develop IASLs in the BW VI Protocol.	Before next FYR in 2017[3]

TABLE 9.0-1. RECOMMENDATIONS TO ADDRESS ISSUES IDENTIFIED IN SECTION 8, TABLE 8.0-1

(Page 2 of 2)

Notes:

(1) See Table 8.0-1 for a determination of whether this issue affects current or future protectiveness.

(2) For every recommended action, the USAF is the lead agency responsible for taking the action. The USEPA is the oversight agency responsible for concurring with actions; the DTSC and Water Board as State agencies signatory to the FFA may also provide concurrence.

(3) See Table 9.0-3 for a milestone schedule of deliverables.

AFRL	Air Force Research Laboratory
ARAR	applicable and relevant and appropriate requirement
BW	Basewide
CA	California
CDPH	California Department of Public Health
COC	chemical of concern
COPC	chemical of potential concern
CZ	containment zone
DTSC	Department of Toxic Substances Control
ESD	Explanation of Significant Difference
FFA	Federal Facility Agreement
FYR	five-year review
HQ	hazard quotient
IASL	indoor air screening level
IAVML	indoor air vapor mitigation level
IRIS	Integrated Risk Information System
NL	Notification Level (CDPH 2010)
OEHHA	Office of Environmental Health Hazard Assessment
PCE	tetrachloroethene
pMCL	primary maximum contaminant level
RBCG	risk-based cleanup goal
ROD	record of decision
TBC	to-be-considered
TCE	trichloroethene
VI	vapor intrusion
VIP	vapor intrusion pathway
USAF	United States Air Force
USEPA	United States Environmental Protection Agency

TABLE 9.0-2. RECOMMENDATIONS TO OPTIMIZE REMEDY COMPONENTS AS IDENTIFIED IN SECTION 8, TABLE 8.0-2
(Page 1 of 3)

Remedy Component	Item	Recommendation[1]	Timeframe
LUCs			
1. Condition of Monitoring Wells	1. Minor repairs needed as listed in Section 6.5.2 and/or Table 4.5-3.	1. Prioritize repairs and implement those considered most critical and/or requiring minimal effort.	Repair as soon as practicable
2. Access to Monitoring Wells	2. Minor issues as listed in Table 4.5-3.	2. Prioritize repairs and implement those considered most critical and/or requiring minimal effort.	Same as above
3. Optimize Well Field	3. Identify wells for re-development, replacement, and/or destruction.	3. Develop a flowchart for this effort as part of developing a RAWP Version 2.0; following approval of the flowchart and after consensus is reached regarding decisions based on use of the flowchart, program funds to implement those decisions.	Develop RAWP Version 2.0 in 2014; complete review cycles and finalize in 2015.
Groundwater			
1. Plume Extent – Site 133	1. Need additional well to better monitor TCE extent at the toe of Site 133 groundwater plume.	Initially, need additional well to better monitor TCE extent at the toe of Site 133 groundwater plume; and additional investigation of water table disparity between Well 13-MW39 and nearby Wells 13-MW38 and 13-MW43 near the toe of the plume. Additional wells supplemented by techniques to be identified in RAWP Version 2.0 may be needed for adequate delineation of this plume front.	By 2014
2. Plume Extent – Site 37	2. Need additional wells to better delineate perchlorate extent at the leading edge of the Site 37 plume.	1. Install one to two wells near leading edge of the Site 37 plume.	By 2014
3. Hydrogeologic Investigations	3. Accelerate investigation of transition to alluvial aquifer and identification of fracture orientations and preferential flow zones that may help to optimize placement of future downgradient monitoring well locations (see also Item 5).	2. Develop a plan to initiate these investigations using techniques to be identified in RAWP Version 2.0. The RAWP will include DQOs and a detailed discussion of empirical data to be collected.	See timeline proposed under LUCs Item 3; and milestone schedule presented in Table 9.0-3.

TABLE 9.0-2. RECOMMENDATIONS TO OPTIMIZE REMEDY COMPONENTS AS IDENTIFIED IN SECTION 8, TABLE 8.0-2
(Page 2 of 3)

Remedy Component	Item	Recommendation[1]	Timeframe
Groundwater *(Continued)*			
4. Estimated Plume Distributions	4. Update CSM to evaluate whether plume shapes should be contoured in a more "fingered" or channelized distribution.	3. Evaluate the utility of this approach for plume distributions based on results from groundwater monitoring event conducted in June-July 2012.	Include in draft annual groundwater monitoring report (targeted for submittal within 6 months of sample collection).
5. Performance (Protectiveness) Indicator	5. Given the change in 2012 model predictions relative to 2005 model simulations, the groundwater model has less value as the primary predictive protectiveness indicator, suggesting the need to collect empirical data to provide sufficient lines of evidence regarding protectiveness for next FYR.	4. As part of ESD recommended on Table 9.0-1, clarify the role of computer modeling as a component of the groundwater remedy, and in RAWP Version 2.0, develop a plan for future groundwater modeling or other predictive methods consistent with the role defined in the ESD.	Complete ESD and RAWP Version 2.0 in 2014; refer to Table 9.0-3
6. Assess Distribution of 1,4-Dioxane.	6. During comprehensive plume monitoring to be conducted during the next FYR period, sampling for 1,4-dioxane should be conducted in a sufficient number of wells at key locations, both current and future, to update the distribution of this chemical particularly with respect to downgradient extent.	5. Select wells to be sampled for 1,4-dioxane and develop DQOs as part of RAWP Version 2.0.	See timeline proposed under LUCs Item 3
7. LTM Strategy	7. Update LTM strategy presented in the RAWP. Use flowchart to guide decisions on frequency of sampling in each well.	6. Develop this flowchart and an updated LTM strategy as part of RAWP Version 2.0. Consider a plan to accelerate installation of boundary sentinel wells to confirm containment of impacted groundwater inside the CZ.	See timeline proposed under LUCs Item 3.
8. LTM Reporting	8. Provide sampling results for South AFRL in a single report.	7. Provide sampling results for South AFRL in a single report.	The USAF plans to implement this recommendation in 2012.
9. Timeliness of Reporting	9. Submit draft report within 6 months of data collection and final within 12 months.	8. Submit draft report within 6 months of data collection and final within 12 months.	This action will be implemented by 2013.

TABLE 9.0-2. RECOMMENDATIONS TO OPTIMIZE REMEDY COMPONENTS AS IDENTIFIED IN SECTION 8, TABLE 8.0-2
(Page 3 of 3)

Remedy Component	Item	Recommendation[1]	Timeframe
Vapor Intrusion			
1. Protocol Used for VI Evaluation	1. Conduct additional sampling as required for consistency with recent guidance and protocols developed for AFRL sites at Edwards AFB	1. Using a collaborative approach, consider the information summarized in Table 6.4-9 and decide on the scope for further VI investigations. Include a plan to conduct this scope in the RAWP Version 2.0.	Complete second VI evaluation in 2016
2. Update of VICB	2. Based on an evaluation of potential updates to the VICB, no revision is needed at this time.	2. No action.	Not applicable.

Notes:

[1] For every recommended action, the USAF is the lead agency responsible for taking the action. The USEPA is the oversight agency responsible for concurring with actions; the DTSC and Water Board are State agencies signatory to the FFA that may also provide concurrence.

AFB	Air Force Base
AFRL	Air Force Research Laboratory
CSM	conceptual site model
CZ	containment zone
DTSC	Department of Toxic Substances Control
FFA	Federal Facility Agreement
FYR	five-year review
LTM	long-term monitoring
LUC	land use control
RAWP	remedial action work plan
TCE	trichloroethene
USEPA	United States Environmental Protection Agency
USAF	United States Air Force
VI	vapor intrusion
VICB	vapor intrusion compliance boundary
WIR	well installation report

TABLE 9.0-3. SHORT-TERM DELIVERABLES (THROUGH 2019)
(Page 1 of 2)

	Deliverable Type	Version	Title	Target Date (Quarter and Year)
1	Annual Groundwater Monitoring Report	D	2012 Groundwater Monitoring Report (CPME)	1st quarter 2013
2	Annual Groundwater Monitoring Report	F	2012 Groundwater Monitoring Report (CPME)	2nd quarter 2013
3	Project-Specific UFP/QAPP (incl. WP/SAP)(1)	D	Plan for Groundwater Sampling in 2013 and 2014	1st quarter 2013
4	Project-Specific UFP/QAPP (incl. WP/SAP)	F	Plan for Groundwater Sampling in 2013 and 2014	2nd quarter 2013
5	Annual Groundwater Monitoring Report(1)	D	2013 Groundwater Monitoring Report (leading edge)	1st quarter 2014
6	Annual Groundwater Monitoring Report	F	2013 Groundwater Monitoring Report (leading edge)	2nd quarter 2014
7	Decision Document (ESD)	D	Explanation of Significant Differences	4th quarter 2013
8	Decision Document (ESD)	DF	Explanation of Significant Differences	2nd quarter 2014
9	Decision Document (ESD)	F	Explanation of Significant Differences	3rd quarter 2014
10	RAWP Version 2.0(2)	D	Remedial Action Work Plan, version 2.0	4th quarter 2014
11	RAWP Version 2.0	DF	Remedial Action Work Plan, version 2.0	2nd quarter 2014
12	RAWP Version 2.0	F	Remedial Action Work Plan, version 2.0	3rd quarter 2014
13	Annual Groundwater Monitoring Report	D	2014 Groundwater Monitoring Report (leading edge)	1st quarter 2015
14	Annual Groundwater Monitoring Report	F	2014 Groundwater Monitoring Report (leading edge)	2nd quarter 2015
15	HI Report	D	Hydrogeologic Investigation/Well Installation Report	4th quarter 2015
16	HI Report	F	Hydrogeologic Investigation/Well Installation Report	2nd quarter 2016
17	Annual Groundwater Monitoring Report	D	2015 Groundwater Monitoring Report (CPME)	1st quarter 2016
18	Annual Groundwater Monitoring Report	F	2015 Groundwater Monitoring Report (CPME)	2nd quarter 2016
19	VI Monitoring Report	D	2016 Evaluation of VIP at South AFRL	4th quarter 2016
20	VI Monitoring Report	F	2016 Evaluation of VIP at South AFRL	1st quarter 2017
21	Annual Groundwater Monitoring Report	D	2016 Groundwater Monitoring Report (leading edge)	4th quarter 2016
22	Annual Groundwater Monitoring Report	F	2016 Groundwater Monitoring Report (leading edge)	1st quarter 2017
23	Five-Year Review	D	2nd FYR for South AFRL	2nd quarter 2017
24	Five-Year Review	DF	2nd FYR for South AFRL	2nd quarter 2017
25	Five-Year Review	F	2nd FYR for South AFRL	3rd quarter 2017

TABLE 9.0-3. SHORT-TERM DELIVERABLES (THROUGH 2019)
(Page 2 of 2)

	Deliverable Type	Version	Title	Target Date (Quarter and Year)
26	Annual groundwater monitoring report	D	2017 Groundwater Monitoring Report (leading edge)	1st quarter 2018
27	Annual groundwater monitoring report	F	2017 Groundwater Monitoring Report (leading edge)	2nd quarter 2018
28	RAWP Version 3.0[3]	D	Remedial Action Work Plan, version 3.0	4th quarter 2018
29	RAWP Version 3.0	DF	Remedial Action Work Plan, version 3.0	2nd quarter 2019
30	RAWP Version 3.0	F	Remedial Action Work Plan, version 3.0	3rd quarter 2019
31	Annual Groundwater Monitoring Report	D	2018 Groundwater Monitoring Report (leading edge)	1st quarter 2019
32	Annual Groundwater Monitoring Report	F	2018 Groundwater Monitoring Report (leading edge)	2nd quarter 2019

Notes:
Dates in out-years (beyond 2nd FYR) are tentative and subject to change.

[1] Plan and report to include installation of one well at toe of Site 133 groundwater plume and two wells at toe of Site 37 groundwater plume. Plan will indicate groundwater samples to be collected in 2013 and 2014 while RAWP Version 2.0 is in preparation.

[2] RAWP Version 2.0 to include a plan for Long-Term Monitoring (LTM) of groundwater beginning in 2015; a plan for future groundwater modeling and/or other predictive methods; DQOs; design for hydrogeologic investigations to identify fracture orientations and preferential pathways and refine the location of transition to an alluvial aquifer; and plan for VI monitoring to be conducted in 2016.

[3] The USAF as lead agency will determine if this and future versions of the RAWP are necessary.

AFRL	Air Force Research Laboratory	incl.	includes
CPME	comprehensive monitoring event	QAPP	Quality Assurance Project Plan
D	draft	RAWP	Remedial Action Work Plan
DF	draft final	SAP	Sampling and Analysis Plan
DQO	data quality objective	UFP	Uniform Federal Policy
ESD	Explanation of Significant Differences	USAF	United States Air Force
F	final	VI	vapor intrusion
FYR	Five-Year Review	VIP	vapor intrusion pathway
HI	Hydrogeologic Investigation	WP	Work Plan

FIGURES

Figure	Title
1.0-1	Edwards Air Force Base Location Map
1.0-2	Sites 37, 120, 133, and 321 Reference Map, South AFRL CZ, and Groundwater LUC Compliance Boundary
1.0-3	South AFRL Vapor Intrusion Compliance Boundaries
1.6-1	Operable Units and Known Areas of Groundwater Contamination at Edwards Air Force Base
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1.6-3	Locations of AFRL Soil and Debris Sites
3.0-1	Sites 37, 120, and 133 Estimated PCE Plume Contours
3.0-2	Sites 37, 120, and 133 Estimated TCE Plume Contours
3.0-3	Sites 37, 120, and 133 Estimated cis-1,2-DCE Plume Contours
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3.0-5	Site 321 Estimated Plume Contours
3.1-1	Approximate Extent of Impacted Groundwater within the South AFRL CZ
3.1-2	Antelope Valley and Vicinity Hydrologic Basins and USGS Subbasins
3.1-3	South AFRL Surface Topography and Groundwater Monitoring Wells
3.1-4	Geologic Map of the AFRL, Edwards AFB
3.1-5	South AFRL Conceptual Site Model Cross Section C-C'-C" (Site 37)
3.1-6	South AFRL Conceptual Site Model Cross Section D-D'-D"-D'" (Site 133)
3.1-7	South AFRL Conceptual Site Model Cross Section E-E'-E" (Site 120)
3.1-8	South AFRL Conceptual Site Model Cross Section F-F' (Site 321)
3.1-9	Sites 37, 120, and 133 Potentiometric Surface Map and GETS - October 2007
3.1-10	South AFRL Potentiometric Surface Map October 2011
3.1-11	South AFRL Containment Zone, Sensitive Natural Resources, and Monitoring Well Locations
3.2-1	Edwards Air Force Base Current Land Use
3.3-1	Source Area for Site 37
3.3-2	CSM for Source Area South of Building 8595
3.3-3	Source Areas for Site 133
3.3-4	Source Area for Site 120

FIGURES (*continued*)

Figure	Title
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3.5-1	Site 37 Exposure Pathways Retained for CERCLA Response
3.5-2	Site 120 Exposure Pathways Retained for CERCLA Response
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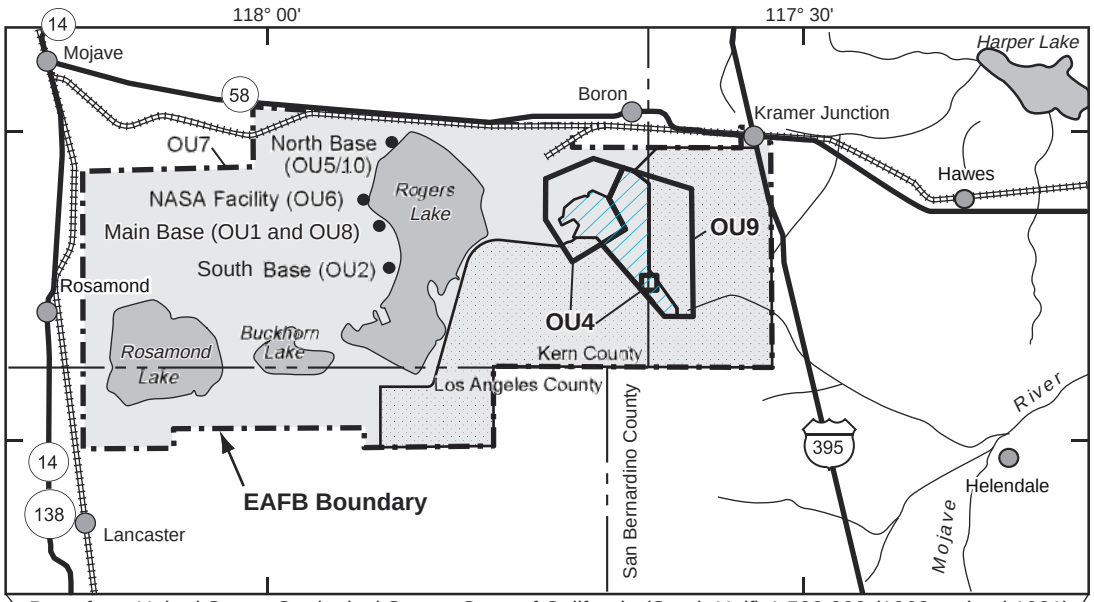
3.5-4	Site 321 Exposure Pathways Retained for CERCLA Response
4.4-1	Wells Installed at Sites 37, 133, and 120 from 2009 to 2011
4.4-2	Well Installed at Site 321 in 2010
6.1-1	Submittal Dates for South AFRL Five-Year Report
6.4-1	PCE Plume Contours 2003, 2008, and 2011
6.4-2	TCE Plume Contours 2003, 2008, and 2011
6.4-3	Perchlorate Plume Contours 2003, 2008, and 2011
6.4-4	Non Detect Wells for VOCs at South AFRL
6.4-5	Estimated TCE Plume Extents Based on Alternative Methods to Depict USEPA Hypothesis
6.4-6	Non Detect Wells for Perchlorate at South AFRL
6.4-7	Site 37 PCE Plume and Site 133 TCE Plume Contours within the GWVCLs-ind Compliance Boundary
6.4-8	Site 37 Vapor Sampling Locations and Results
6.4-9	Site 133 Vapor Sampling Locations and Results
6.4-10	Building 8595 Indoor Air and Extraction Well Sampling Results
6.4-11	Projected Extent of PCE Contours at 13 μg/L and 300 μg/L (Using the 2012 Groundwater Model)
6.4-12	Projected Extent of TCE Contours at 30 μg/L (Using the 2012 Groundwater Model)
6.4-13	Comparison of the 2007 ROD VICB to the 30-Year Projected Extent of the Combined 300 μg/L PCE and 30 μg/L TCE Contours (Using the 2012 Groundwater Model)
6.4-14	Site 37 PCE Plume and Site 133 TCE Plume Contours within the Revised GWVCLs-ind Compliance Boundary Calculated using Updated Toxicity Criteria
6.5-1	South AFRL Site Inspection Tour Stops



Base from United States Geological Survey State of California (South Half) 1:500,000 (1968 revised 1981)

0 10 20 miles

0 10 20 30 kilometers

Scale

NORTH

Explanation

AFB	Air Force Base
AFRL	Air Force Research Laboratory
FYR	Five-Year Review
EAFB	Edwards Air Force Base
NASA	National Aeronautics and Space Administration
OU	Operable Unit
	Air Force Research Laboratory Area
	Precision Impact Range Area (PIRA)
	Cities
	Railroads
	County Lines
	Rivers

First FYR for South AFRL

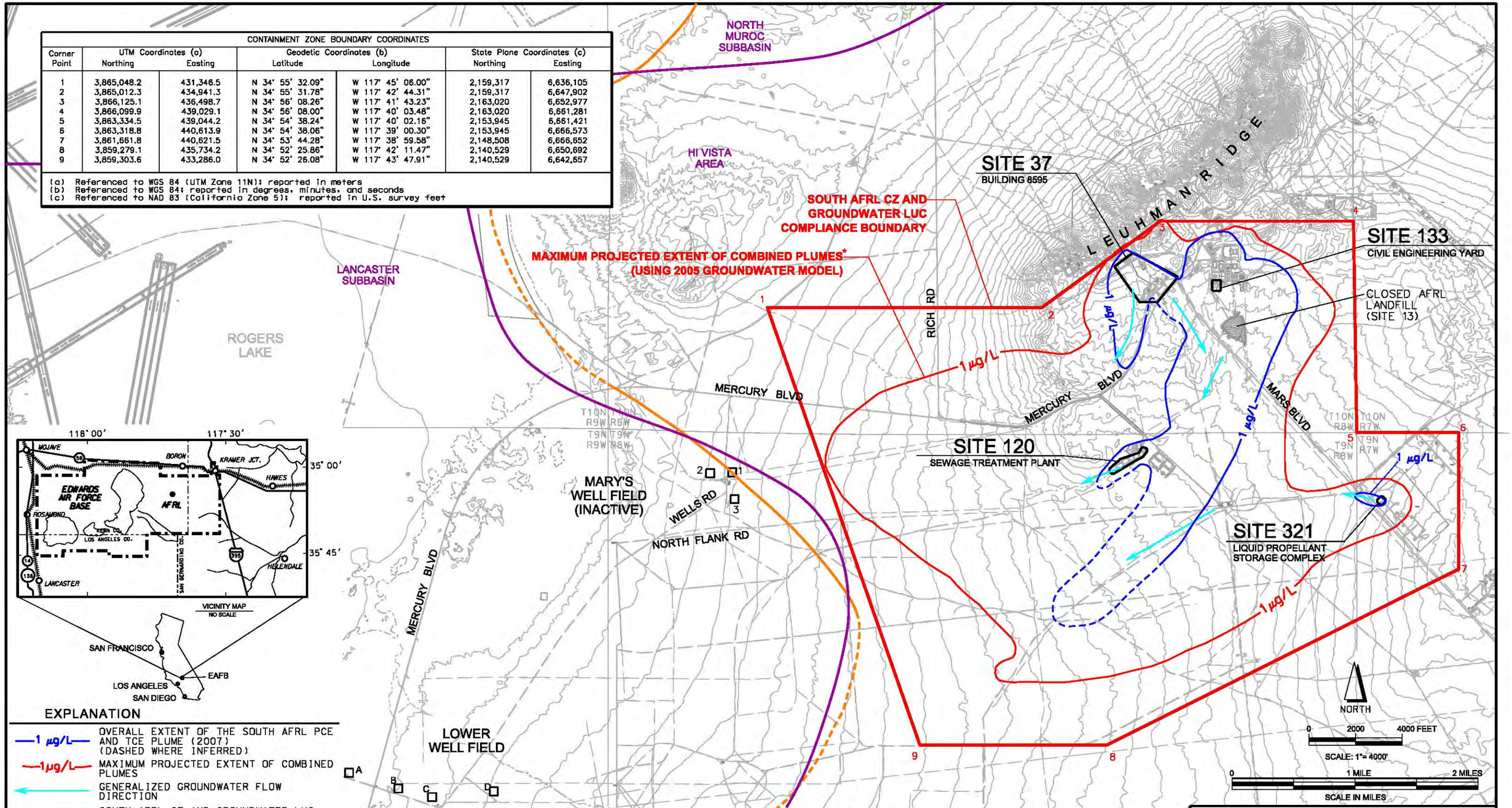
Edwards Air Force Base Location Map

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		**1.0-1**

6022-5193.10.07 First 5 yr Rpt - S. AFRL

CONTAINMENT ZONE BOUNDARY COORDINATES						
Corner Point	UTM Coordinates (a) Northing	UTM Coordinates (a) Easting	Geodetic Coordinates (b) Latitude	Geodetic Coordinates (b) Longitude	State Plane Coordinates (c) Northing	State Plane Coordinates (c) Easting
1	3,865,048.2	431,346.5	N 34° 55' 32.09"	W 117° 45' 06.00"	2,159,317	6,636,105
2	3,865,012.3	434,941.3	N 34° 55' 31.78"	W 117° 42' 44.31"	2,159,317	6,647,902
3	3,866,125.1	436,498.7	N 34° 56' 08.26"	W 117° 41' 43.23"	2,163,020	6,652,977
4	3,866,099.9	439,029.1	N 34° 56' 08.00"	W 117° 40' 03.48"	2,163,020	6,661,281
5	3,863,334.5	439,044.2	N 34° 54' 38.24"	W 117° 40' 02.16"	2,153,945	6,661,421
6	3,863,318.8	440,613.9	N 34° 54' 38.06"	W 117° 39' 00.30"	2,153,945	6,666,573
7	3,861,661.8	440,621.5	N 34° 53' 44.28"	W 117° 38' 59.58"	2,148,508	6,666,652
8	3,859,279.1	435,734.2	N 34° 52' 25.86"	W 117° 42' 11.47"	2,140,529	6,650,692
9	3,859,303.6	433,286.0	N 34° 52' 26.08"	W 117° 43' 47.91"	2,140,529	6,642,657

(a) Referenced to WGS 84 (UTM Zone 11N); reported in meters
(b) Referenced to WGS 84; reported in degrees, minutes, and seconds
(c) Referenced to NAD 83 (California Zone 5); reported in U.S. survey feet



EXPLANATION

- 1 µg/L — OVERALL EXTENT OF THE SOUTH AFRL PCE AND TCE PLUME (2007) (DASHED WHERE INFERRED)
- 1µg/L — MAXIMUM PROJECTED EXTENT OF COMBINED PLUMES
- GENERALIZED GROUNDWATER FLOW DIRECTION
- SOUTH AFRL CZ AND GROUNDWATER LUC COMPLIANCE BOUNDARY
- SITE BOUNDARY
- GROUNDWATER PRODUCTION WELL (ACTIVE OR INACTIVE)
- ESTIMATED BEDROCK TO ALLUVIAL AQUIFER TRANSITION (DASHED WHERE INFERRED)
- BASIN BOUNDARIES (SEE NOTE 1)
- * GENERATED USING TRANSPORT MODELS (EARTH TECH 2005b) FOR PCE (SITES 37 AND 321) AND TCE (SITES 120 AND 133). SIMULATION RUN FOR 1,000 YEARS, BUT MAXIMUM PLUME EXTENT IS PROJECTED AT APPROXIMATELY 800 YEARS.

µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
BLVD	BOULEVARD
CO.	COUNTY
CZ	CONTAINMENT ZONE
FYR	FIVE-YEAR REVIEW
JCT.	JUNCTION
LUC	LAND USE CONTROL
NAD 83	NORTH AMERICAN DATUM (1983)
PCE	TETRACHLOROETHENE
RD	ROAD
TCE	TRICHLOROETHENE
U.S.	UNITED STATES
UTM	UNIVERSAL TRANSVERSE MERCATOR
USGS	UNITED STATES GEOLOGICAL SURVEY
WGS 84	WORLD GEODETIC SYSTEM 1984

NOTE:
1. BOUNDARIES OF NORTH MUROC AND LANCASTER SUBBASINS AND HI VISTA RECHARGE AREA FROM USGS 2005 FACT SHEET (SNEED ET AL. 2006) AS ADAPTED FROM CARLSON ET AL. (1998) BASED ON GEOPHYSICAL EVIDENCE.
2. ADAPTED FROM FIGURE 2.1-2 OF THE SOUTH AFRL ROD (USAF 2007).

First FYR for South AFRL

Sites 37, 120, 133, and 321 Reference Map, South AFRL CZ, and Groundwater LUC Compliance Boundary

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		1.0-2

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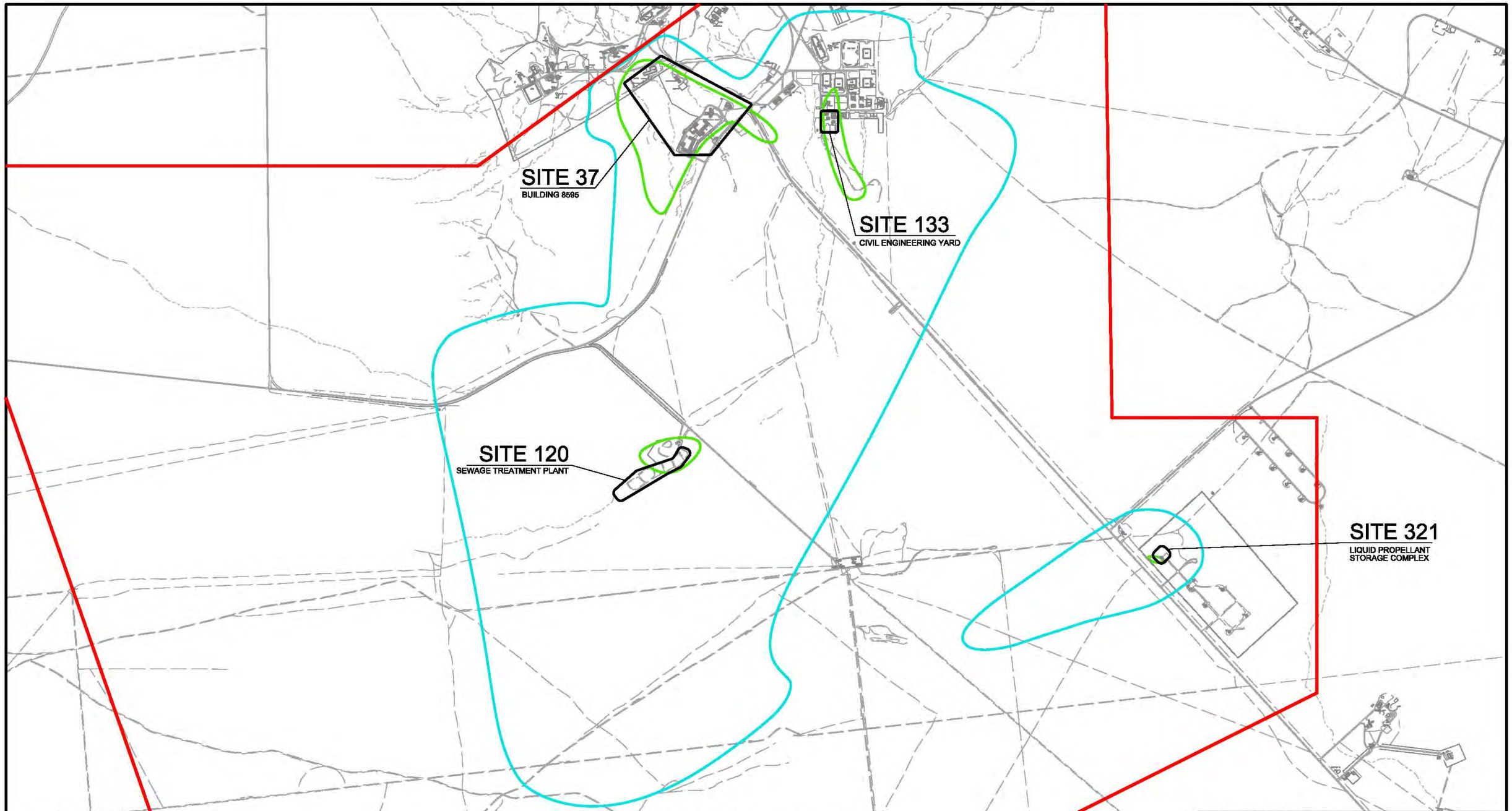

EXPLANATION

- SOUTH AFRL CONTAINMENT ZONE/GROUNDWATER LUCs BOUNDARY
- CONTOUR LINE OF GWVCL–IND BASED ON THE 2005 EXTENT OF TCE AND PCE AT A 10^{-6} RISK LEVEL FOR INDUSTRIAL EXPOSURE
- VICB BASED ON THE 30–YEAR PROJECTED EXTENT (FROM EARTH TECH 2005b) OF THE GWVCLs–RES FOR TCE AND PCE AT A 10^{-6} RISK LEVEL FOR RESIDENTIAL USE

µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
FYR	FIVE–YEAR REVIEW
GWVCL–IND	GROUND WATER VAPOR COMPLIANCE LEVEL FOR INDUSTRIAL EXPOSURE
GWVCL–RES	GROUND WATER VAPOR COMPLIANCE LEVEL FOR RESIDENTIAL EXPOSURE
LUC	LAND USE CONTROL
PCE	TETRACHLOROETHENE
TCE	TRICHLOROETHENE
VICB	VAPOR INTRUSION COMPLIANCE BOUNDARY

NOTE:
1. ADAPTED FROM FIGURE 2.7–1 OF THE SOUTH AFRL ROD (USAF 2007).

NORTH

0 1000 2000 FEET

SCALE: 1"= 2000'

First FYR for South AFRL

South AFRL Vapor Intrusion Compliance Boundaries

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		1.0-3

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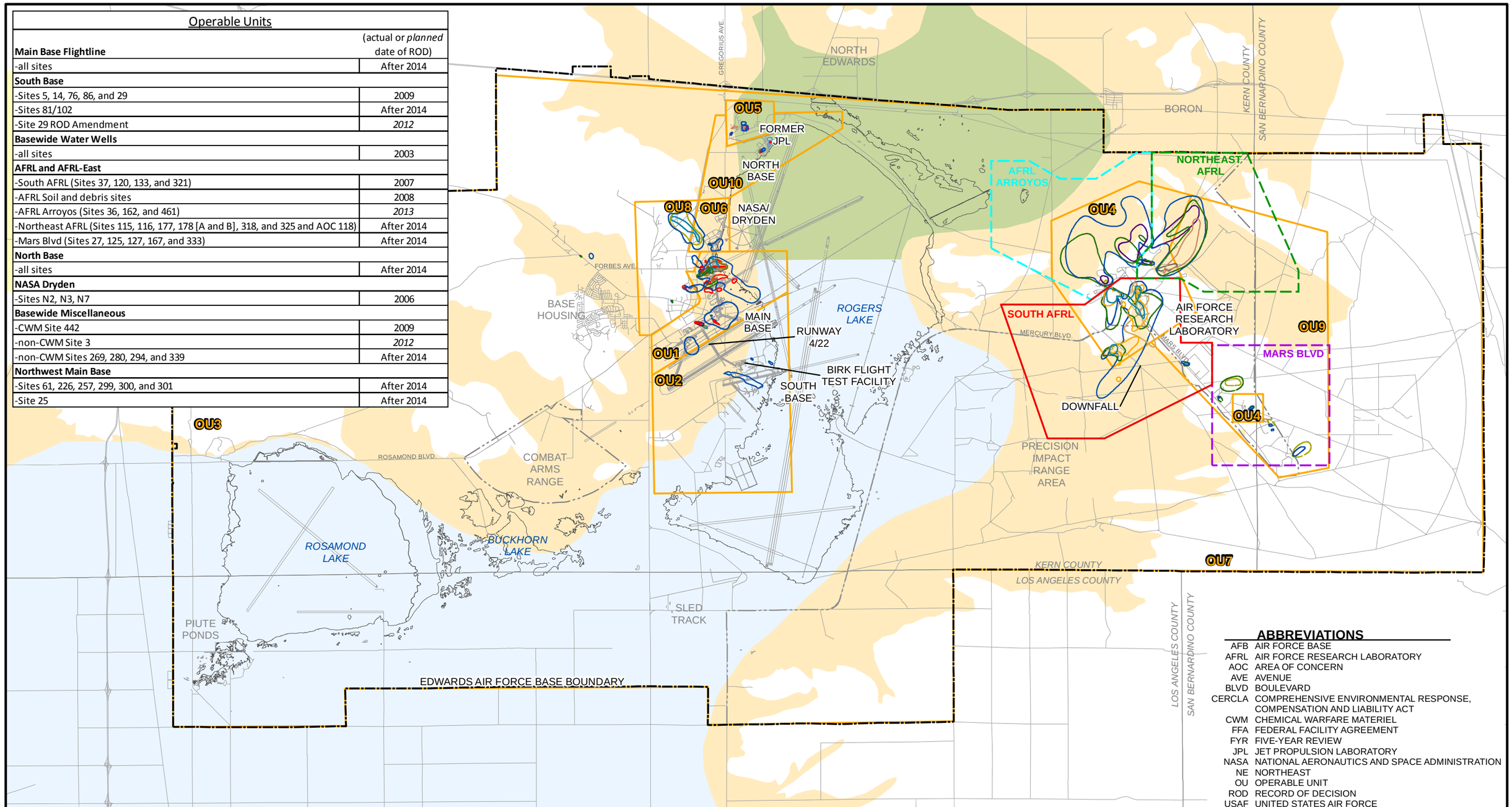

Operable Units

	(actual or *planned* date of ROD)
Main Base Flightline	
-all sites	After 2014
South Base	
-Sites 5, 14, 76, 86, and 29	2009
-Sites 81/102	After 2014
-Site 29 ROD Amendment	*2012*
Basewide Water Wells	
-all sites	2003
AFRL and AFRL-East	
-South AFRL (Sites 37, 120, 133, and 321)	2007
-AFRL Soil and debris sites	2008
-AFRL Arroyos (Sites 36, 162, and 461)	*2013*
-Northeast AFRL (Sites 115, 116, 177, 178 [A and B], 318, and 325 and AOC 118)	After 2014
-Mars Blvd (Sites 27, 125, 127, 167, and 333)	After 2014
North Base	
-all sites	After 2014
NASA Dryden	
-Sites N2, N3, N7	2006
Basewide Miscellaneous	
-CWM Site 442	2009
-non-CWM Site 3	*2012*
-non-CWM Sites 269, 280, 294, and 339	After 2014
Northwest Main Base	
-Sites 61, 226, 257, 299, 300, and 301	After 2014
-Site 25	After 2014

ABBREVIATIONS

AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
AOC	AREA OF CONCERN
AVE	AVENUE
BLVD	BOULEVARD
CERCLA	COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT
CWM	CHEMICAL WARFARE MATERIEL
FFA	FEDERAL FACILITY AGREEMENT
FYR	FIVE-YEAR REVIEW
JPL	JET PROPULSION LABORATORY
NASA	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NE	NORTHEAST
OU	OPERABLE UNIT
ROD	RECORD OF DECISION
USAF	UNITED STATES AIR FORCE

EXPLANATION

- SOUTH AFRL CONTAINMENT ZONE
- NORTHEAST AFRL GROUNDWATER AREA
- AFRL ARROYOS GROUNDWATER AREA
- MARS BLVD GROUNDWATER AREA
- ROAD/AIRFIELD MARKING
- BASE BOUNDARY
- ALLUVIAL FANS
- GLOSTER SUBBASIN
- LANCASTER SUBBASIN
- NORTH MUROC SUBBASIN
- TRICHLOROETHENE PLUME
- TETRACHLOROETHENE PLUME
- 1,4-DIOXANE PLUME
- 1,1-DICHLOROETHENE PLUME
- BENZENE PLUME
- 1,2-DICHLOROETHANE PLUME
- CARBON TETRACHLORIDE PLUME
- TERT BUTYL ALCOHOL PLUME
- METHYL TERT BUTYL ETHER PLUME
- TRANS-1,2-DICHLOROETHENE PLUME
- PERCHLORATE PLUME
- N-NITROSODIMETHYLAMINE PLUME
- N-NITROSODIMETHYLAMINE PLUME (NE AFRL)
- DIESEL PLUME

NOTE

1. AN UPDATE TO THE FFA SCHEDULE IS IN PROGRESS CONCURRENT WITH A CHANGE IN THE USAF'S ACQUISITION STRATEGY FOR COMPLETION OF PRIMARY CERCLA DELIVERABLES. THEREFORE, THE DATE SHOWN FOR ALL PLANNED RODS NOT CURRENTLY IN PROGRESS IS LISTED AS "AFTER 2014".
2. EXTENT OF PLUME ISOCONCENTRATION CONTOUR BASED ON THE CONTAMINANT CONCENTRATION IN GROUNDWATER GREATER THAN THE MAXIMUM CONTAMINANT LEVEL (MCL) IN DRINKING WATER.

NORTH

0 1.25 2.5 Miles

1 " = 2.5 miles

First FYR for South AFRL

Operable Units and Known Areas of Groundwater Contamination at Edwards Air Force Base

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		1.6-1

File: Q:\EDWRD_ArcGIS_maps_Final\OU4_9\2012 SAFRL 5 Year Review\B9266fga.mxd
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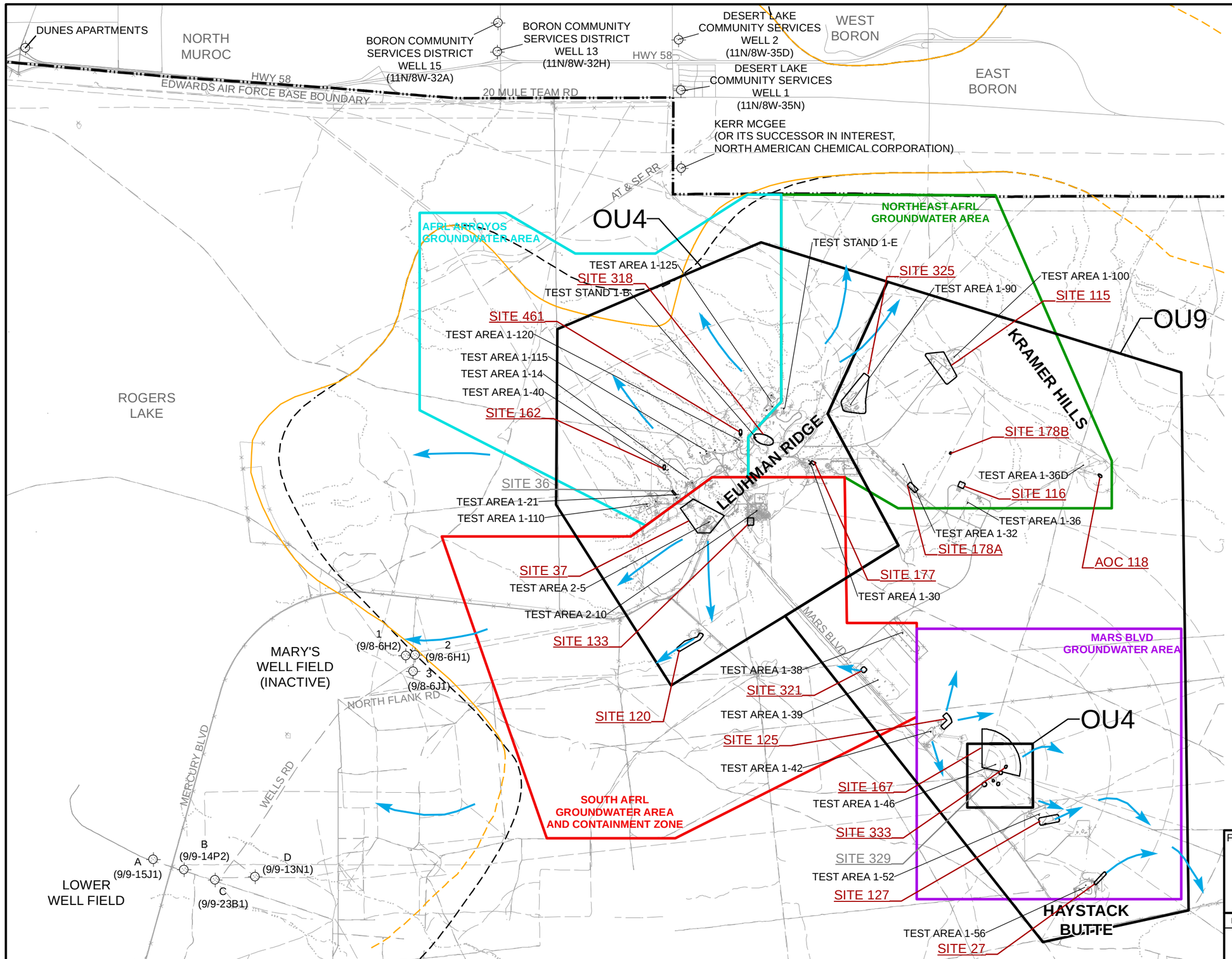

EXPLANATION

- OPERABLE UNIT (OU) BOUNDARY
- PRODUCTION WELL
- GENERALIZED GROUNDWATER FLOW DIRECTION
- EDWARDS AFB BOUNDARY
- ESTIMATED BEDROCK TO ALLUVIAL AQUIFER TRANSITION (DASHED WHERE INFERRED)
- ALLUVIAL AQUIFER TRANSITION (BASED ON DATA PRIOR TO 2010)
- SOUTH AFRL GROUNDWATER AREA AND CONTAINMENT ZONE BOUNDARY
- AFRL ARROYOS GROUNDWATER AREA
- NORTHEAST AFRL GROUNDWATER AREA
- MARS BLVD GROUNDWATER AREA
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- TOPOGRAPHY DRAINAGE

ABBREVIATIONS

AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
AOC	AREA OF CONCERN
AT & SF	ATCHINSON TOPEKA AND SANTA FE
BLVD	BOULEVARD
FYR	FIVE-YEAR REVIEW
HWY	HIGHWAY
OU	OPERABLE UNIT
RD	ROAD
RR	RAILROAD

NOTE

1. FOR EASE OF LONG-TERM MANAGEMENT, GROUNDWATER PLUMES IN OU4 AND OU9 HAVE BEEN ASSIGNED TO ONE OF FOUR GEOGRAPHIC AREAS: SOUTH AFRL, AFRL ARROYOS, NORTHEAST AFRL, AND MARS BOULEVARD.

First FYR for South AFRL

Groundwater Areas in OU4/OU9 and Site Boundaries (Source Areas)

Date 09-12 Project No. 60225193	Air Force Research Laboratory Edwards AFB	Figure 1.6-2

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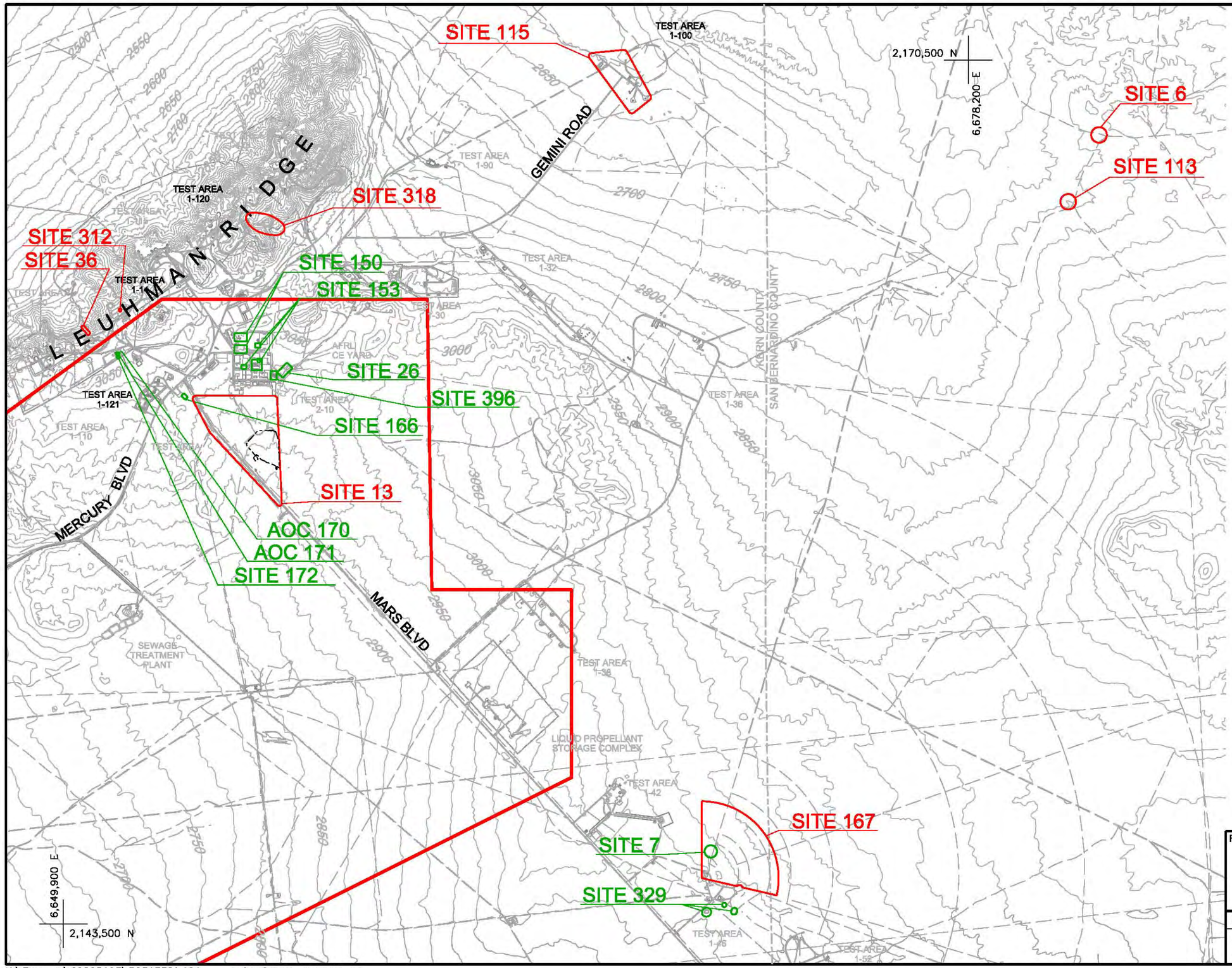

EXPLANATION

- BUILDING
- STORAGE TANK
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- SOUTH ARFL CZ BOUNDARY
- SITES CODED IN RED REQUIRE FURTHER ACTION
- SITES CODED IN GREEN REQUIRE NO FURTHER ACTION

AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
AOC	AREA OF CONCERN
BLVD	BOULEVARD
CZ	CONTAMINANT ZONE
FYR	FIVE-YEAR REVIEW

NORTH

0 1500 3000 FEET

SCALE: 1"= 3000'

First FYR for South AFRL

Locations of AFRL Soil and Debris Sites

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		1.6-3

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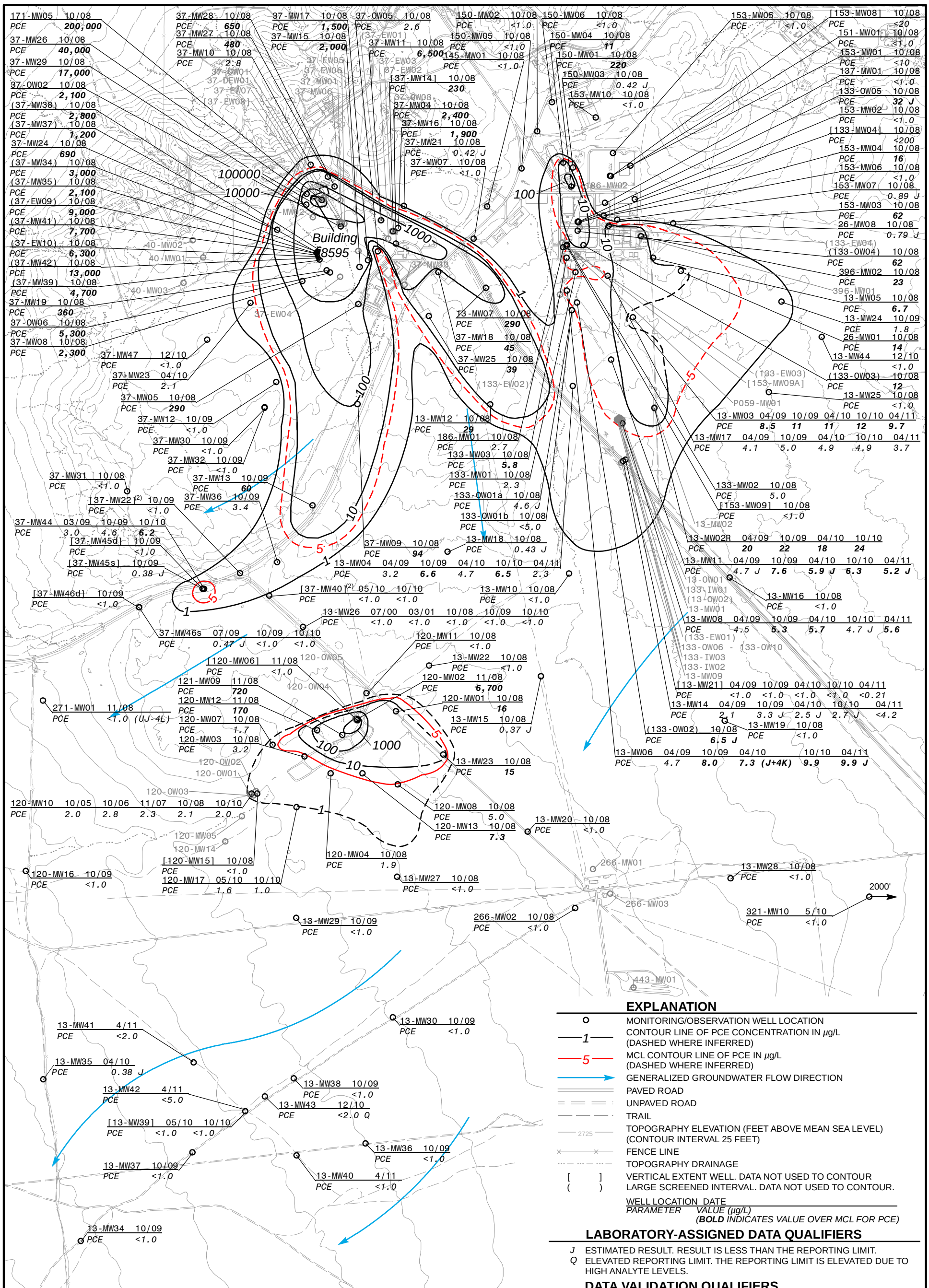

EXPLANATION

- MONITORING/OBSERVATION WELL LOCATION
- 1 — CONTOUR LINE OF PCE CONCENTRATION IN µg/L (DASHED WHERE INFERRED)
- 5 — MCL CONTOUR LINE OF PCE IN µg/L (DASHED WHERE INFERRED)
- GENERALIZED GROUNDWATER FLOW DIRECTION
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- 2725 — TOPOGRAPHY ELEVATION (FEET ABOVE MEAN SEA LEVEL) (CONTOUR INTERVAL 25 FEET)
- FENCE LINE
- TOPOGRAPHY DRAINAGE
- [ ] VERTICAL EXTENT WELL. DATA NOT USED TO CONTOUR
- ( ) LARGE SCREENED INTERVAL. DATA NOT USED TO CONTOUR.

WELL LOCATION DATE
PARAMETER *VALUE (µg/L)*
(***BOLD*** *INDICATES VALUE OVER MCL FOR PCE)*

LABORATORY-ASSIGNED DATA QUALIFIERS

- *J* ESTIMATED RESULT. RESULT IS LESS THAN THE REPORTING LIMIT.
- *Q* ELEVATED REPORTING LIMIT. THE REPORTING LIMIT IS ELEVATED DUE TO HIGH ANALYTE LEVELS.

DATA VALIDATION QUALIFIERS

- *(J+4K)* ESTIMATED VALUE. RECOVERIES FOR ONE OR MORE SURROGATES ARE ABOVE THE QC LIMIT. VALUES MAY BE BIASED HIGH.
- *(UJ-4L)* REPORTING LIMIT ESTIMATED. RECOVERIES FOR ONE OR MORE SURROGATES ARE BELOW THE QC LIMITS. INDICATES POSSIBLE LOW BIAS.

ABBREVIATIONS

<	LESS THAN
µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
FYR	FIVE-YEAR REVIEW
MCL	MAXIMUM CONTAMINANT LEVEL (CALIFORNIA DEPARTMENT OF PUBLIC HEALTH 2011)
MDL	METHOD DETECTION LIMIT
PCE	TETRACHLOROETHENE
QC	QUALITY CONTROL
RL	REPORTING LIMIT

NOTES

1. GRAY SCALING INDICATES ANALYTE NOT SAMPLED DURING THE 2008-2010 SAMPLING EVENTS.
2. THE SHALLOWER WATER-BEARING ZONE WAS INDISTINCT IN THIS WELL AND NOT SCREENED.

NORTH

0 700 1,400 Feet

1 " = 1,400 '

First FYR for South AFRL

Sites 37, 120, and 133 Estimated PCE Plume Contours

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure 3.0-1
Project No. 60225193		

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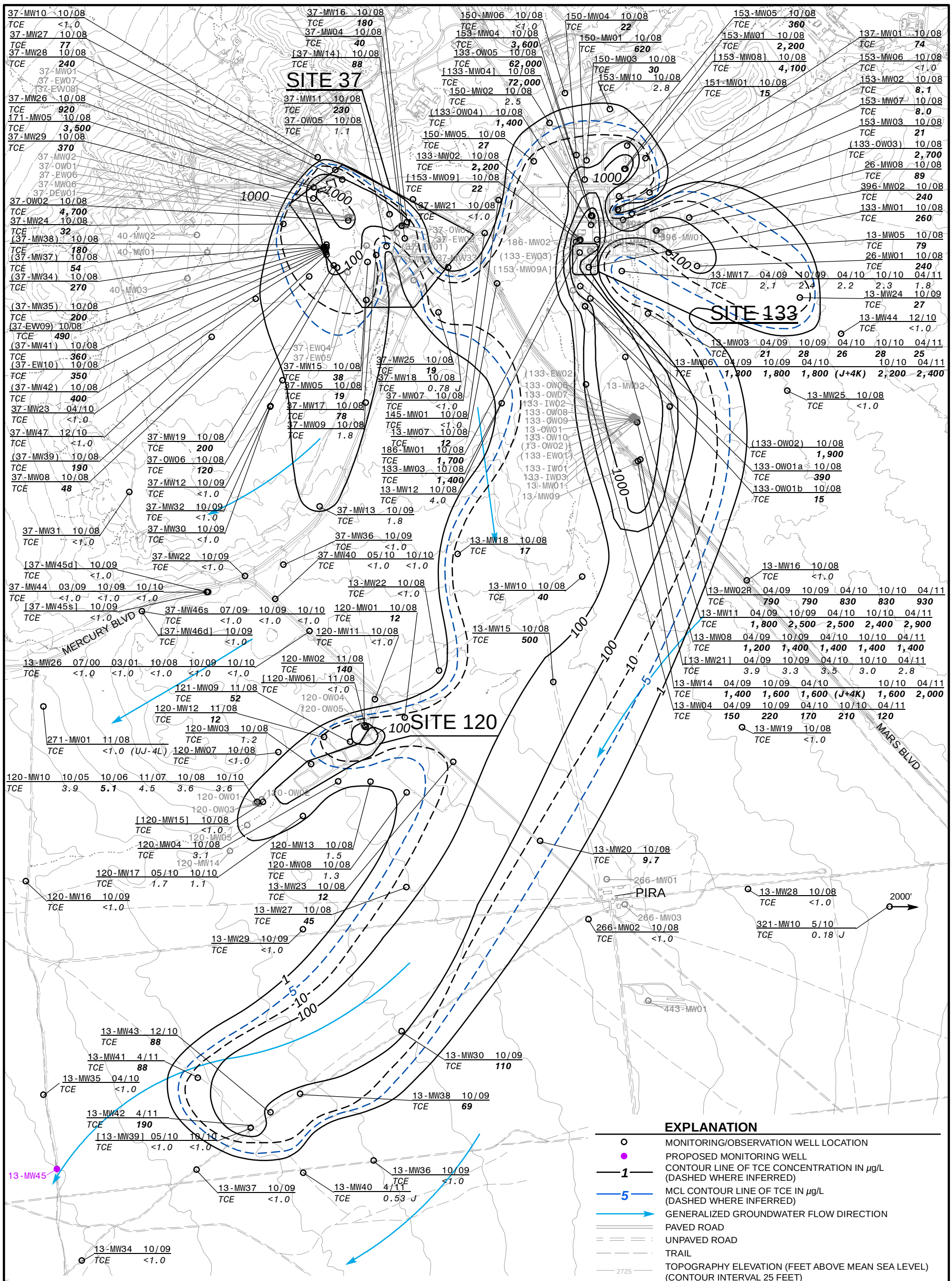

EXPLANATION

- MONITORING/OBSERVATION WELL LOCATION
- PROPOSED MONITORING WELL
- 1 — CONTOUR LINE OF TCE CONCENTRATION IN µg/L (DASHED WHERE INFERRED)
- 5 — MCL CONTOUR LINE OF TCE IN µg/L (DASHED WHERE INFERRED)
- GENERALIZED GROUNDWATER FLOW DIRECTION
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- 2725 — TOPOGRAPHY ELEVATION (FEET ABOVE MEAN SEA LEVEL) (CONTOUR INTERVAL 25 FEET)
- FENCE LINE
- TOPOGRAPHY DRAINAGE
- [ ] ( ) VERTICAL EXTENT WELL. DATA NOT USED TO CONTOUR LARGE SCREENED INTERVAL. DATA NOT USED TO CONTOUR.

WELL LOCATION DATE
PARAMETER VALUE (µg/L)
*(**BOLD** INDICATES VALUE OVER MCL FOR TCE)*

ABBREVIATIONS

<	LESS THAN
µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
FYR	FIVE-YEAR REVIEW
MCL	MAXIMUM CONTAMINANT LEVEL (CALIFORNIA DEPARTMENT OF PUBLIC HEALTH 2011)
PIRA	PRECISION IMPACT RANGE AREA
QC	QUALITY CONTROL
TCE	TRICHLOROETHENE

LABORATORY-ASSIGNED DATA QUALIFIERS

J	ESTIMATED RESULT. RESULT IS LESS THAN THE REPORTING LIMIT.

DATA VALIDATION QUALIFIERS

(J+4K)	ESTIMATED VALUE. RECOVERIES FOR ONE OR MORE SURROGATES ARE ABOVE THE QC LIMIT. VALUES MAY BE BIASED HIGH.
(UJ-4L)	REPORTING LIMIT ESTIMATED. RECOVERIES FOR ONE OR MORE SURROGATES ARE BELOW THE QC LIMITS. INDICATES POSSIBLE LOW BIAS.

NOTES

1. GRAY SCALING INDICATES ANALYTE NOT SAMPLED DURING THE 2008-2010 SAMPLING EVENTS.

First FYR for South AFRL

Sites 37, 120, and 133 Estimated TCE Plume Contours

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure 3.0-2
Project No. 60225193		

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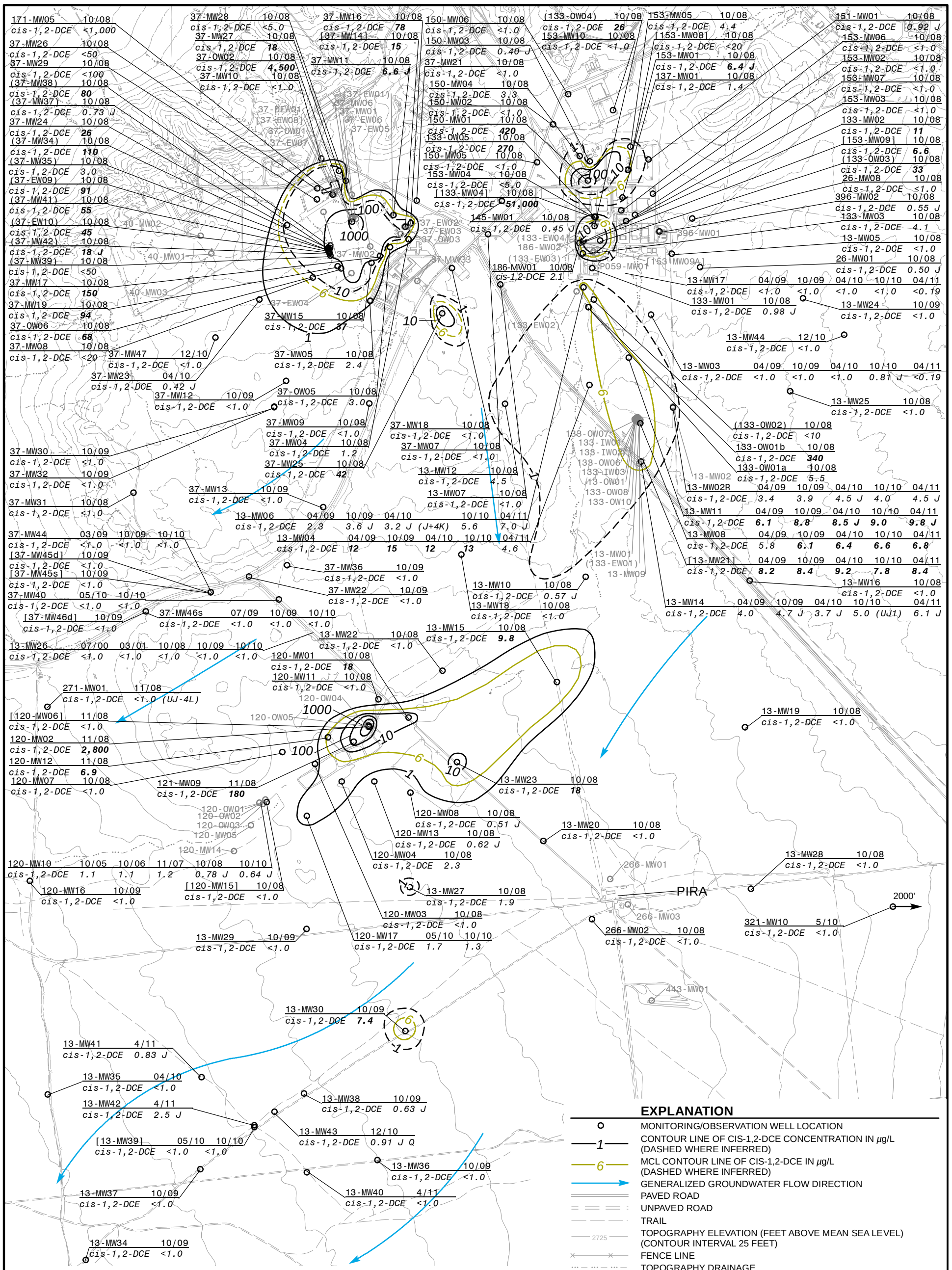

EXPLANATION

- MONITORING/OBSERVATION WELL LOCATION
- CONTOUR LINE OF CIS-1,2-DCE CONCENTRATION IN µg/L (DASHED WHERE INFERRED)
- MCL CONTOUR LINE OF CIS-1,2-DCE IN µg/L (DASHED WHERE INFERRED)
- GENERALIZED GROUNDWATER FLOW DIRECTION
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- TOPOGRAPHY ELEVATION (FEET ABOVE MEAN SEA LEVEL) (CONTOUR INTERVAL 25 FEET)
- FENCE LINE
- TOPOGRAPHY DRAINAGE
- [ ] VERTICAL EXTENT WELL. DATA NOT USED TO CONTOUR
- ( ) LARGE SCREENED INTERVAL. DATA NOT USED TO CONTOUR.

WELL LOCATION DATE
PARAMETER VALUE (µg/L)
(**BOLD** INDICATES VALUE OVER MCL FOR cis-1,2-DCE)

ABBREVIATIONS

<	LESS THAN
µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
DCE	DICHLOROETHENE
FYR	FIVE-YEAR REVIEW
MCL	MAXIMUM CONTAMINANT LEVEL (CALIFORNIA DEPARTMENT OF PUBLIC HEALTH 2011)
PIRA	PRECISION IMPACT RANGE AREA
QC	QUALITY CONTROL

LABORATORY-ASSIGNED DATA QUALIFIERS

J	ESTIMATED RESULT. RESULT IS LESS THAN THE REPORTING LIMIT.
Q	ELEVATED REPORTING LIMIT. THE REPORTING LIMIT IS ELEVATED DUE TO HIGH ANALYTE LEVELS.

DATA VALIDATION QUALIFIERS

(J+4K)	ESTIMATED VALUE.RECOVERIES FOR ONE OR MORE SURROGATES ARE ABOVE THE QC LIMIT. VALUES MAY BE BIASED HIGH.
(UJ-4L)	REPORTING LIMIT ESTIMATED. RECOVERIES FOR ONE OR MORE SURROGATES ARE BELOW THE QC LIMITS. INDICATES POSSIBLE LOW BIAS.
(UJ1)	ESTIMATED VALUE. BLANK CONTAMINATION: THE VALUE IN THE LABORATORY BLANK IS BELOW THE REPORTING LIMIT. INDICATES POSSIBLE HIGH BIAS AND/OR FALSE POSITIVES.

NOTES

1. GRAY SCALING INDICATES ANALYTE NOT SAMPLED DURING THE 2008-2010 SAMPLING EVENTS.

First FYR for South AFRL

Sites 37, 120, and 133 Estimated cis-1,2-DCE Plume Contours

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		3.0-3

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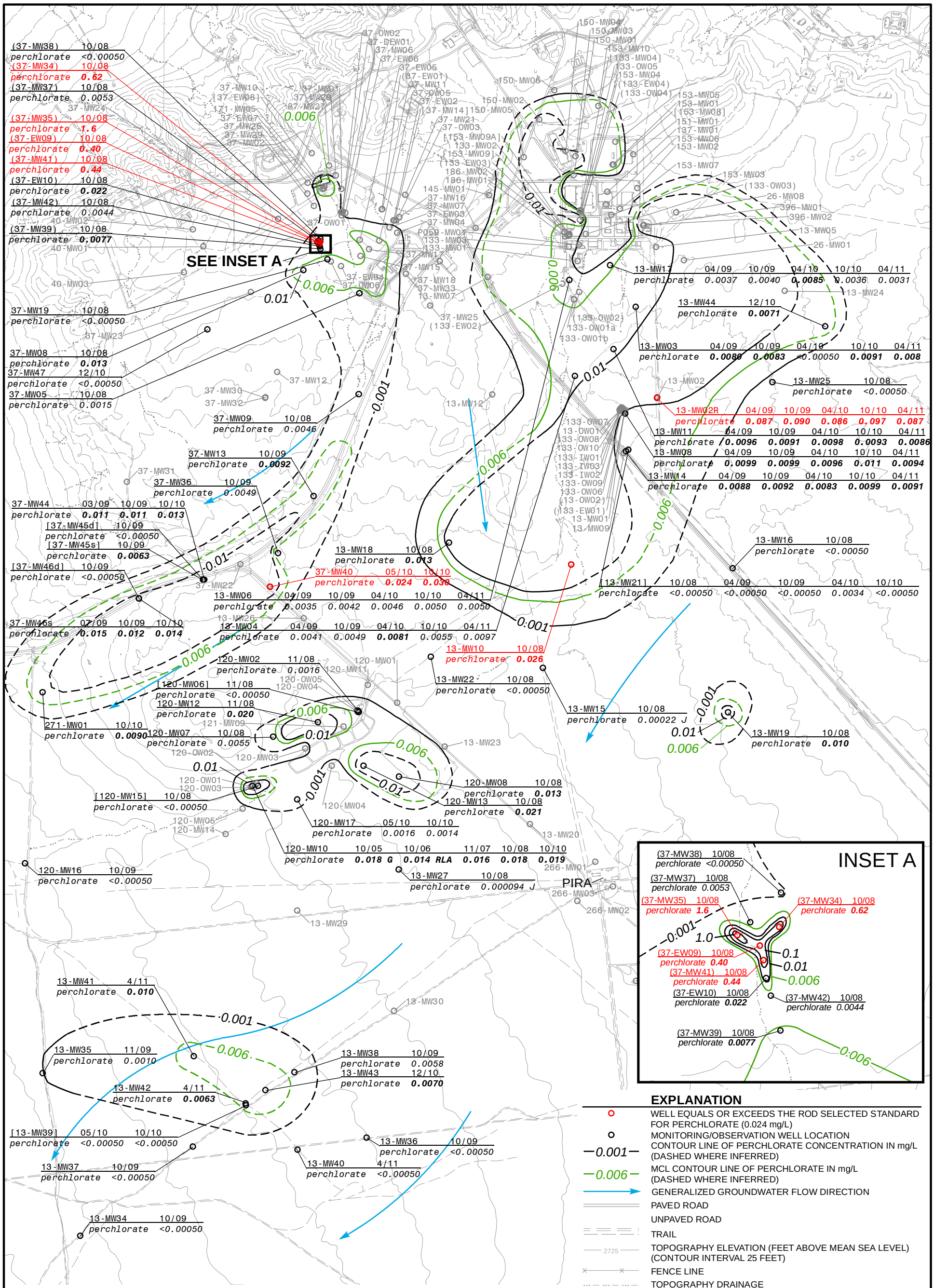

EXPLANATION

- WELL EQUALS OR EXCEEDS THE ROD SELECTED STANDARD FOR PERCHLORATE (0.024 mg/L)
- MONITORING/OBSERVATION WELL LOCATION
- 0.001 — CONTOUR LINE OF PERCHLORATE CONCENTRATION IN mg/L (DASHED WHERE INFERRED)
- 0.006 — MCL CONTOUR LINE OF PERCHLORATE IN mg/L (DASHED WHERE INFERRED)
- GENERALIZED GROUNDWATER FLOW DIRECTION
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- 2725 — TOPOGRAPHY ELEVATION (FEET ABOVE MEAN SEA LEVEL) (CONTOUR INTERVAL 25 FEET)
- FENCE LINE
- TOPOGRAPHY DRAINAGE
- [ ] VERTICAL EXTENT WELL. DATA NOT USED TO CONTOUR
- ( ) LARGE SCREENED INTERVAL. DATA NOT USED TO CONTOUR.

WELL LOCATION DATE
PARAMETER *VALUE (mg/L)*
(***BOLD*** *INDICATES VALUE OVER MCL FOR PERCHLORATE)*

ABBREVIATIONS

'	FOOT
<	LESS THAN
mg/L	MILLIGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
FYR	FIVE-YEAR REVIEW
MCL	MAXIMUM CONTAMINANT LEVEL (CALIFORNIA DEPARTMENT OF PUBLIC HEALTH 2011)
PIRA	PRECISION IMPACT RANGE AREA

LABORATORY-ASSIGNED DATA QUALIFIERS

J	ESTIMATED RESULT. RESULT IS LESS THAN THE REPORTING LIMIT.
RLA	ELEVATED REPORTING LIMIT. THE REPORTING LIMIT IS ELEVATED DUE TO SAMPLE DILUTION.

NOTE

1. GRAY SCALING INDICATES ANALYTE NOT SAMPLED DURING THE 2008-2010 SAMPLING EVENTS.

First FYR for South AFRL

Sites 37, 120, and 133 Estimated Perchlorate Plume Contours

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		3.0-4

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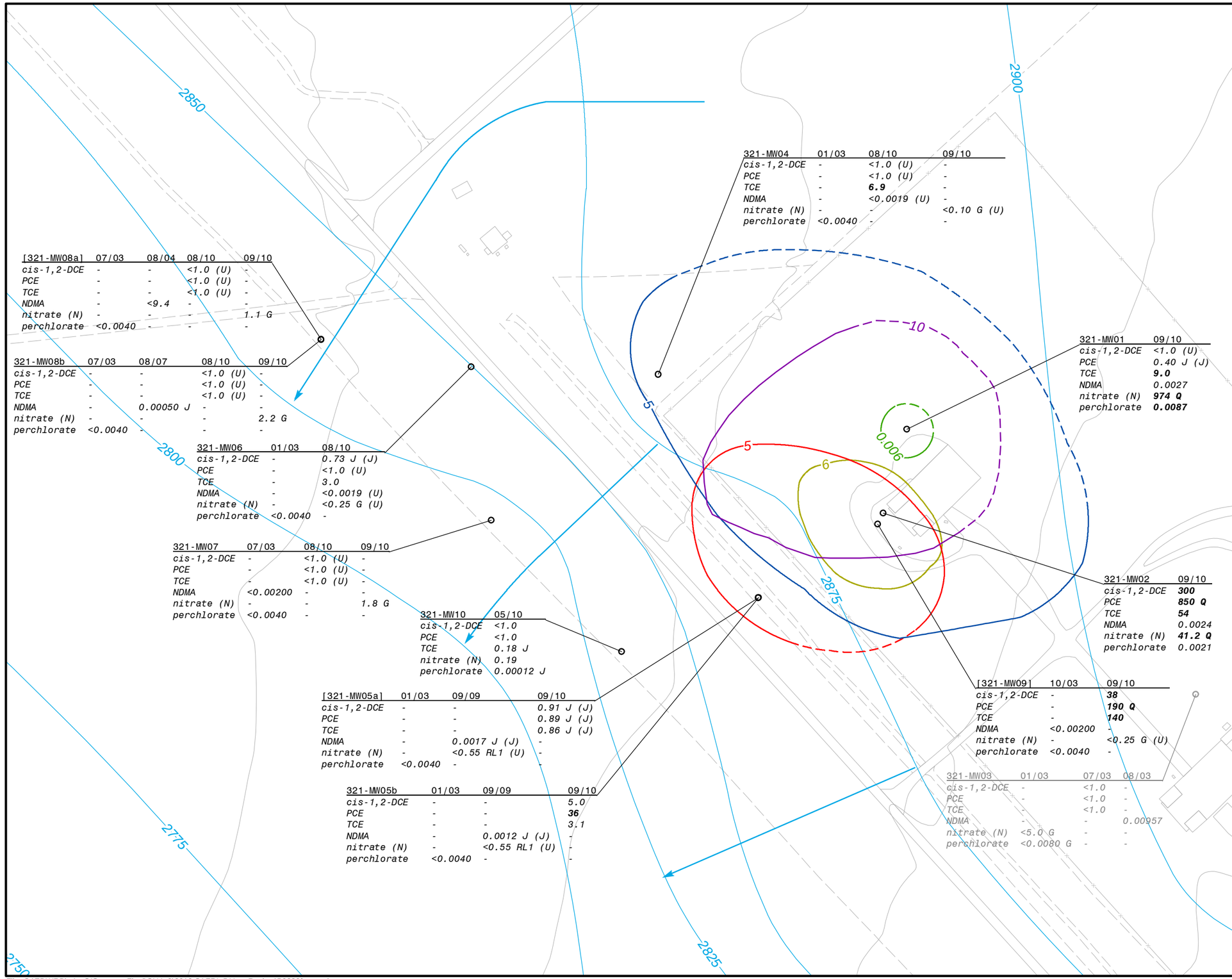

321-MW04	01/03	08/10	09/10
cis-1,2-DCE	-	<1.0 (U)	-
PCE	-	<1.0 (U)	-
TCE	-	**6.9**	-
NDMA	-	<0.0019 (U)	-
nitrate (N)	-	-	<0.10 G (U)
perchlorate	<0.0040	-	-

[321-MW08a]	07/03	08/04	08/10	09/10
cis-1,2-DCE	-	-	<1.0 (U)	-
PCE	-	-	<1.0 (U)	-
TCE	-	-	<1.0 (U)	-
NDMA	-	<9.4	-	-
nitrate (N)	-	-	-	1.1 G
perchlorate	<0.0040	-	-	-

321-MW08b	07/03	08/07	08/10	09/10
cis-1,2-DCE	-	-	<1.0 (U)	-
PCE	-	-	<1.0 (U)	-
TCE	-	-	<1.0 (U)	-
NDMA	-	0.00050 J	-	-
nitrate (N)	-	-	-	2.2 G
perchlorate	<0.0040	-	-	-

321-MW01	09/10
cis-1,2-DCE	<1.0 (U)
PCE	0.40 J (J)
TCE	**9.0**
NDMA	0.0027
nitrate (N)	**974 Q**
perchlorate	**0.0087**

321-MW06	01/03	08/10
cis-1,2-DCE	-	0.73 J (J)
PCE	-	<1.0 (U)
TCE	-	3.0
NDMA	-	<0.0019 (U)
nitrate (N)	-	<0.25 G (U)
perchlorate	<0.0040	-

321-MW07	07/03	08/10	09/10
cis-1,2-DCE	-	<1.0 (U)	-
PCE	-	<1.0 (U)	-
TCE	-	<1.0 (U)	-
NDMA	<0.00200	-	-
nitrate (N)	-	-	1.8 G
perchlorate	<0.0040	-	-

321-MW10	05/10
cis-1,2-DCE	<1.0
PCE	<1.0
TCE	0.18 J
nitrate (N)	0.19
perchlorate	0.00012 J

321-MW02	09/10
cis-1,2-DCE	**300**
PCE	**850 Q**
TCE	**54**
NDMA	0.0024
nitrate (N)	**41.2 Q**
perchlorate	0.0021

[321-MW05a]	01/03	09/09	09/10
cis-1,2-DCE	-	-	0.91 J (J)
PCE	-	-	0.89 J (J)
TCE	-	-	0.86 J (J)
NDMA	-	0.0017 J (J)	-
nitrate (N)	-	<0.55 RL1 (U)	-
perchlorate	<0.0040	-	-

[321-MW09]	10/03	09/10
cis-1,2-DCE	-	**38**
PCE	-	**190 Q**
TCE	-	**140**
NDMA	<0.00200	-
nitrate (N)	-	<0.25 G (U)
perchlorate	<0.0040	-

321-MW05b	01/03	09/09	09/10
cis-1,2-DCE	-	-	5.0
PCE	-	-	**36**
TCE	-	-	3.1
NDMA	-	0.0012 J (J)	-
nitrate (N)	-	<0.55 RL1 (U)	-
perchlorate	<0.0040	-	-

321-MW03	01/03	07/03	08/03
cis-1,2-DCE	-	<1.0	-
PCE	-	<1.0	-
TCE	-	<1.0	-
NDMA	-	-	0.00957
nitrate (N)	<5.0 G	-	-
perchlorate	<0.0080 G	-	-

EXPLANATION

- MONITORING/OBSERVATION WELL RECENTLY SAMPLED
- MONITORING/OBSERVATION WELL NOT RECENTLY SAMPLED
- MCL CONTOUR LINE OF TCE CONCENTRATION IN µg/L (DASHED WHERE INFERRED)
- MCL CONTOUR LINE OF PCE CONCENTRATION IN µg/L (DASHED WHERE INFERRED)
- MCL CONTOUR LINE OF PERCHLORATE CONCENTRATION IN mg/L
- MCL CONTOUR LINE OF CIS-1,2-DCE IN µg/L
- MCL CONTOUR LINE OF NITRATE (AS N) IN mg/L (DASHED WHERE INFERRED)
- GROUNDWATER ELEVATION CONTOUR (OCTOBER 2010) 25-FOOT INTERVALS (FEET ABOVE MEAN SEA LEVEL)
- GENERALIZED GROUNDWATER FLOW DIRECTION
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- RAILROAD
- 2725 — TOPOGRAPHY ELEVATION (FEET ABOVE MEAN SEA LEVEL) (CONTOUR INTERVAL 25 FEET)
- FENCE LINE
- TOPOGRAPHY DRAINAGE
- [ ] VERTICAL EXTENT WELL; DATA NOT USED TO CONTOUR.

WELL LOCATION DATE
PARAMETER VALUE (µg/L OR mg/L)
(BOLD INDICATES VALUE OVER MCL/NL FOR ANALYTE)

ABBREVIATIONS

<	LESS THAN
µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
DCE	DICHLOROETHENE
FYR	FIVE-YEAR REVIEW
MCL	MAXIMUM CONTAMINANT LEVEL (CALIFORNIA DEPARTMENT OF PUBLIC HEALTH 2011)
MDL	METHOD DETECTION LIMIT
mg/L	MILLIGRAMS PER LITER
N	NITROGEN
NDMA	N-NITROSODIMETHYLAMINE
NL	NOTIFICATION LEVEL (CALIFORNIA DEPARTMENT OF PUBLIC HEALTH 2010)
PCE	TETRACHLOROETHENE
RL	REPORTING LIMIT
TCE	TRICHLOROETHENE

LABORATORY-ASSIGNED DATA QUALIFIERS

G	ELEVATED REPORTING LIMIT. THE REPORTING LIMIT IS ELEVATED DUE TO MATRIX INTERFERENCE.
J	ESTIMATED VALUE. ANALYTE DETECTED AT A LEVEL LESS THAN THE RL AND GREATER THAN OR EQUAL TO THE MDL. THE USER OF THIS DATA SHOULD BE AWARE THAT THIS DATA IS OF LIMITED RELIABILITY.
Q	ELEVATED REPORTING LIMIT. THE REPORTING LIMIT IS ELEVATED DUE TO HIGH ANALYTE LEVELS.
RL1	REPORTING LIMIT RAISED DUE TO SAMPLE MATRIX EFFECTS.

DATA VALIDATION QUALIFIERS

(J)	ANALYTE WAS PRESENT BUT REPORTED VALUE MAY NOT BE ACCURATE OR PRECISE. (JT3 QUALIFIER)
(U)	ANALYTE WAS ANALYZED FOR BUT NOT DETECTED AT THE SPECIFIED DETECTION LIMIT. (JT3 QUALIFIER)

NORTH

0 100 200 Feet
1 " = 200 '

First FYR for South AFRL

Site 321
Estimated Plume Contours

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		3.0-5

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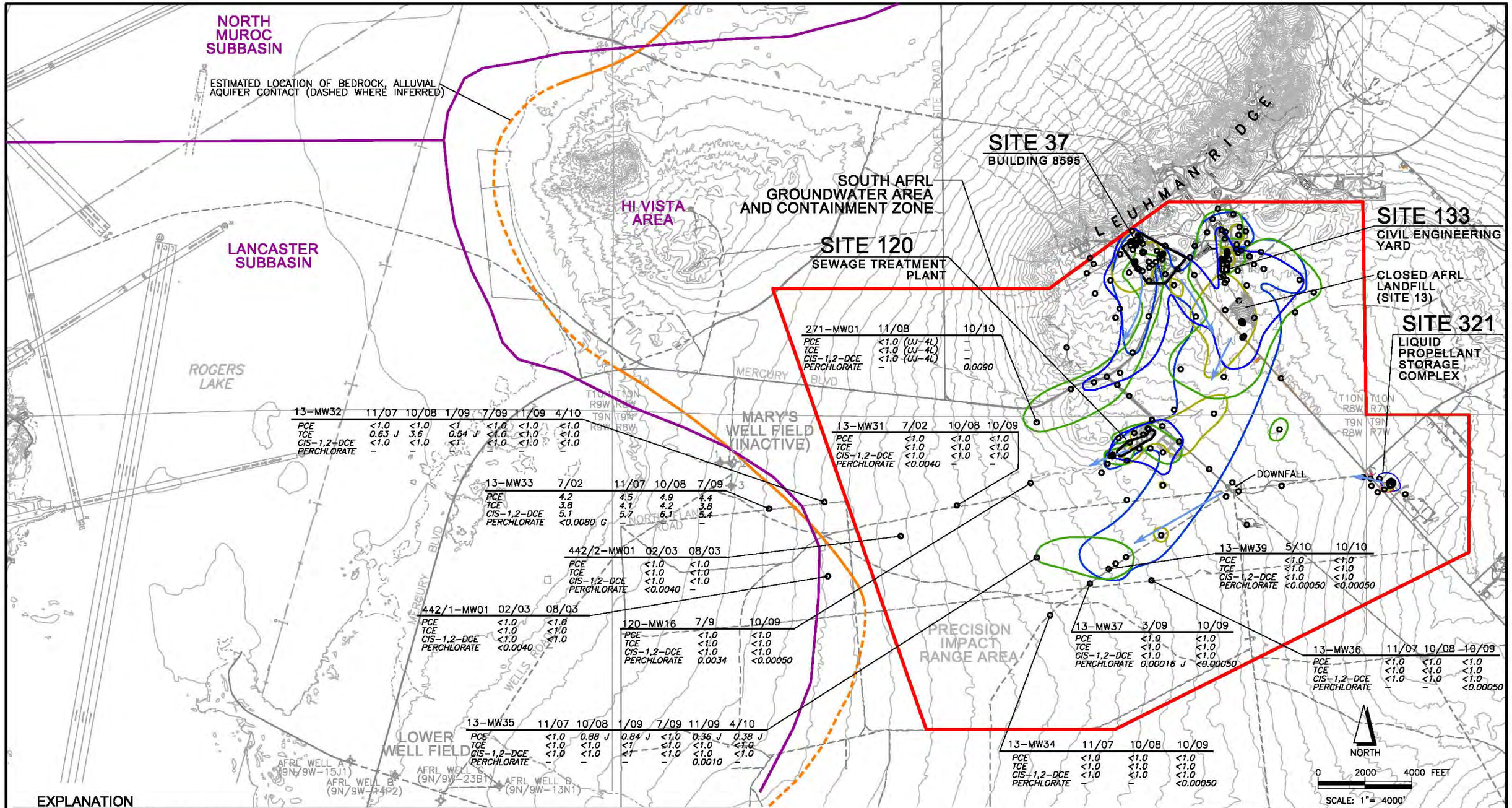

EXPLANATION

- EXTRACTION/INJECTION/MONITORING/OBSERVATION WELL LOCATION
- GROUNDWATER PRODUCTION WELL (ACTIVE OR INACTIVE)
- CONTOUR LINE OF TCE CONCENTRATION IN 1 µg/L
- CONTOUR LINE OF PCE CONCENTRATION IN 1 µg/L
- CONTOUR LINE OF CIS-1,2-DCE CONCENTRATION IN 1 µg/L
- CONTOUR LINE OF PERCHLORATE CONCENTRATION IN 0.001 mg/L
- GENERALIZED GROUNDWATER FLOW DIRECTION
- SITE BOUNDARY
- SOUTH AFRL CZ BOUNDARY
- BASIN BOUNDARIES (SEE NOTE 1)
- ESTIMATED BEDROCK TO ALLUVIAL AQUIFER TRANSITION (DASHED WHERE INFERRED)

µg/L	MICROGRAMS PER LITER
mg/L	MILLIGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
BLVD	BOULEVARD
CZ	CONTAINMENT ZONE
DCE	DICHLOROETHENE
FYR	FIVE-YEAR REVIEW
PCE	TETRACHLOROETHENE
TCE	TRICHLOROETHENE
USGS	UNITED STATES GEOLOGICAL SURVEY

NOTES

1. BOUNDARIES OF NORTH MUROC AND LANCASTER SUBBASINS FROM USGS 2005 FACT SHEET AS ADAPTED FROM CARLSON ET AL. (1998) BASED ON GEOPHYSICAL EVIDENCE.

First FYR for South AFRL

Approximate Extent of Impacted Groundwater within the South AFRL CZ

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		3.1-1

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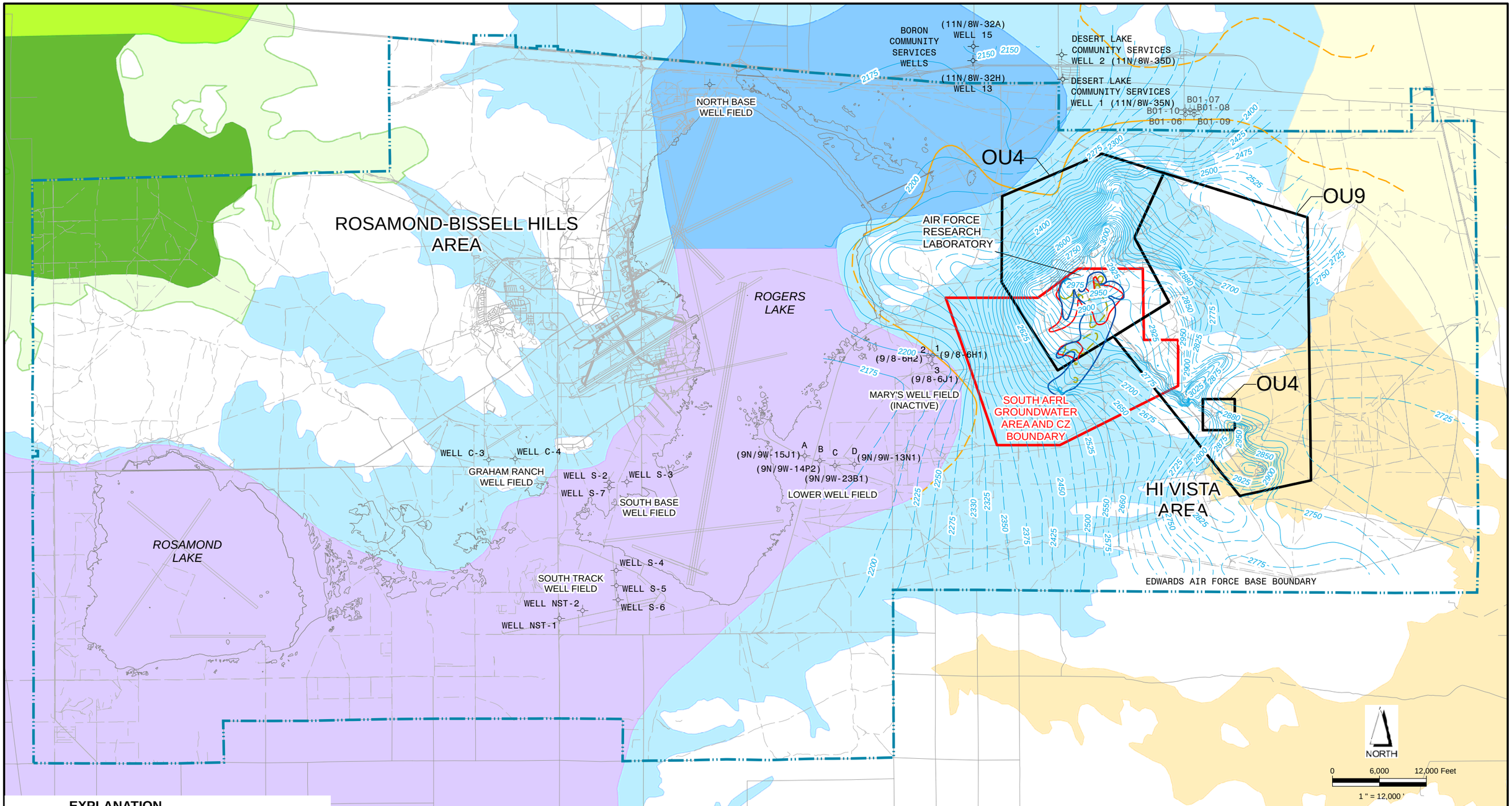

EXPLANATION

- WATER SUPPLY WELL
- ESTIMATED BEDROCK TO ALLUVIAL AQUIFER TRANSITION (DASHED WHERE INFERRED)
- 1 µg/L CONCENTRATION CONTOUR LINE FOR TCE (DASHED WHERE INFERRED)
- 1 µg/L CONCENTRATION CONTOUR LINE FOR PCE (DASHED WHERE INFERRED)
- 1 µg/L CONCENTRATION CONTOUR LINE FOR CIS-1,2-DCE (DASHED WHERE INFERRED)
- 2400 GROUNDWATER ELEVATION CONTOUR (APRIL, 2010) (FEET ABOVE MEAN SEA LEVEL)
- SOUTH AFRL CONTAINMENT ZONE

ABBREVIATIONS

µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
CZ	CONTAINMENT ZONE
DCE	DICHLOROETHENE
DWR	DEPARTMENT OF WATER RESOURCES
FYR	FIVE-YEAR REVIEW
OU	OPERABLE UNIT
PCE	TETRACHLOROETHENE
TCE	TRICHLOROETHENE
USGS	UNITED STATES GEOLOGICAL SURVEY

NOTES

1. HYDROLOGIC UNITS BASED ON DWR BULLETIN 118 (DWR 2003).
2. USGS SUBBASIN BOUNDARIES FROM USGS OPEN FILE REPORT (CARLSON ET AL. 1998)
3. WHITE ZONES DENOTE PLUTONIC ROCK AREAS.

6-44 ANTELOPE VALLEY BASIN (DWR)

- RECHARGE AREA (DWR)
- LANCASTER SUBBASIN (USGS)
- NORTH MUROC SUBBASIN (USGS)

6-46 FREMONT VALLEY BASIN (DWR)

- RECHARGE AREA (DWR)
- GLOSTER SUBBASIN (USGS)
- CHAFFEE SUBBASIN (USGS)

6-41 MIDDLE MOJAVE RIVER VALLEY BASIN (DWR)

- RECHARGE AREA (DWR)

6-47 HARPER VALLEY BASIN (DWR)

- RECHARGE AREA (DWR)

First FYR for South AFRL

Antelope Valley and Vicinity Hydrologic Basins and USGS Subbasins

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		3.1-2

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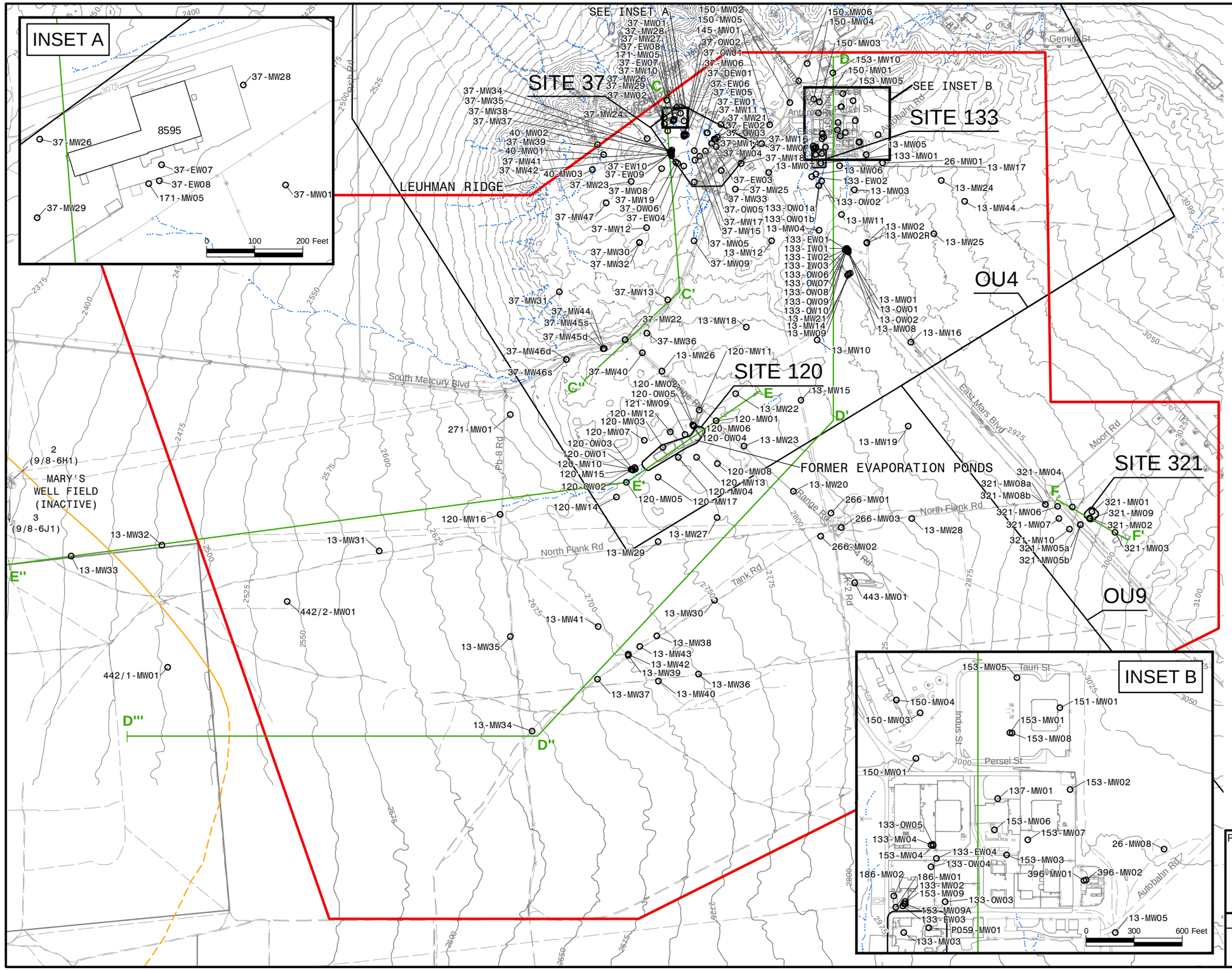

EXPLANATION

- EXTRACTION/INJECTION/MONITORING/OBSERVATION WELL LOCATION
- ESTIMATED BEDROCK TO ALLUVIAL AQUIFER TRANSITION (DASHED WHERE INFERRED)
- APPROXIMATE SOUTH AFRL TRANSPORT MODEL AREA
- CROSS SECTION LINE (SHOWN ON FIGURES 3.1-5 THROUGH 3.1-8)
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- 2600 TOPOGRAPHY CONTOUR
- TOPOGRAPHY DRAINAGE

ABBREVIATIONS

AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
BLVD	BOULEVARD
FYR	FIVE-YEAR REVIEW
GW	GROUNDWATER
OU	OPERABLE UNIT
RD	ROAD
ST	STREET

NORTH

0 1,250 2,500 Feet

1 " = 2,500 '

First FYR for South AFRL

South AFRL Surface Topography and Groundwater Monitoring Wells

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		3.1-3

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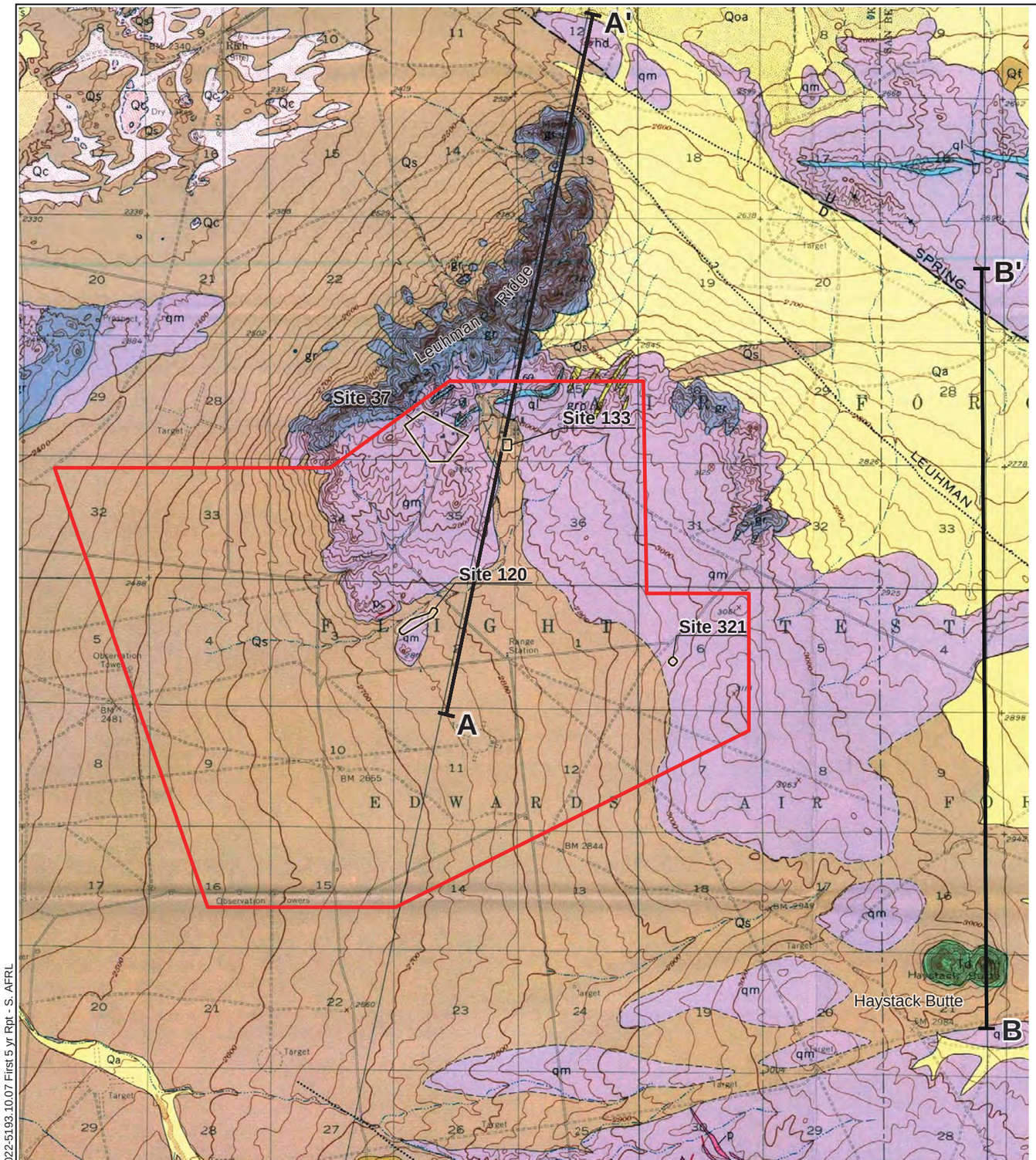
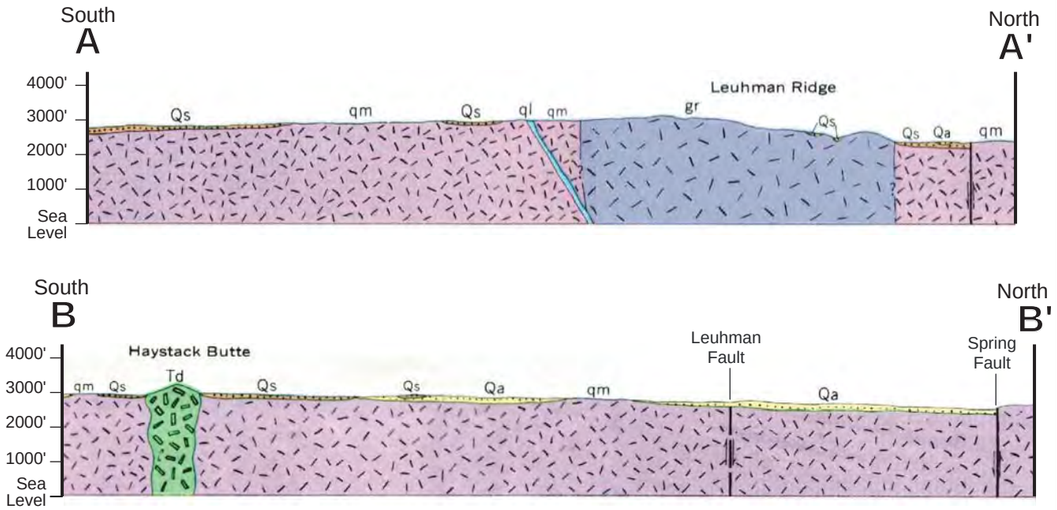




EXPLANATION

SEDIMENTARY AND VOLCANIC ROCKS

- Qa — Alluvium (Holocene)
- Qc — Pleistocene non-marine
- Qcs — Playa clay and windblown sand
- Qs — Windblown sand
- Qoa — Older Alluvium
- Qf — Fanglomerate
- Td — Dacite

DIKE ROCKS

- ql — Quartz Latite

PLUTONIC ROCKS

- gr — Granite
- p — Dikes of Pegmatite and Aplite
- qm — Quartz Monzonite
- hd — Hornblende Diorite
- grp — Complex of granitic and Pegmatite-Aplite dikes

- South AFRL Containment Zone
- AFB — Air Force Base
- AFRL — Air Force Research Laboratory
- FYR — Five-Year Review

U FAULT D — Fault line, dashed where indefinite; dotted where concealed and inferred.
U = Upthrown side
D = Downthrown side

North

0 1 2 3 miles

Scale Contour Interval: 25 feet

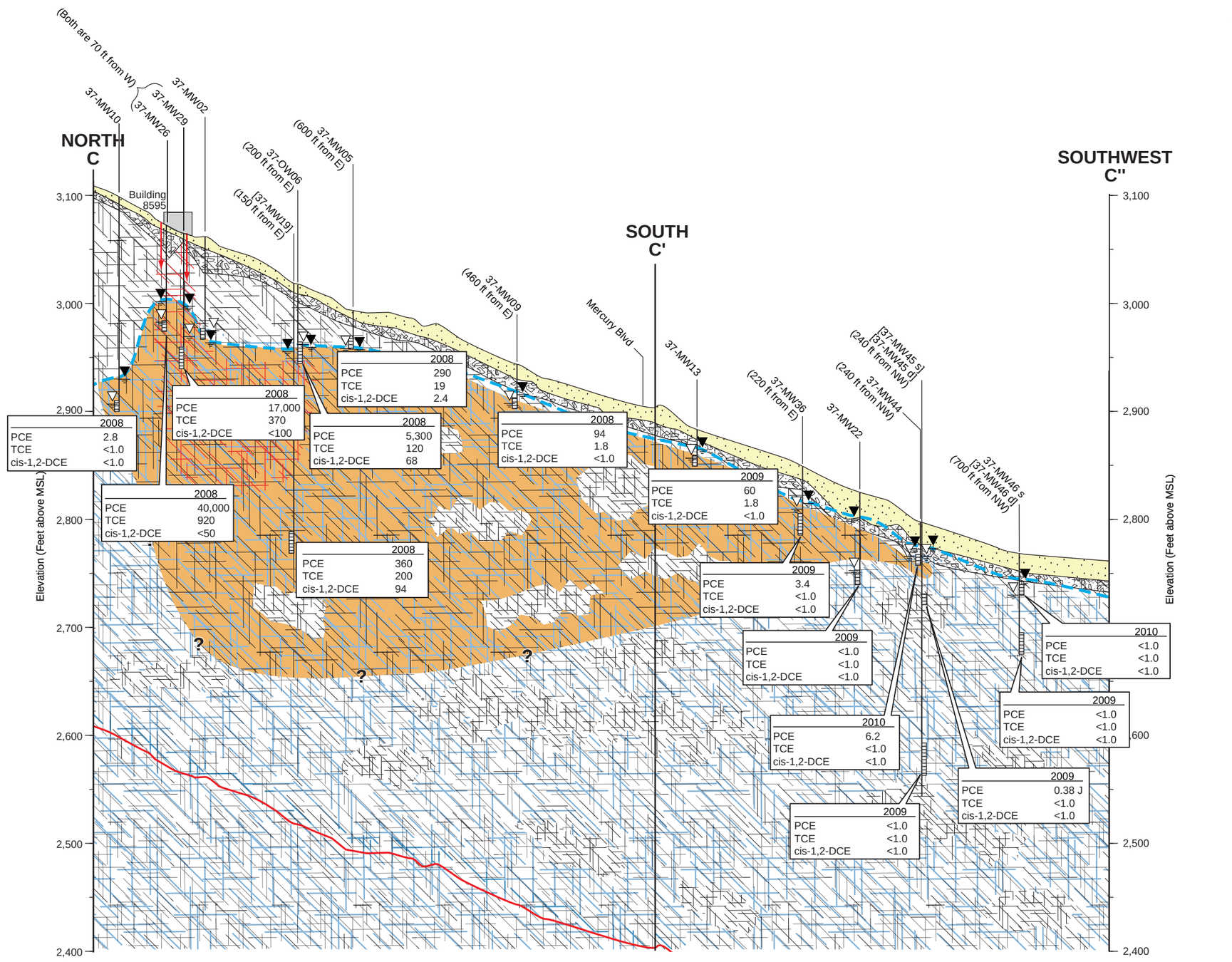
Modified from Dibblee (1960)

First FYR for South AFRL

Geologic Map of the AFRL, Edwards AFB

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure 3.1-4
Project No. 60225193		

6022-5193.10.07 First 5 yr Rpt - S. AFRL



Explanation

- Potentiometric surface elevation October 2010
- Static Groundwater level October 2010
- Groundwater first encountered
- Well screen
- [ ] Vertical extent well
- Unconsolidated sediment
- Weathered/fractured bedrock
- Fractured/competent bedrock - no water-filled fractures
- Fractured/competent bedrock - with water-filled fractures (Groundwater confined to connective fractures)
- Residual DNAPL filled fractures (Conceptual)
- Conceptual distribution of dissolved contaminants within the fracture network
- Possible initial pathway of contaminant migration to deeper water-bearing fractures
- South AFRL Containment Zone
- ? Extent either inferred or unknown
- < Less than
- AFB Air Force Base
- AFRL Air Force Research Laboratory
- Blvd Boulevard
- d Deep
- DCE Dichloroethene
- DNAPL Dense Non-Aqueous Phase Liquid
- E East
- ft Feet
- FYR Five-Year Review
- MSL Mean Sea Level
- NW Northwest
- s Shallow
- PCE Tetrachloroethene
- TCE Trichloroethene
- W West

Laboratory Data Qualifier

J Estimated result. Result is less than the reporting limit.

Notes:

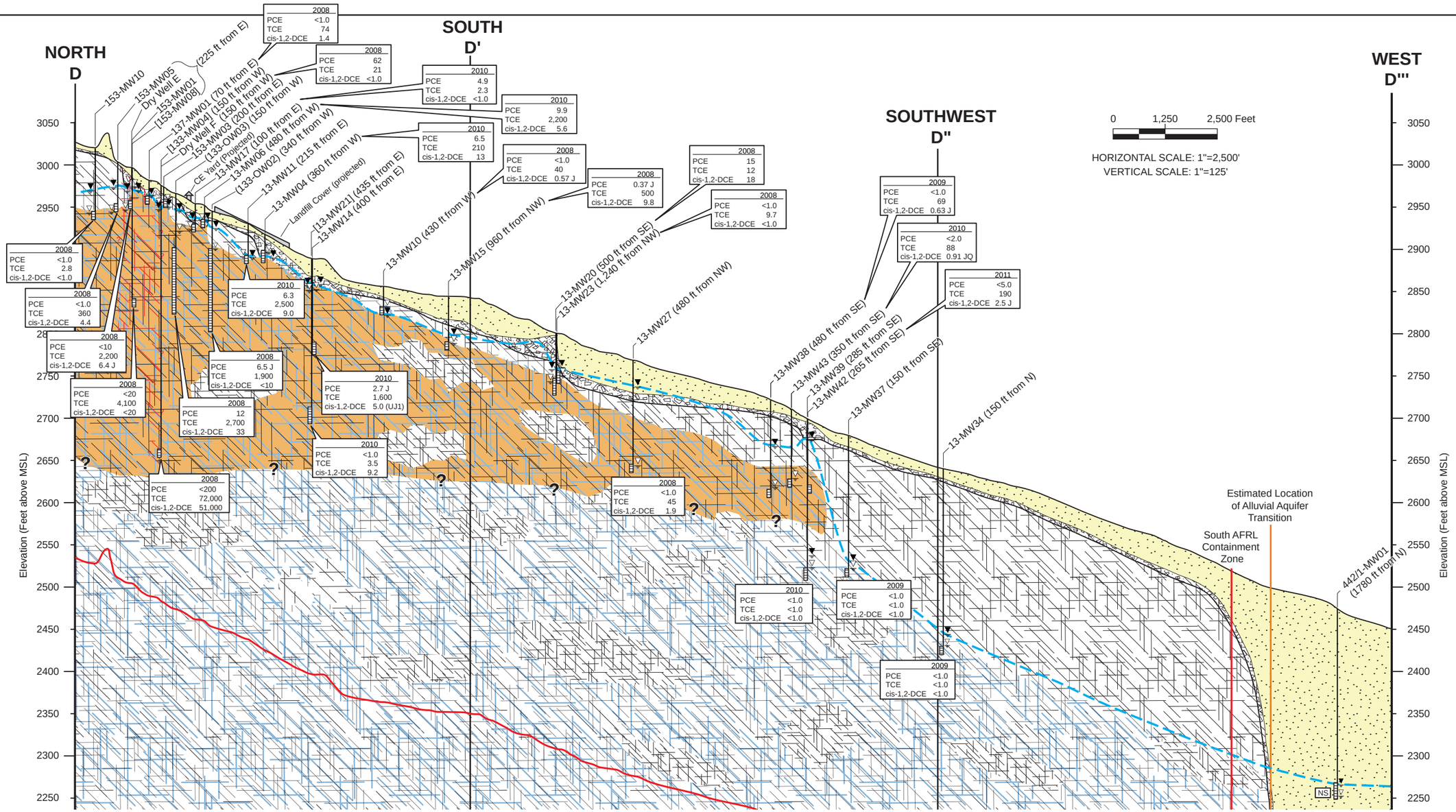
1) PCE, TCE, and cis-1,2-DCE concentrations are in micrograms per liter.
2) Distance and direction to the cross section line for projected wells are shown in parentheses.
3) Location of cross section line is shown on Figure 3.1-3.

First FYR for South AFRL

South AFRL Conceptual Site Model Cross Section C-C'-C" (Site 37)

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		3.1-5

6022-5193.10.07 First 5 yr Rpt - S. AFRL



Explanation

- Potentiometric surface elevation October 2010
- Static Groundwater level October 2010
- Groundwater first encountered
- Well screen
- [ ] Vertical extent well
- ( ) Large Screened Interval
- Unconsolidated Sediment
- Weathered/fractured bedrock
- Fractured/competent bedrock - no water-filled fractures
- Fractured/competent bedrock - with water-filled fractures (Groundwater confined to connected fractures)
- Residual DNAPL filled fractures (Conceptual)
- Conceptual distribution of dissolved contaminants within the fracture network
- Inferred bedrock to alluvial aquifer transition
- South AFRL Containment Zone

?	Extent either inferred or unknown
<	Less than
AFB	Air Force Base
AFRL	Air Force Research Laboratory
CE	Civil Engineering
DCE	Dichloroethene
DNAPL	Dense Non-Aqueous Phase Liquid
E	East
ft	Feet
FYR	Five-Year Review
MSL	Mean Sea Level
N	North
NS	Not Sampled
NW	Northwest
PCE	Tetrachloroethene
SE	Southeast
TCE	Trichloroethene
W	West

Notes:

1) PCE, TCE, and cis-1,2-DCE concentrations are in micrograms per liter.
2) Distance and direction to the cross section line for projected wells are shown in parentheses.
3) Location of cross section line is shown on Figure 3.1-3.

Laboratory Data Qualifier

J	Estimated result. Result is less than the reporting limit.
Q	Elevated reporting limit. The reporting limit is elevated due to high analyte levels.

Validation Data Qualifier

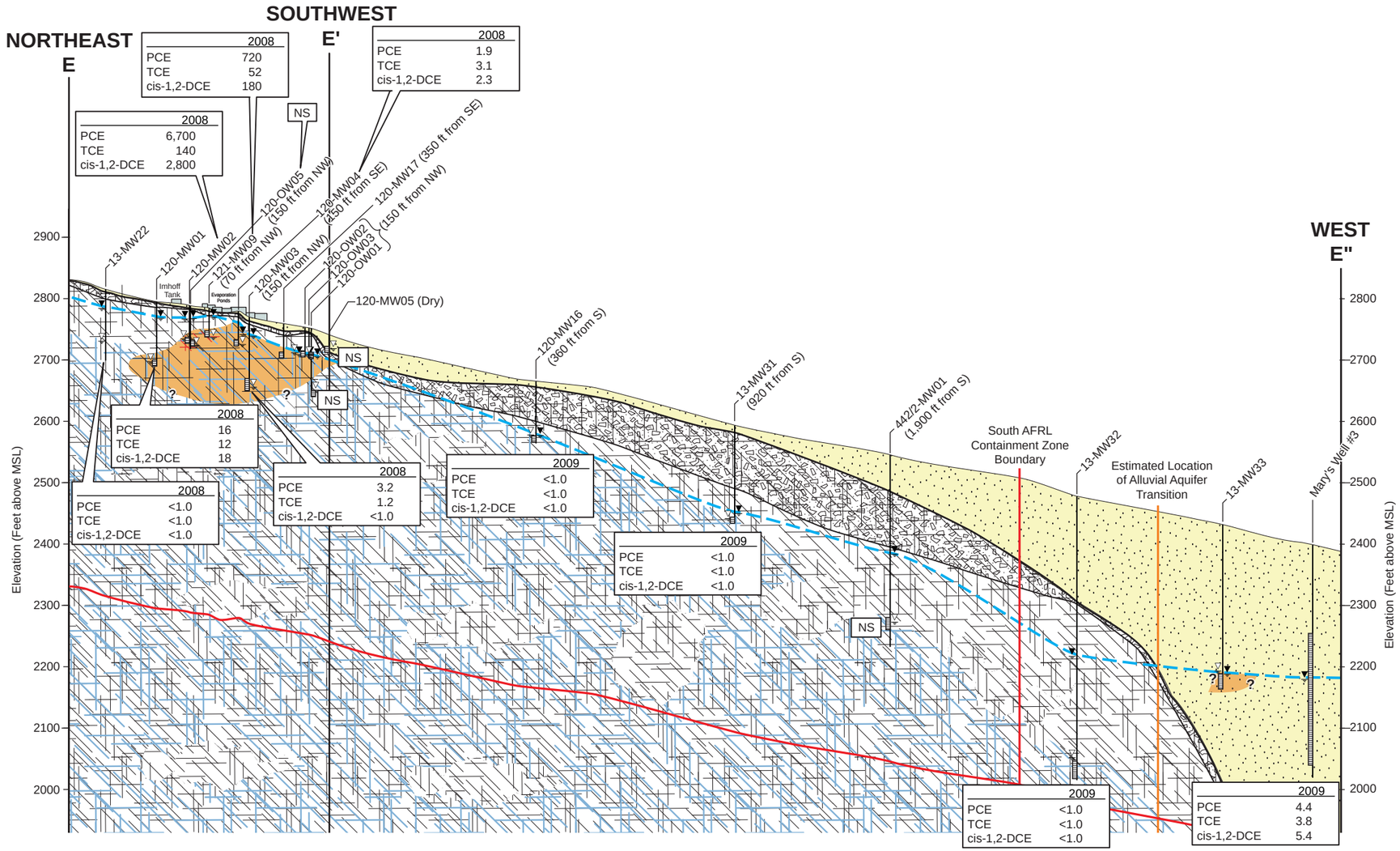
(UJ1)	Estimated value. Blank contamination: the value in the laboratory blank is below the reporting limit. Indicates possible high bias and/or false positive.

First FYR for South AFRL

South AFRL Conceptual Site Model Cross Section D-D'-D"-D''' (Site 133)

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure 3.1-6
Project No. 60225193		

6022-5193.10.07 First 5 yr Rpt - S. AFRL



Explanation

- Potentiometric surface elevation October 2010
- Static groundwater level October 2010
- Groundwater first encountered
- Well screen
- Unconsolidated sediment
- Weathered/fractured bedrock
- Fractured/competent bedrock - no water-filled fractures
- Fractured/competent bedrock - with water-filled fractures (Groundwater confined to connected fractures)
- Residual DNAPL filled fractures (Conceptual)
- Conceptual distribution of dissolved contaminants within the fracture network
- Inferred bedrock to alluvial aquifer transition
- South AFRL Containment Zone
- ? Extent either inferred or unknown
- < Less than
- AFB Air Force Base
- AFRL Air Force Research Laboratory
- DCE Dichloroethene
- DNAPL Dense Non-Aqueous Phase Liquid
- ft Feet
- FYR Five-Year Review
- MSL Mean Sea Level
- NS Not Sampled
- NW Northwest
- PCE Tetrachloroethene
- S South
- SE Southeast
- TCE Trichloroethene

0 1,000 2,000 FEET

HORIZONTAL SCALE: 1"=2,000'
VERTICAL SCALE: 1"=200'

Notes:

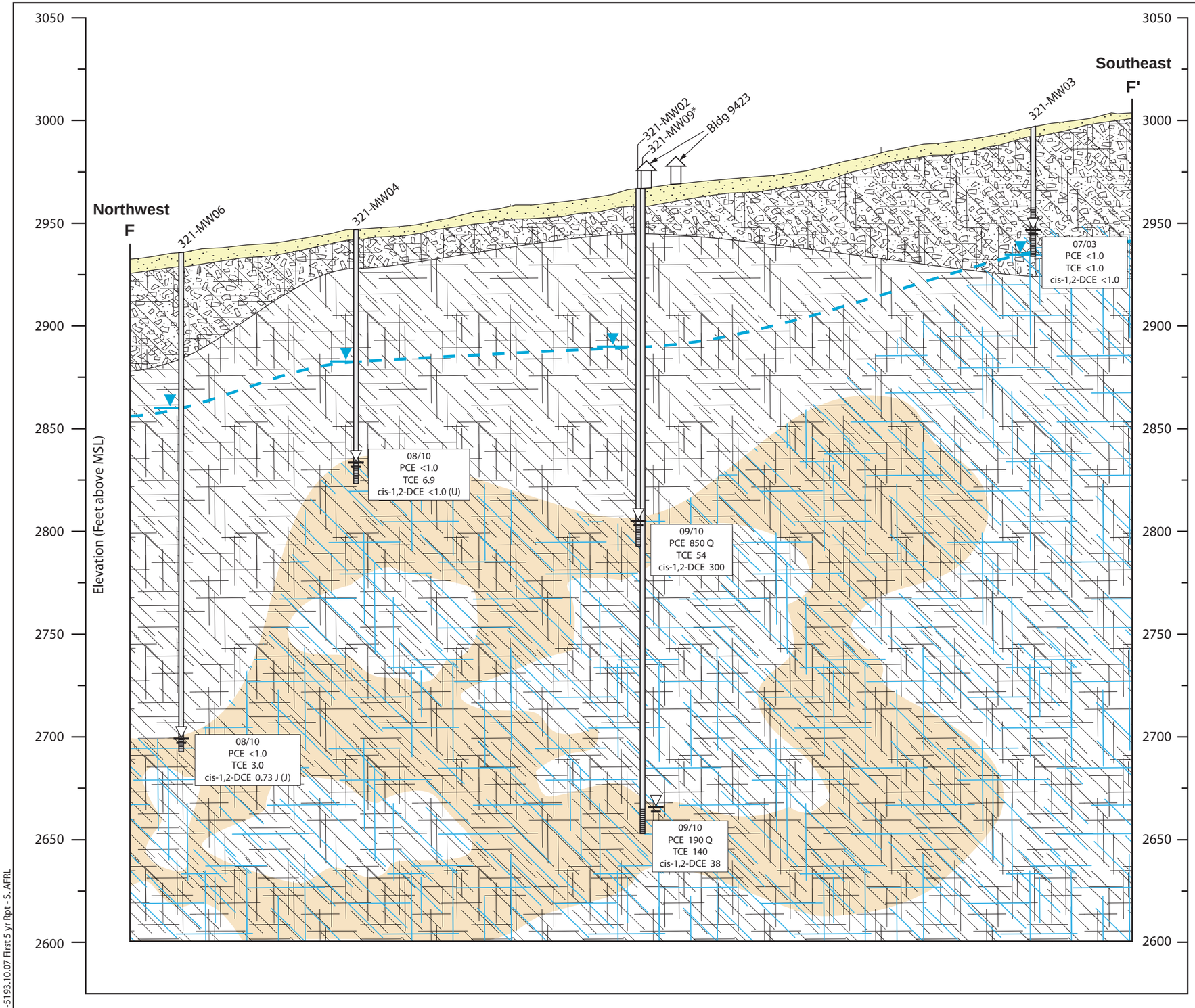
1) PCE, TCE, and cis-1,2-DCE concentrations are in micrograms per liter.
2) Distance and direction to the cross section line for projected wells are shown in parentheses.
3) Location of cross section line is shown on Figure 3.1-3.

First FYR for South AFRL

South AFRL Conceptual Site Model Cross Section E-E'-E'' (Site 120)

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure 3.1-7
Project No. 60225193		

6022-5193.10.07 First 5 yr Rpt - S. AFRL



Explanation

- Groundwater encountered
- Potentiometric surface elevation 10/11
- Unconsolidated sediment
- Weathered/fractured bedrock
- Fractured/competent bedrock - no water-filled fractures
- Fractured/competent bedrock - with water-filled fractures (Groundwater confined to connective fractures)
- Conceptual distribution of dissolved contaminants within the fracture network

1st	First
AFB	Air Force Base
AFRL	Air Force Research Laboratory
Bldg	building
DCE	Dichloroethene
ft	feet
FYR	Five-Year Review
MSL	mean sea level
PCE	tetrachloroethene
TCE	trichloroethene

*Vertical extent monitoring well. Well screened at least 100 ft below 1st encountered groundwater and not included in generating potentiometric surface elevation.

Laboratory-Assigned Data Qualifiers

J	Estimated result. Result is less than the reporting limit.
Q	Reporting limit raised due to high level of another analyte in the sample. The qualifier applies to all analytes in the sample.

Data Validation Qualifiers

(J)	Analyte was present but reported value may not be accurate or precise.
(U)	Analyte was analyzed for but not detected at the specified detection limit.

Notes:

1) PCE, TCE, and cis-1,2-DCE concentrations are in micrograms per liter.
2) Location of cross section line is shown on Figure 3.1-3.
3) Adapted from Figure A.2-8 of the South AFRL Remedial Action Work Plan (Earth Tech 2009a).

0 500 1000 FEET

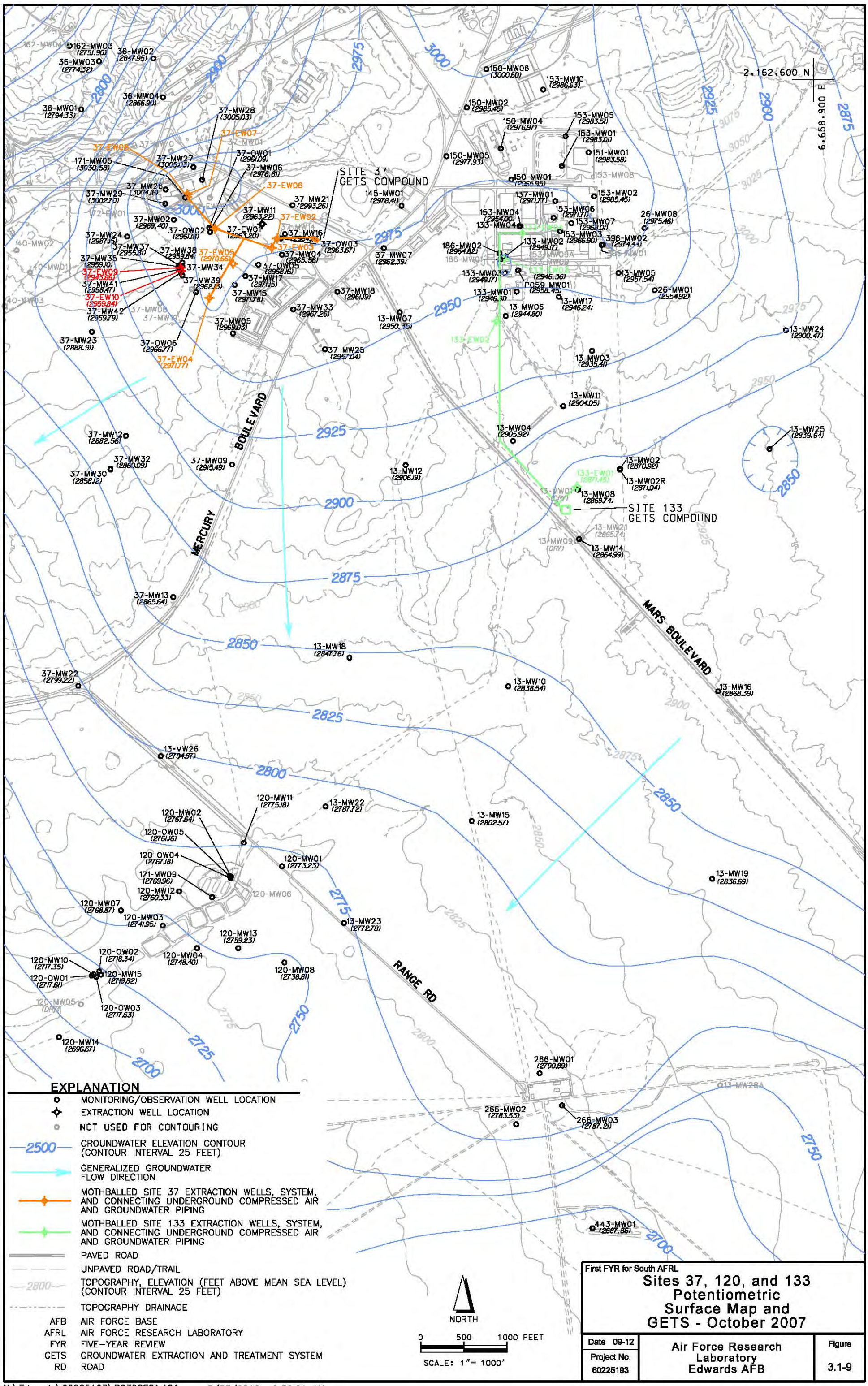
HORIZONTAL SCALE: 1"=1000'
VERTICAL SCALE: 1"=50'

First FYR for South AFRL

South AFRL Conceptual Site Model Cross Section F-F' (Site 321)

Date 09-12 Project No. 60225193	Air Force Research Laboratory Edwards AFB	Figure **3.1-8**

6022-5193.10.07 First 5 yr Rpt - S. AFRL



EXPLANATION

- MONITORING/OBSERVATION WELL LOCATION
- EXTRACTION WELL LOCATION
- NOT USED FOR CONTOURING
- 2500 — GROUNDWATER ELEVATION CONTOUR (CONTOUR INTERVAL 25 FEET)
- GENERALIZED GROUNDWATER FLOW DIRECTION
- MOTHBALLED SITE 37 EXTRACTION WELLS, SYSTEM, AND CONNECTING UNDERGROUND COMPRESSED AIR AND GROUNDWATER PIPING
- MOTHBALLED SITE 133 EXTRACTION WELLS, SYSTEM, AND CONNECTING UNDERGROUND COMPRESSED AIR AND GROUNDWATER PIPING
- PAVED ROAD
- UNPAVED ROAD/TRAIL
- 2800 — TOPOGRAPHY, ELEVATION (FEET ABOVE MEAN SEA LEVEL) (CONTOUR INTERVAL 25 FEET)
- TOPOGRAPHY DRAINAGE

AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
FYR	FIVE-YEAR REVIEW
GETS	GROUNDWATER EXTRACTION AND TREATMENT SYSTEM
RD	ROAD

NORTH

0 500 1000 FEET

SCALE: 1"= 1000'

First FYR for South AFRL

Sites 37, 120, and 133 Potentiometric Surface Map and GETS - October 2007

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		3.1-9

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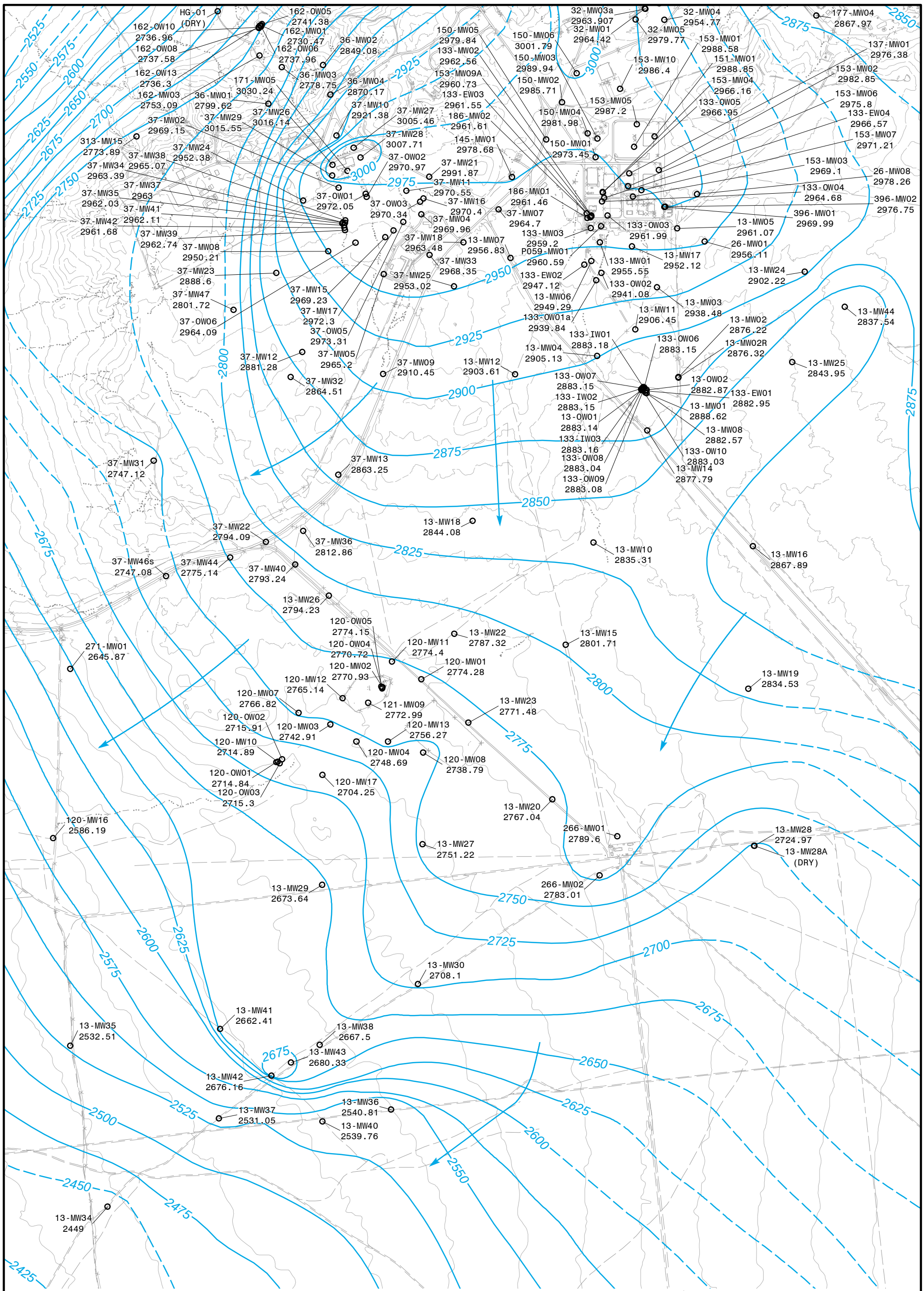

EXPLANATION

- MONITORING/OBSERVATION WELL LOCATION
- 2850 — GROUNDWATER ELEVATION CONTOUR (CONTOUR INTERVAL 25 FEET) (DASHED WHERE APPROXIMATE)
- GENERALIZED GROUNDWATER FLOW DIRECTION
- PAVED ROAD
- UNPAVED ROAD
- 2725 — TOPOGRAPHY ELEVATION (FEET ABOVE MEAN SEA LEVEL) (CONTOUR INTERVAL 25 FEET)
- TRAIL
- FENCE LINE
- TOPOGRAPHY DRAINAGE
- [ ] VERTICAL EXTENT WELL. DATA NOT USED TO CONTOUR

ABBREVIATIONS

AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
FYR	FIVE-YEAR REVIEW

First FYR for South AFRL

South AFRL Potentiometric Surface Map October 2011

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		3.1-10

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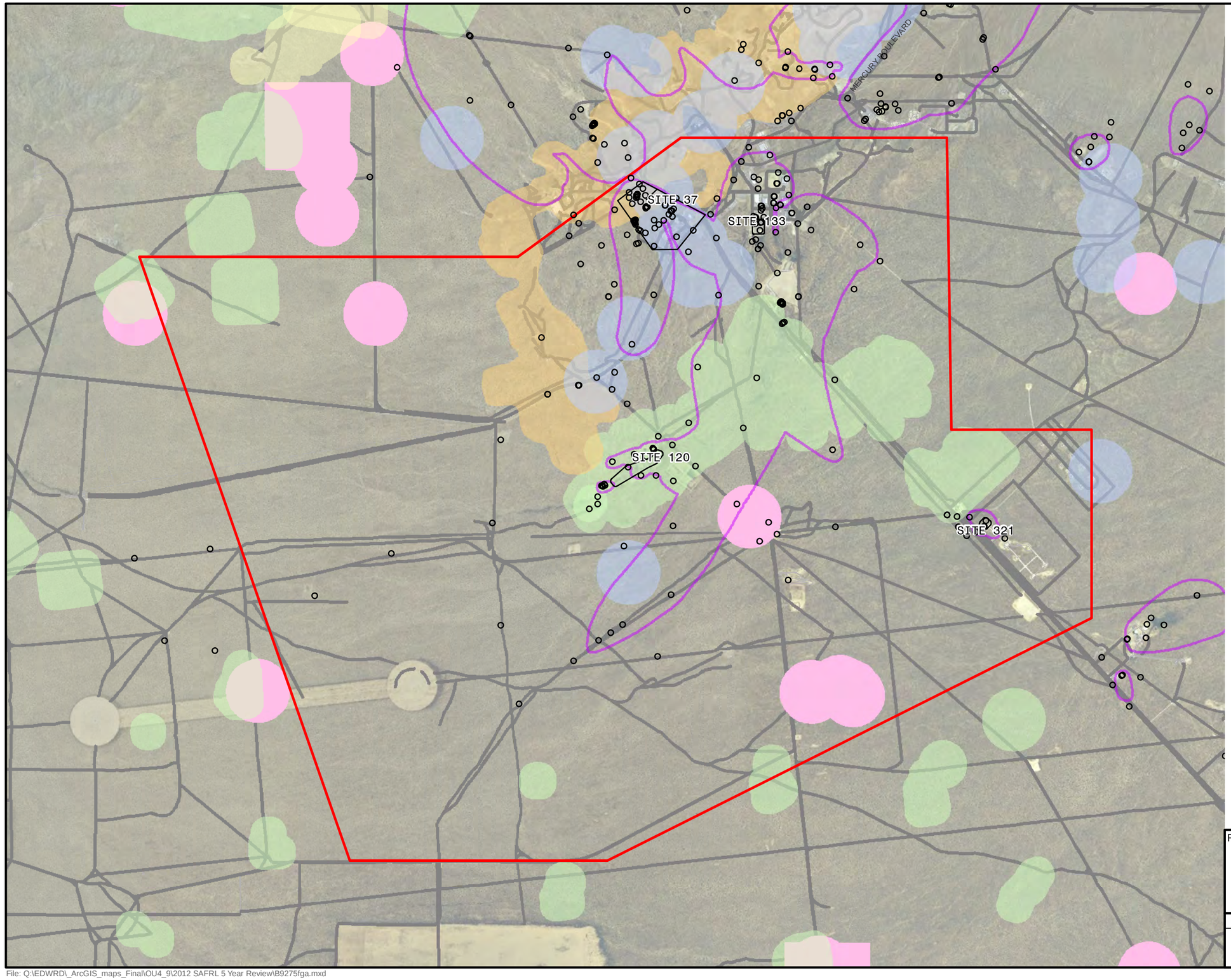

EXPLANATION

- EXISTING MONITORING/OBSERVATION WELL
- SOUTH AFRL CONTAINMENT ZONE BOUNDARY
- BARSTOW WOOLLY SUNFLOWER
- CHUCKWALLA HABITAT
- DESERT CYMOPTERUS
- DESERT TORTOISE
- MOHAVE GROUND SQUIRREL
- ROADS/TRAILS
- GROUNDWATER TOTAL COMBINED 2011 CONTAMINATION PLUME
- SITE BOUNDARY

ABBREVIATIONS

AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
FYR	FIVE-YEAR REVIEW

NORTH

0 1,500 3,000 Feet

1 " = 3,000 '

First FYR for South AFRL

South AFRL Containment Zone, Sensitive Natural Resources, and Monitoring Well Locations

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		3.1-11

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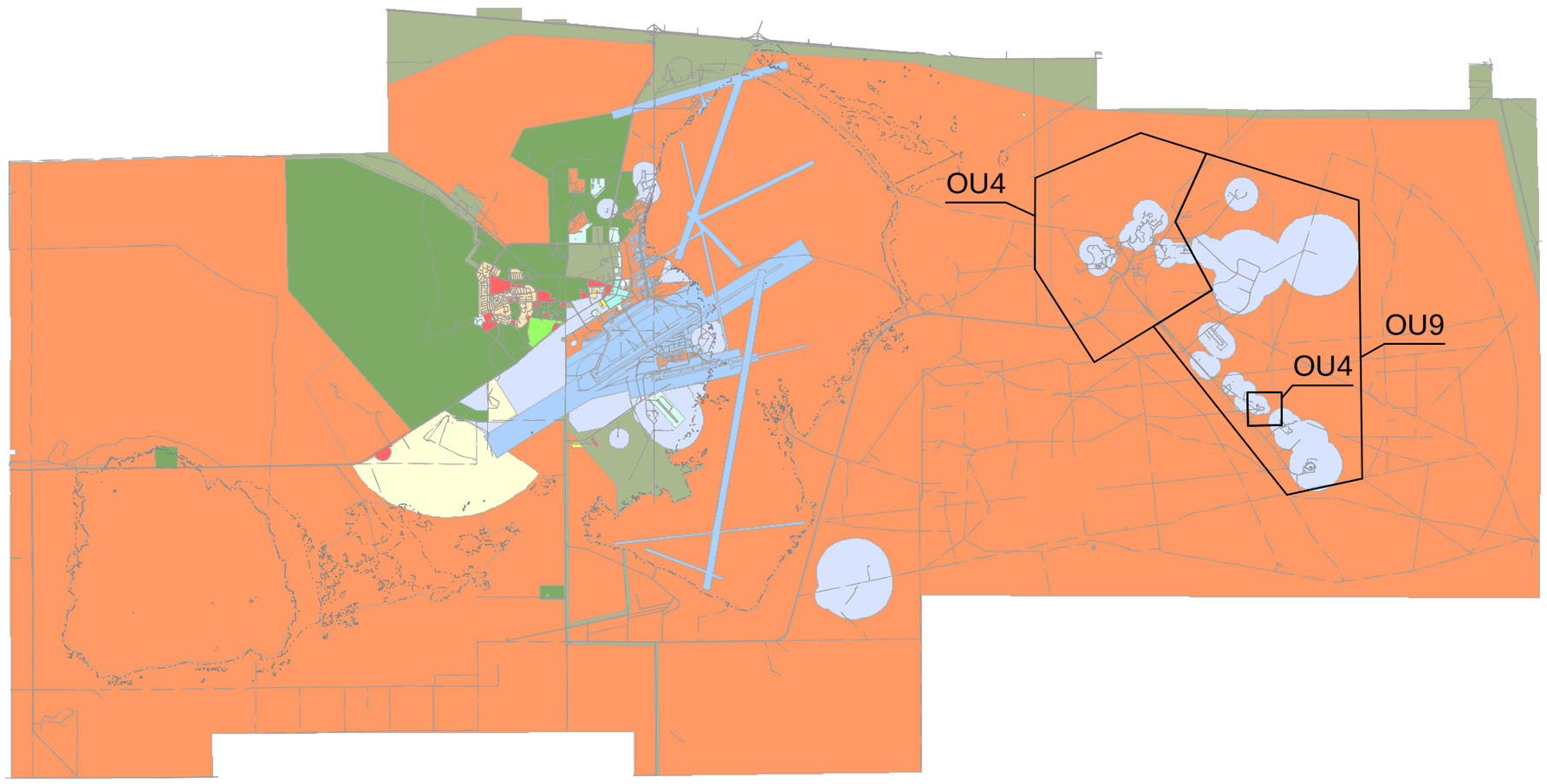

EXPLANATION

- AIRFIELD
- COMMUNICATION SYSTEM
- FOREST AND WILDLIFE
- HOUSING
- INSTITUTIONAL
- MISC. MILITARY LAND
- NAVIGATION AND TRAFFIC AIDS
- OFFICE BUILDING LOCATION
- OTHER
- PARKS AND HISTORIC SITES
- POST OFFICE
- RESEARCH AND DEVELOPMENT
- STORAGE
- TRAINING LAND
- VACANT
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- TOPOGRAPHY DRAINAGE

ABBREVIATIONS

AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
FYR	FIVE-YEAR REVIEW
MISC.	MISCELLANEOUS
USAF	UNITED STATES AIR FORCE

NOTE

1. FIGURE ADAPTED FROM THE USAF EDWARDS AFB GENERAL PLAN (USAF 2011b)

NORTH

0 1.5 3 Miles

1 " = 3 Miles

First FYR for South AFRL

Edwards Air Force Base Current Land Use

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		3.2-1

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ARA STREET

2,161,400 N

6,651,420 E

ORIGINAL BUILDING 8595

8595

FORMER ACID DIP PAD (LATER USED AS PAINT AND SANDBLAST AREA)

UTILITY LINE TRENCH (CONCRETE)

UTILITY VAULT

FLOOR DRAIN

PARTS WASHER

AOC 170
FORMER VAPOR DEGREASER PIT

AOC 171
FORMER INDOOR CAUSTIC AND ACID DIP TANKS SUMP

BUILDING 8595 ADDITION

172-EW06

FLOOR DRAIN

172-SG28

FORMER LOCATION OF 10,500 GALLON PCE STORAGE TANK

172-EW07

G

OUTDOOR PIPE TRENCH

172-SG32

3" PVC

37-EW07

FORMER ABOVEGROUND STORAGE TANK

172-EW02

172-EW03

FORMER OUTDOOR WASTE SUMP

172-SG29

171-MW05

37-EW08

FORMER COLLECTION BOX

172-EW01

BYPASS LINE (TO GROUND SURFACE)

MODELED VOC SOURCE 1

172-SG30

CONCRETE PAD

172-SG31

TO SANITARY SEWER

172-EW05

SITE 172
BUILDING 8595 WASTE SUMP

DRAIN LINE (TO GROUND SURFACE)

172-EW04

G'

NORTH

NOTE:

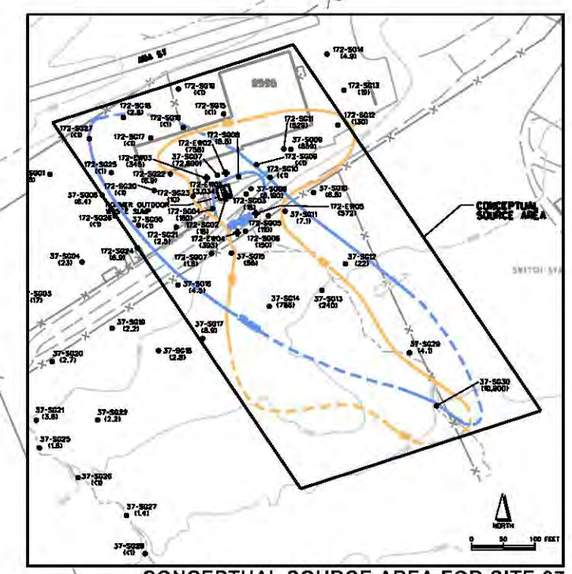
LOCATION OF ALL PIPING APPROXIMATE

0 15 30 FEET

SCALE: 1" = 30'

EXPLANATION

- SITE/AOC BOUNDARY
- PIPING (ABOVE GROUND)
- PIPING (BELOW GROUND)
- G—G' CROSS SECTION LINE (SEE FIGURE 3.3-2)
- SOIL VAPOR EXTRACTION WELL
- MONITORING WELL LOCATION
- EXTRACTION WELL LOCATION
- SOIL VAPOR MONITORING WELL LOCATION
- AFB AIR FORCE BASE
- AFRL AIR FORCE RESEARCH LABORATORY
- AOC AREA OF CONCERN
- FYR FIVE-YEAR REVIEW
- PCE TETRACHLOROETHENE
- PVC POLYVINYL CHLORIDE
- ROD RECORD OF DECISION
- SVE SOIL VAPOR EXTRACTION
- VOC VOLATILE ORGANIC COMPOUND



CONCEPTUAL SOURCE AREA FOR SITE 37 ADAPTED FROM SOUTH AFRL ROD (USAF 2007)

First FYR for South AFRL

Source Area for Site 37

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		3.3-1

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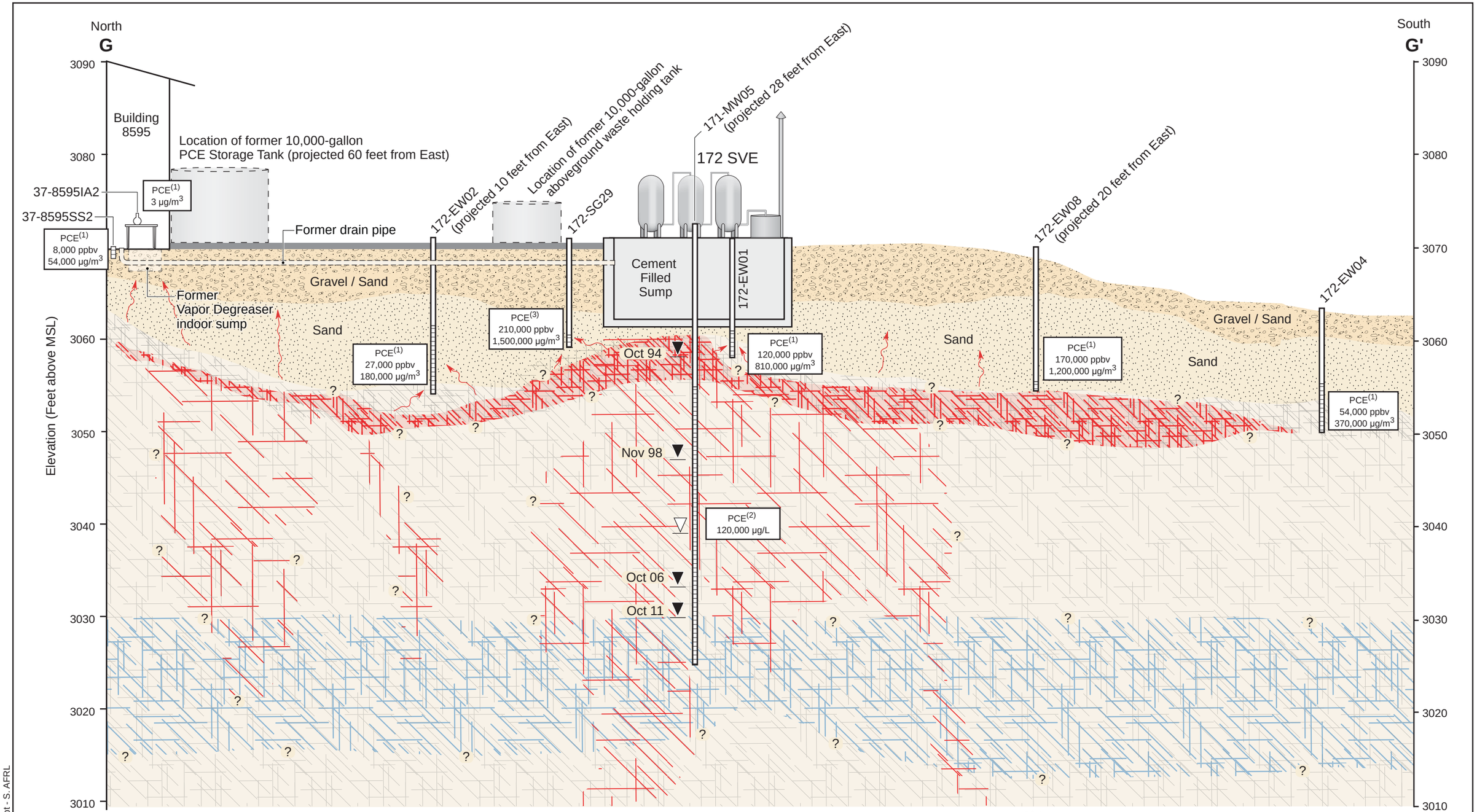


Explanation

- Sorbed DNAPL PCE
- Dissolved PCE in groundwater
- Fractured bedrock
- Weathered bedrock with clay
- Sand
- Gravel / Sand
- First water encountered
- Static water level
- Asphalt
- Volatilization
- ? Extent either inferred or unknown

µg/L	micrograms per liter
µg/m³	micrograms per cubic meter
AFB	Air Force Base
AFRL	Air Force Research Laboratory
CSM	Conceptual Site Model
DNAPL	Dense Non-Aqueous Phase Liquid
FYR	Five-Year Review
MSL	Mean Sea Level
Nov	November
Oct	October
PCE	tetrachloroethene
ppbv	parts per billion by volume
SVE	Soil Vapor Extraction

(1) January 2011 vapor concentration
(2) October 2008 groundwater concentration
(3) February 2010 vapor concentration

Notes:
1) Location of cross section line is shown on Figure 3.3-1.
2) Adapted from Figure A-5 (Earth Tech 2008b)

Vertical Scale: 0, 5, 10 ft
Horizontal Scale: 0, 5, 10 ft

First FYR for South AFRL

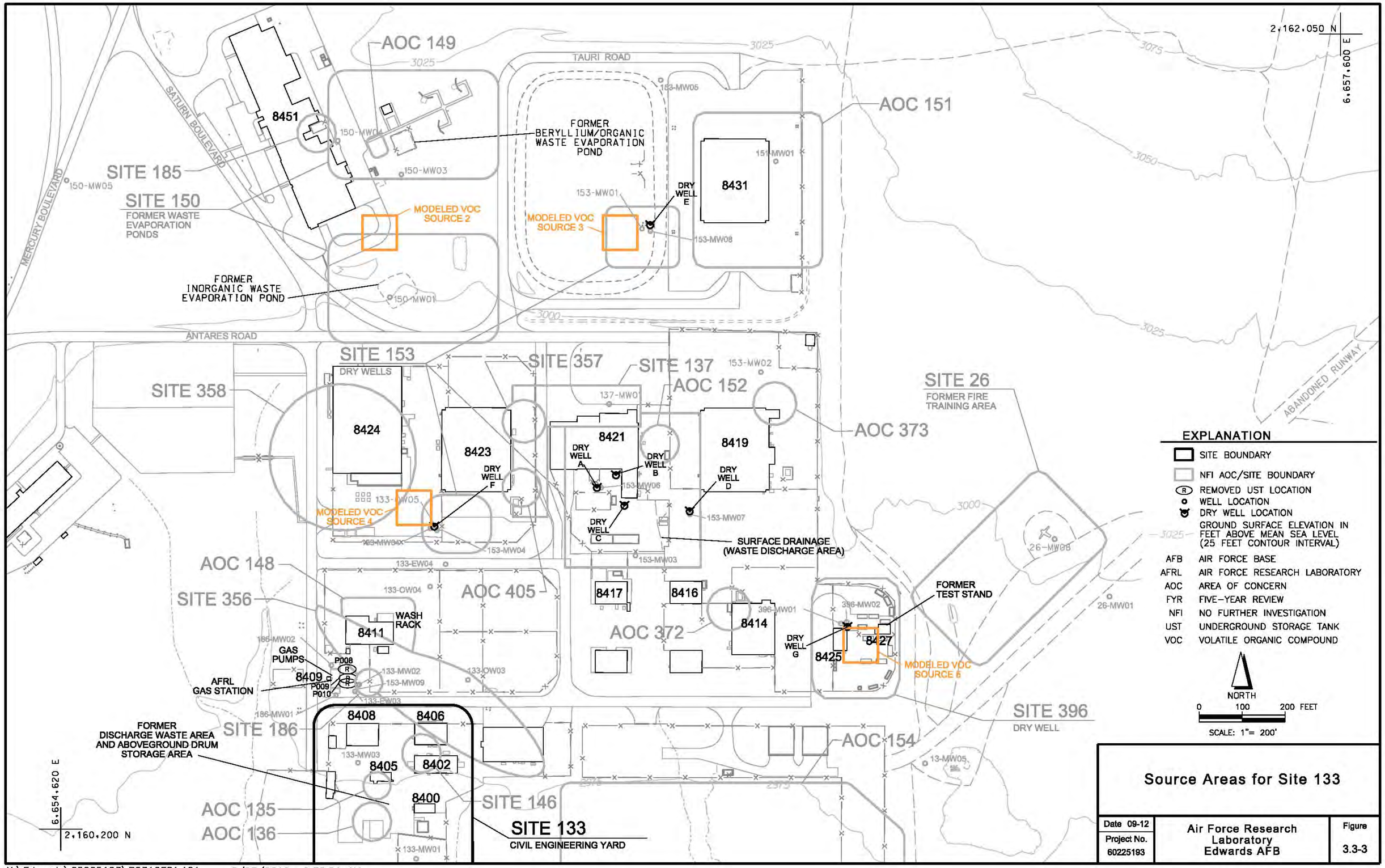
CSM for Source Area South of Building 8595

Date 09-12
Project No. 60225193

Air Force Research Laboratory
Edwards AFB

Figure **3.3-2**

6022-5193.10.07 First 5 yr Rpt - S. AFRL



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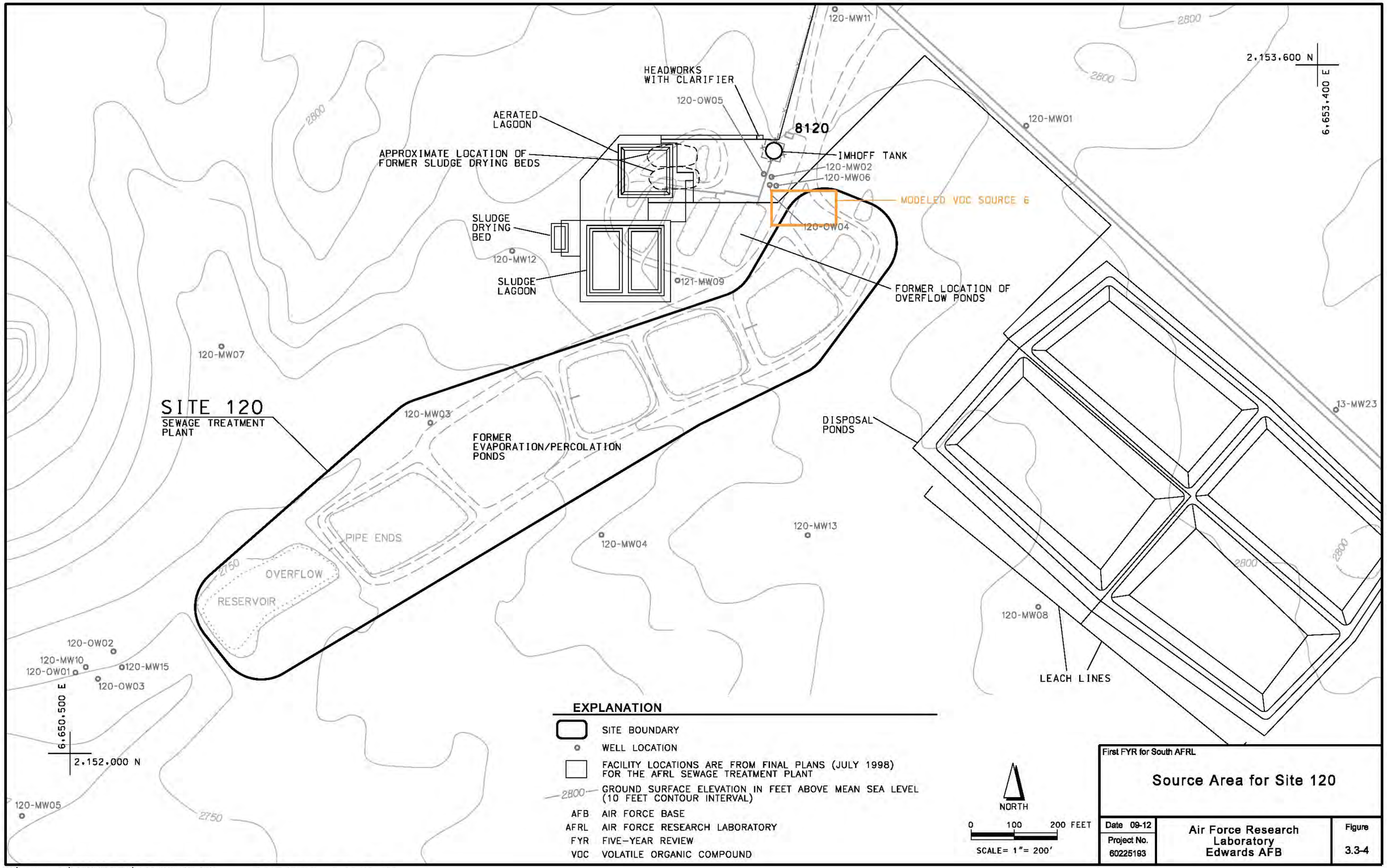

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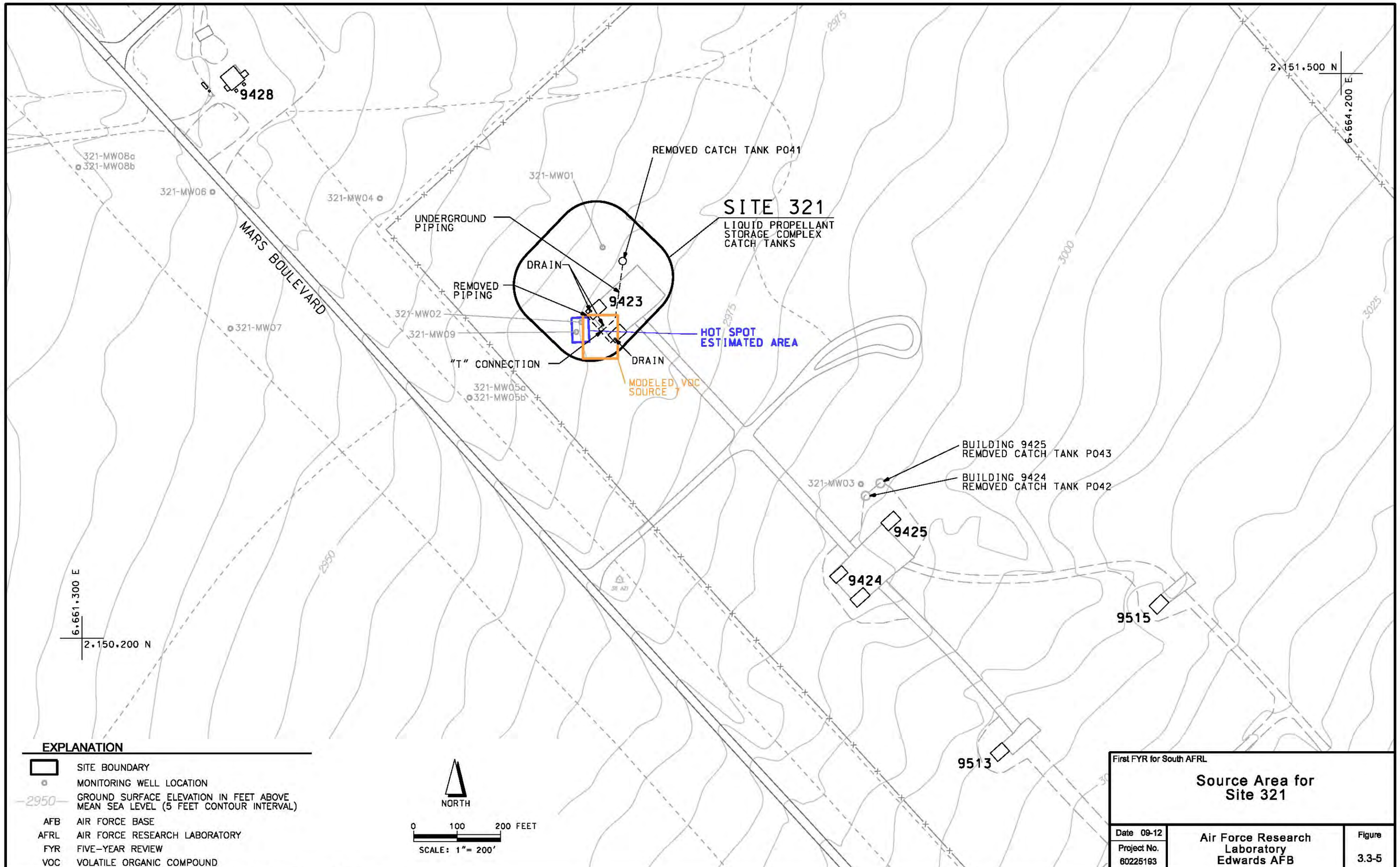

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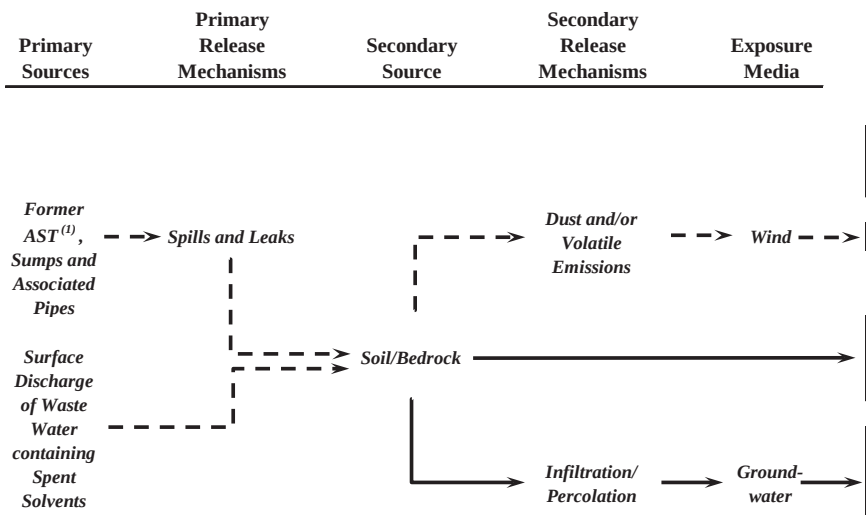


	Receptor: Human					Receptor: Ecological		
Exposure Route	Current Industrial	Future Industrial	Future Construction	Future Res/Sens	Risk Mgt. Decisions/RA	Terrestrial	Aquatic	Risk Mgt. Decisions/ RA
Inhalation[2]	No[5]	No[5]	No[5]	No[5]	a	No[5]	No[5]	a
Ingestion	No[5]	No[5]	No[2]	No[5]	a	No[5]	No[5]	a
Dermal Contact	No[5]	No[5]	No[2]	No[5]	a	No[5]	No[5]	a
Inhalation-VIP	Yes[3]	Yes[4]	No[2]	Yes[4]	b, d	No[5]	No[5]	c
Ingestion	No[5]	Yes[4]	No[6]	Yes[4]	d	No[5]	No[5]	
Inhalation-Dir	No[5]	Yes[4]	No[6]	Yes[4]	d	No[5]	No[5]	
Inhalation-VIP	Yes[3]	Yes[4]	No[6]	Yes[4]	b, d	No[5]	No[5]	c
Dermal Contact	No[5]	Yes[4]	No[6]	Yes[4]	d	No[5]	No[5]	

Notes:

Current and Future, as used in this figure, are defined relative to the point at which the ROD was signed.

"Yes" means the exposure pathway is complete or potentially complete; "No" means the pathway is incomplete. A complete pathway is characterized by (a) the presence of site-related chemicals in environmental media (i.e. soil, air, groundwater), which (b) potential receptors may contact, ultimately resulting in (c) intake of the chemical(s). A pathway is incomplete if it is missing one or more of the elements (a-c) needed for a complete pathway; and is not anticipated to result in exposure to receptors.

[1] The AST held PCE used in a vapor degreaser inside the building. Drip tanks containing caustics and acids also drained to the sumps.

[2] This pathway is considered to be incomplete because surface soil is sparse and not contaminated.

[3] complete pathway

[4] potential pathway, currently incomplete

[5] incomplete pathway

[6] This pathway is considered incomplete because (1) depth to groundwater exceeds the maximum depth for typical construction work (i.e., 8-10 feet); and (2) construction work does not meet realistic assumptions for exposure via the VIP (such as for industrial workers where inhalation of indoor air for up to 8 hours per day over 25 years is assumed).

Yellow highlights indicate pathway retained for a CERCLA response

Gray shading indicates pathways not retained either because pathway does not exist or risks are within acceptable limits

Pathway no longer exists because AST has been removed; sumps cleaned and backfilled with clean pea gravel covered by concrete; pipes removed or plugged; and surface discharge of waste water is no longer practiced.

Risk Mgt. Decision/RA:

a. Based on RI sampling results as evaluated in the baseline HHRA and ERA, a risk management decision (Earth Tech 2004) was reached, which found that risk via inhalation, ingestion or dermal contact with soil was acceptable for human and ecological receptors. This decision was confirmed by a selection of NFA for the soil medium in the *South AFRL ROD* (USAF 2007)

b. Previous sampling has confirmed VIP complete inside Building 8595; SVE operated as a short-term mitigation; the FYR demonstrates that the 2007 remedy is protective of the VIP exposures.

c. Risk to burrowing animals via inhalation pathway identified as very low to no adverse effect in Validation Study (USGS 2002)

d. ICs and LUCs in place

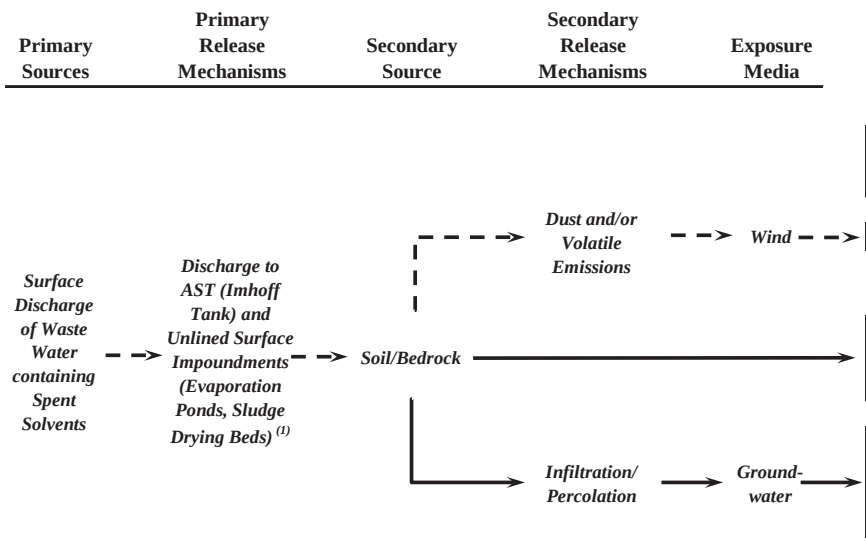
AST	above ground storage tank	PCE	tetrachloroethene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act	RA	remedial action
Dir	direct	Res/Sens	residential/sensitive use
ERA	ecological risk assessment	ROD	Record of Decision
HHRA	human health risk assessment	VIP	vapor intrusion
IC	institutional controls	VIP	vapor intrusion pathway
LUC	land use controls		
Mgt.	management		
NFA	no further action		

First FYR for South AFRL

Site 37 Exposure Pathways Retained for a CERCLA Response

Date 09-12	Edwards AFB	Figure
Project No. 60225193		3.5-1

6022-5193.10.07 First 5 yr Rpt - S. AFRL



	Receptor							
	Human					Ecological		
Exposure Route	Current Industrial	Future Industrial	Future Construction	Future Res/Sens	Risk Mgt. Decisions/RA	Terrestrial	Aquatic	Risk Mgt. Decisions/ RA
Inhalation(2)	No(4)	No(4)	No(4)	No(4)	a	No(4)	No(4)	a
Ingestion	No(4)	No(4)	No(2)	No(4)	a	No(4)	No(4)	a
Dermal Contact	No(4)	No(4)	No(2)	No(4)	a	No(4)	No(4)	a
Inhalation-VIP	No(4)	Yes(3)	No(2)	Yes(3)	b, d	No(4)	No(4)	c
Ingestion	No(4)	Yes(3)	No(5)	Yes(3)	d	No(4)	No(4)	
Inhalation-Dir	No(4)	Yes(3)	No(5)	Yes(3)	d	No(4)	No(4)	
Inhalation-VIP	No(4)	Yes(3)	No(5)	Yes(3)	b, d	No(4)	No(4)	c
Dermal Contact	No(4)	Yes(3)	No(5)	Yes(3)	d	No(4)	No(4)	

Notes:

Current and Future, as used in this figure, are defined relative to the point at which the ROD was signed.

"Yes" means the exposure pathway is complete or potentially complete; "No" means the pathway is incomplete. A complete pathway is characterized by (a) the presence of site-related chemicals in environmental media (i.e. soil, air, groundwater), which (b) potential receptors may contact, ultimately resulting in (c) intake of the chemical(s). A pathway is incomplete if it is missing one or more of the elements (a-c) needed for a complete pathway; and is not anticipated to result in exposure to receptors.

[1] The Imhoff Tank and Ponds have been abandoned and the ponds have been backfilled and relocated.

[2] This pathway is considered to be incomplete with No Action determination for the soil medium selected in the *South AFRL ROD* (USAF 2007)

[3] potential pathway, currently incomplete

[4] incomplete pathway

[5] This pathway is considered incomplete because (1) depth to groundwater exceeds the maximum depth for typical construction work (i.e., 8-10 feet); and (2) construction work does not meet realistic assumptions for exposure via the VIP (such as for industrial workers where inhalation of indoor air for up to 8 hours per day over 25 years is assumed).

AST	above ground storage tank
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Dir	direct
ERA	ecological risk assessment
HHRA	human health risk assessment
IC	institutional controls
LUC	land use controls
Mgt.	management
NFA	no further action
PCE	tetrachloroethene
RA	remedial action
Res/Sens	residential/sensitive use
ROD	Record of Decision
VIP	vapor intrusion
VIP	vapor intrusion pathway

Yellow highlights indicate pathway retained for a CERCLA response

Gray shading indicates pathways not retained either because pathway does not exist or risks are within acceptable limits

Pathway no longer exists because AST (Imhoff Tank) and ponds/drying beds have been abandoned and ponds/drying beds have been backfilled.

Risk Mgt. Decision/RA:

a. Based on RI sampling results as evaluated in the baseline HHRA and ERA, a risk management decision (Earth Tech 2004) was reached, which found that risk via inhalation, ingestion or dermal contact with soil was acceptable for human and ecological receptors. This decision was confirmed by a selection of NFA for the soil medium in the *South AFRL ROD* (USAF 2007)

b. No occupied buildings or buildings designed for occupancy so no current receptors (see *South AFRL VI Report* [AECOM 2012c])

c. Risk to burrowing animals via inhalation pathway identified as very low to no adverse effect in Validation Study (USGS 2002)

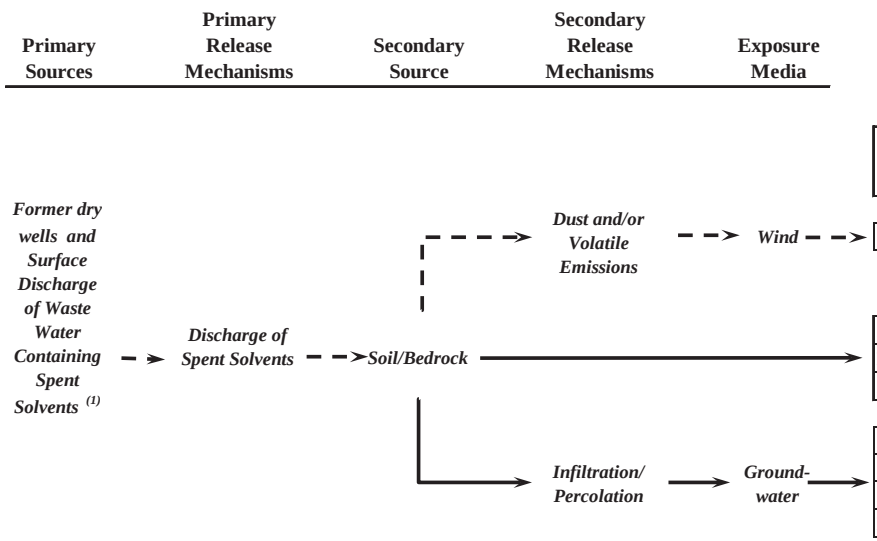
d. ICs and LUCs in place

First FYR for South AFRL

Site 120 Exposure Pathways Retained for a CERCLA Response

Date 09-12	Edwards AFB	Figure
Project No. 60225193		3.5-2

6022-5193.10.07 First 5 yr Rpt - S. AFRL



Exposure Route	Human: Current Industrial	Human: Future Industrial	Human: Future Construction	Human: Future Res/Sens	Human: Risk Mgt. Decisions/RA	Ecological: Terrestrial	Ecological: Aquatic	Ecological: Risk Mgt. Decisions/ RA
Inhalation[2]	No[5]	No[5]	No[5]	No[5]	a	No[5]	No[5]	a
Ingestion	No[5]	No[5]	No[2]	No[5]	a	No[5]	No[5]	a
Dermal Contact	No[5]	No[5]	No[2]	No[5]	a	No[5]	No[5]	a
Inhalation-VIP	Yes[3]	Yes[4]	No[2]	Yes[4]	b, d	No[5]	No[5]	c
Ingestion	No[5]	Yes[4]	No[6]	Yes[4]	d	No[5]	No[5]	
Inhalation-Dir	No[5]	Yes[4]	No[6]	Yes[4]	d	No[5]	No[5]	
Inhalation-VIP	Yes[3]	Yes[4]	No[6]	Yes[4]	b, d	No[5]	No[5]	c
Dermal Contact	No[5]	Yes[4]	No[6]	Yes[4]	d	No[5]	No[5]	

Notes:

Current and Future, as used in this figure, are defined relative to the point at which the ROD was signed.

"Yes" means the exposure pathway is complete or potentially complete; "No" means the pathway is incomplete. A complete pathway is characterized by (a) the presence of site-related chemicals in environmental media (i.e. soil, air, groundwater), which (b) potential receptors may contact, ultimately resulting in (c) intake of the chemical(s). A pathway is incomplete if it is missing one or more of the elements (a-c) needed for a complete pathway; and is not anticipated to result in exposure to receptors.

[1] The dry wells have been abandoned and waste water management practices enacted.

[2] This pathway is considered to be incomplete with No Action determination for the soil medium selected in the *South AFRL ROD* (USAF 2007).

[3] complete pathway

[4] potential pathway, currently incomplete

[5] incomplete pathway

[6] This pathway is considered incomplete because (1) depth to groundwater exceeds the maximum depth for typical construction work (i.e., 8-10 feet); and (2) construction work does not meet realistic assumptions for exposure via the VIP (such as for industrial workers where inhalation of indoor air for up to 8 hours per day over 25 years is assumed).

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Dir	direct
ERA	ecological risk assessment
HHRA	human health risk assessment
IC	institutional controls
LUC	land use controls
Mgt.	management
NFA	no further action
RA	remedial action
Res/Sens	residential/sensitive use
ROD	Record of Decision
VIP	vapor intrusion
VIP	vapor intrusion pathway

Yellow highlights indicate pathway retained for a CERCLA response

Gray shading indicates pathways not retained either because pathway does not exist or risks are within acceptable limits

Pathway no longer exists because dry wells have been abandoned; surface discharge of waste water is no longer practiced.

Risk Mgt. Decision/RA:

a. Based on RI sampling results as evaluated in the baseline HHRA and ERA, a risk management decision (Earth Tech 2004) was reached, which found that risk via inhalation, ingestion or dermal contact with soil was acceptable for human and ecological receptors. This decision was confirmed by a selection of NFA for the soil medium in the *South AFRL ROD* (USAF 2007)

b. Post-ROD sampling for VI at Buildings 8402 through 8408, 8411, 8423, 8424, and 8431 suggest VI risk to current receptors is within the risk management range (AECOM 2012c).

c. Risk to burrowing animals via inhalation pathway identified as very low to no adverse effect in Validation Study (USGS 2002)

d. ICs and LUCs in place

First FYR for South AFRL

Site 133 Exposure Pathways Retained for a CERCLA Response

Date 09-12	Edwards AFB	Figure
Project No. 60225193		3.5-3

Primary Sources	Primary Release Mechanisms	Secondary Source	Secondary Release Mechanisms	Exposure Media
Catch Tanks and Associated Piping Receiving Waste Water containing Spent Solvents [1]	*Leaks and Spills*	*Soil/Bedrock*	*Dust and/or Volatile Emissions*	*Wind*
			Infiltration/ Percolation	*Ground-water*

Exposure Route	Human: Current Industrial	Human: Future Industrial	Human: Future Construction	Human: Future Res/Sens	Human: Risk Mgt. Decisions/RA	Ecological: Terrestrial	Ecological: Aquatic	Ecological: Risk Mgt. Decisions/ RA
Inhalation[2]	No[4]	No[4]	No[4]	No[4]	a	No[4]	No[4]	a
Ingestion	No[4]	No[4]	No[2]	No[4]	a	No[4]	No[4]	a
Dermal Contact	No[4]	No[4]	No[2]	No[4]	a	No[4]	No[4]	a
Inhalation-VIP	No[4]	Yes[3]	No[2]	Yes[3]	b, d	No[4]	No[4]	c
Ingestion	No[4]	Yes[3]	No[5]	Yes[3]	d	No[4]	No[4]	
Inhalation-Dir	No[4]	Yes[3]	No[5]	Yes[3]	d	No[4]	No[4]	
Inhalation-VIP	No[4]	Yes[3]	No[5]	Yes[3]	b, d	No[4]	No[4]	c
Dermal Contact	No[4]	Yes[3]	No[5]	Yes[3]	d	No[4]	No[4]	

Notes:

Current and Future, as used in this figure, are defined relative to the point at which the ROD was signed.

"Yes" means the exposure pathway is complete or potentially complete; "No" means the pathway is incomplete. A complete pathway is characterized by (a) the presence of site-related chemicals in environmental media (i.e. soil, air, groundwater), which (b) potential receptors may contact, ultimately resulting in (c) intake of the chemical(s). A pathway is incomplete if it is missing one or more of the elements (a-c) needed for a complete pathway; and is not anticipated to result in exposure to receptors.

[1] The Catch Tanks have been removed and waste water management practices enacted.

[2] This pathway is considered to be incomplete with No Action determination for the soil medium selected in the *South AFRL ROD* (USAF 2007).

[3] potential pathway, currently incomplete

[4] incomplete pathway

[5] This pathway is considered incomplete because (1) depth to groundwater exceeds the maximum depth for typical construction work (i.e., 8-10 feet); and (2) construction work does not meet realistic assumptions for exposure via the VIP (such as for industrial workers where inhalation of indoor air for up to 8 hours per day over 25 years is assumed).

Yellow highlights indicate pathway retained for a CERCLA response

Gray shading indicates pathways not retained either because pathway does not exist or risks are within acceptable limits

Pathway no longer exists because catch tanks have been removed and waste water practices .

Risk Mgt. Decision/RA:

a. Based on RI sampling results as evaluated in the baseline HHRA and ERA, a risk management decision (Earth Tech 2004) was reached, which found that risk via inhalation, ingestion or dermal contact with soil was acceptable for human and ecological receptors. This decision was confirmed by a selection of NFA for the soil medium in the *South AFRL ROD* (USAF 2007)

b. No occupied buildings or buildings designed for occupancy so no current receptors (see *South AFRL VI Report* [AECOM 2012c])

c. Risk to burrowing animals via inhalation pathway identified as very low to no adverse effect in Validation Study (USGS 2002)

d. ICs and LUCs in place

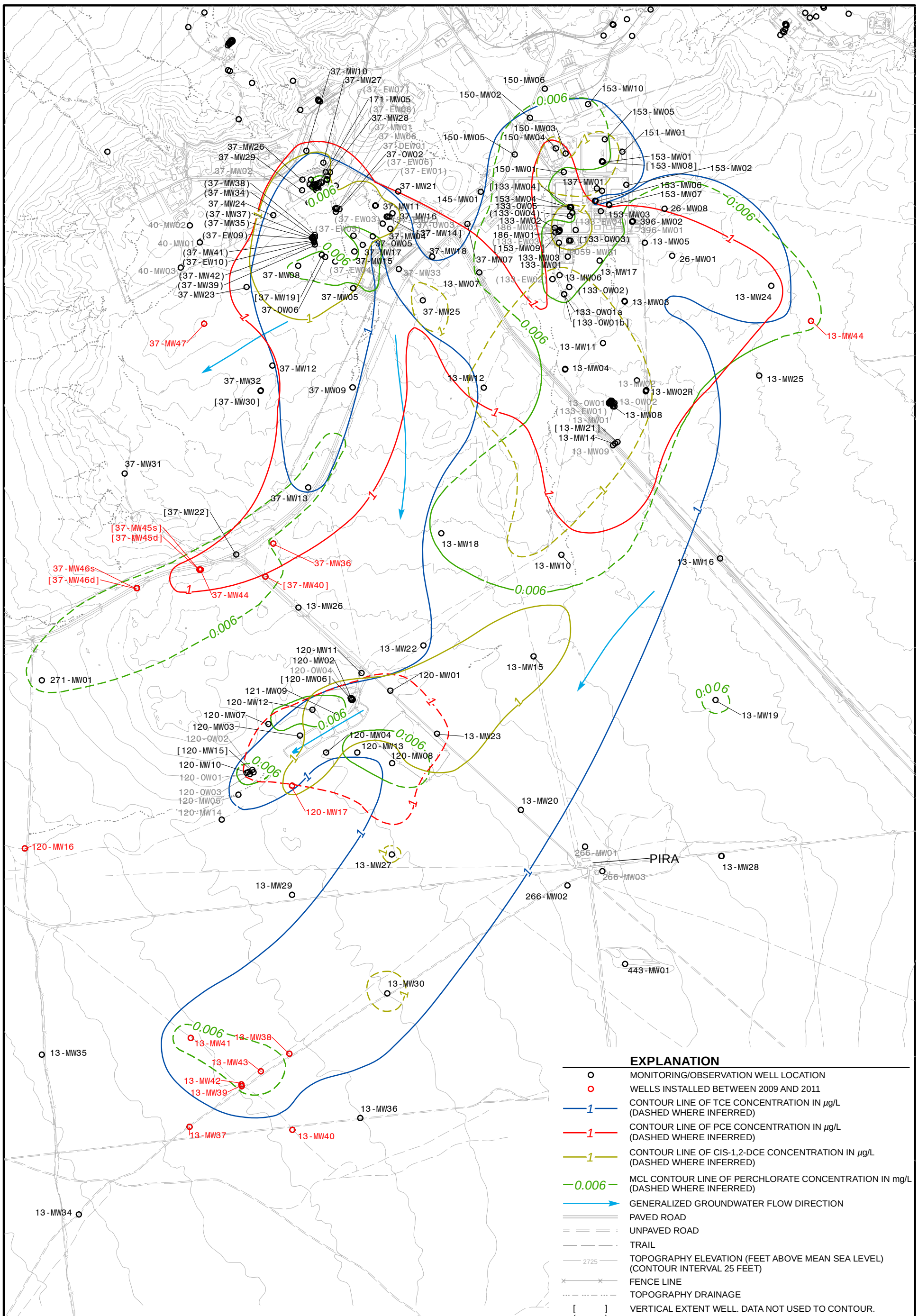
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act	Res/Sens	residential/sensitive use
Dir	direct	ROD	Record of Decision
ERA	ecological risk assessment	VIP	vapor intrusion
HHRA	human health risk assessment	VIP	vapor intrusion pathway
IC	institutional controls		
LUC	land use controls		
Mgt.	management		
NFA	no further action		
RA	remedial action		

First FYR for South AFRL

Site 321 Exposure Pathways Retained for a CERCLA Response

Date 09-12	Edwards AFB	Figure
Project No. 60225193		3.5-4

6022-5193.10.07 First 5 yr Rpt - S. AFRL



EXPLANATION

- MONITORING/OBSERVATION WELL LOCATION
- WELLS INSTALLED BETWEEN 2009 AND 2011
- CONTOUR LINE OF TCE CONCENTRATION IN µg/L (DASHED WHERE INFERRED)
- CONTOUR LINE OF PCE CONCENTRATION IN µg/L (DASHED WHERE INFERRED)
- CONTOUR LINE OF CIS-1,2-DCE CONCENTRATION IN µg/L (DASHED WHERE INFERRED)
- MCL CONTOUR LINE OF PERCHLORATE CONCENTRATION IN mg/L (DASHED WHERE INFERRED)
- GENERALIZED GROUNDWATER FLOW DIRECTION
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- TOPOGRAPHY ELEVATION (FEET ABOVE MEAN SEA LEVEL) (CONTOUR INTERVAL 25 FEET)
- FENCE LINE
- TOPOGRAPHY DRAINAGE
- [ ] VERTICAL EXTENT WELL. DATA NOT USED TO CONTOUR.
- ( ) LARGE SCREENED INTERVAL. DATA NOT USED TO CONTOUR.

ABBREVIATIONS

µg/L	MICROGRAMS PER LITER
mg/L	MILLIGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
DCE	DICHLOROETHENE
FYR	FIVE-YEAR REVIEW
MCL	MAXIMUM CONTAMINANT LEVEL
PCE	TETRACHLOROETHENE
PIRA	PRECISION IMPACT RANGE AREA
TCE	TRICHLOROETHENE

NOTE

1. PLUMES ARE DRAWN BASED ON 2008 RESULTS UPDATED WITH 2009-2011 RESULTS.

NORTH

0 700 1,400 Feet

1 " = 1,400 '

First FYR for South AFRL

Wells Installed at Sites 37, 133, and 120 From 2009 to 2011

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		4.4-1

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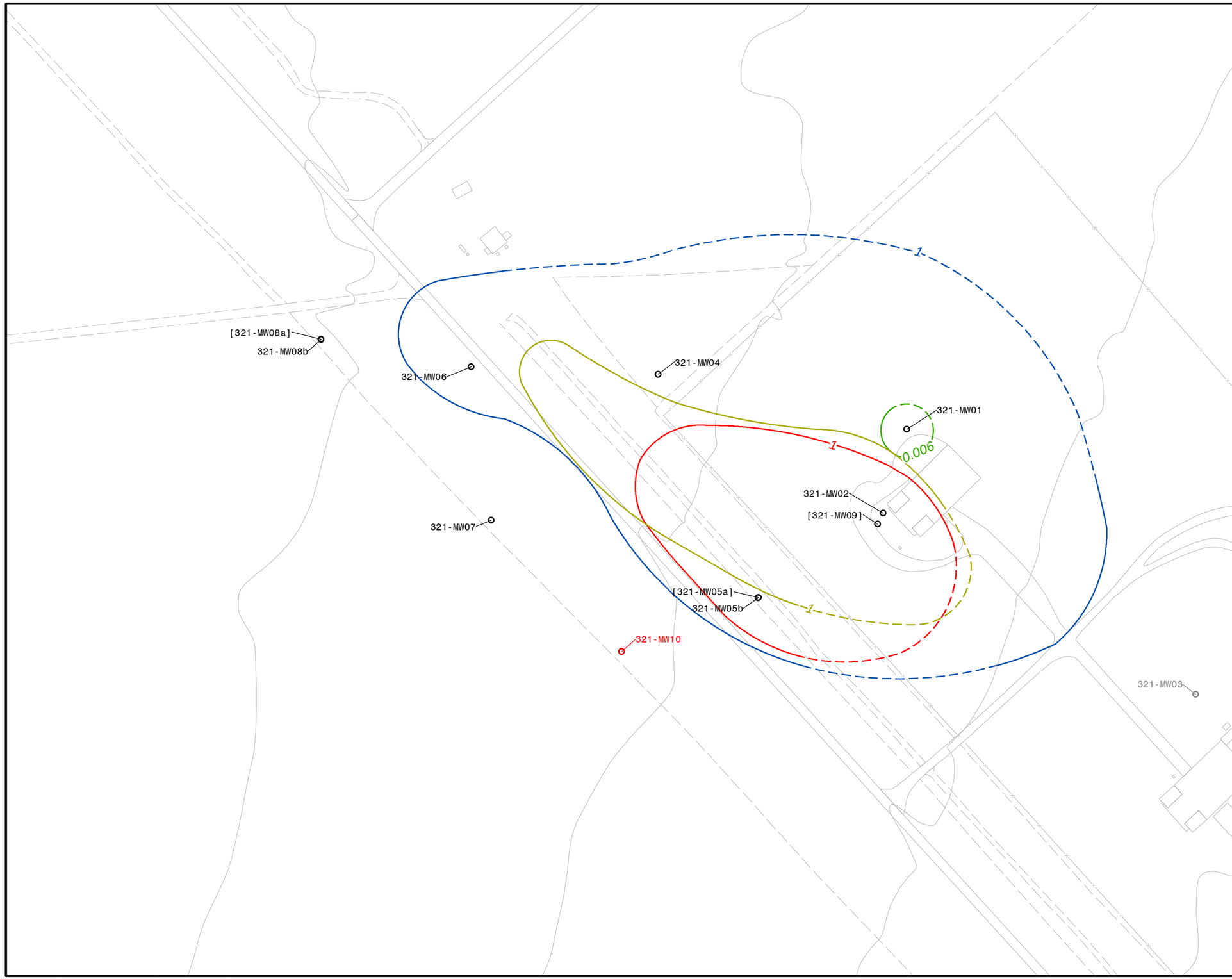

EXPLANATION

- MONITORING/OBSERVATION WELL RECENTLY SAMPLED
- MONITORING/OBSERVATION WELL NOT RECENTLY SAMPLED
- 1 µg/L CONTOUR LINE OF TCE CONCENTRATION (DASHED WHERE INFERRED)
- 1 µg/L CONTOUR LINE OF PCE CONCENTRATION (DASHED WHERE INFERRED)
- MCL CONTOUR LINE OF PERCHLORATE CONCENTRATION IN mg/L (DASHED WHERE INFERRED)
- 1 µg/L CONTOUR LINE OF CIS-1,2-DCE (DASHED WHERE INFERRED)
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- RAILROAD
- 2725 — TOPOGRAPHY ELEVATION (FEET ABOVE MEAN SEA LEVEL) (CONTOUR INTERVAL 25 FEET)
- FENCE LINE
- TOPOGRAPHY DRAINAGE
- [ ] VERTICAL EXTENT WELL; DATA NOT USED TO CONTOUR.

ABBREVIATIONS

µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
DCE	DICHLOROETHENE
FYR	FIVE-YEAR REVIEW
MCL	MAXIMUM CONTAMINANT LEVEL (CALIFORNIA DEPARTMENT OF PUBLIC HEALTH 2011)
mg/L	MILLIGRAMS PER LITER
PCE	TETRACHLOROETHENE
TCE	TRICHLOROETHENE

NORTH

0 100 200 Feet

1 " = 200 '

First FYR for South AFRL

Well Installed at Site 321 in 2010

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		4.4-2

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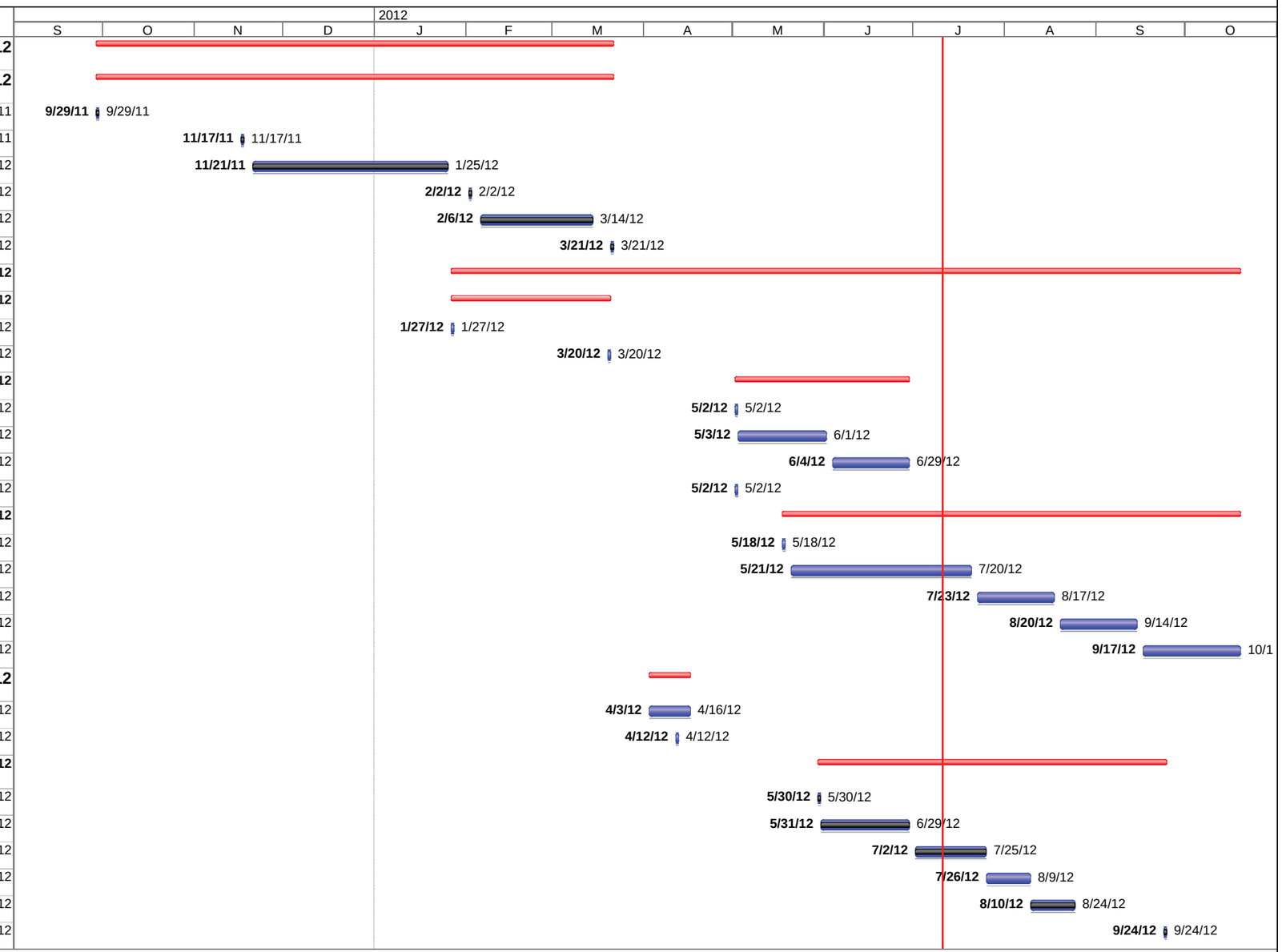
Date: Wednesday, August 22, 2012 8:36:16 AM

South AFRL - First Five-Year Review
Sites 37, 133, 120, and 321
Edwards Air Force Base

ID	Task Name	Start	Finish
1	**South AFRL Five-Year Review**	**Thu 9/29/11**	**Wed 3/21/12**
2	**Planning**	**Thu 9/29/11**	**Wed 3/21/12**
3	Award of Contract	Thu 9/29/11	Thu 9/29/11
4	1st Discussion at RPM Meeting	Thu 11/17/11	Thu 11/17/11
5	Preparation of Outline	Mon 11/21/11	Wed 1/25/12
6	2nd Discussion at RPM Meeting	Thu 2/2/12	Thu 2/2/12
7	Review/Revision of Outline	Mon 2/6/12	Wed 3/14/12
8	3rd Discussion at RPM Meeting	Wed 3/21/12	Wed 3/21/12
9	**Submit Feeder Documents**	**Fri 1/27/12**	**Fri 10/19/12**
10	**Groundwater Monitoring; Well Installation**	**Fri 1/27/12**	**Tue 3/20/12**
11	Submit Final 2010 AGMR	Fri 1/27/12	Fri 1/27/12
12	Submit Final 2010/2011 WIR	Tue 3/20/12	Tue 3/20/12
13	**South AFRL Post-ROD VIP Monitoring**	**Wed 5/2/12**	**Fri 6/29/12**
14	Submit revised draft post-ROD VIP report	Wed 5/2/12	Wed 5/2/12
15	RPM Review	Thu 5/3/12	Fri 6/1/12
16	Incorporate revisions and submit final	Mon 6/4/12	Fri 6/29/12
17	Submit SVE Reactivation Memo	Wed 5/2/12	Wed 5/2/12
18	**2012 South AFRL Groundwater Modeling Report**	**Fri 5/18/12**	**Fri 10/19/12**
19	Submit draft report for RPM review	Fri 5/18/12	Fri 5/18/12
20	RPM Review	Mon 5/21/12	Fri 7/20/12
21	Incorporate revisions; submit draft final	Mon 7/23/12	Fri 8/17/12
22	RPM review of draft final	Mon 8/20/12	Fri 9/14/12
23	Incorporate revisions and submit final	Mon 9/17/12	Fri 10/19/12
24	**Conduct FYR**	**Tue 4/3/12**	**Mon 4/16/12**
25	Conduct Site Interviews	Tue 4/3/12	Mon 4/16/12
26	Conduct Site Inspection	Thu 4/12/12	Thu 4/12/12
27	**FYR Submittals**	**Wed 5/30/12**	**Mon 9/24/12**
28	Submit draft report for RPM review	Wed 5/30/12	Wed 5/30/12
29	RPM Review	Thu 5/31/12	Fri 6/29/12
30	Incorporate revisions; submit draft final	Mon 7/2/12	Wed 7/25/12
31	RPM Review	Thu 7/26/12	Thu 8/9/12
32	Incorporate revisions and submit final	Fri 8/10/12	Fri 8/24/12
33	USEPA Determination on Protectiveness	Mon 9/24/12	Mon 9/24/12



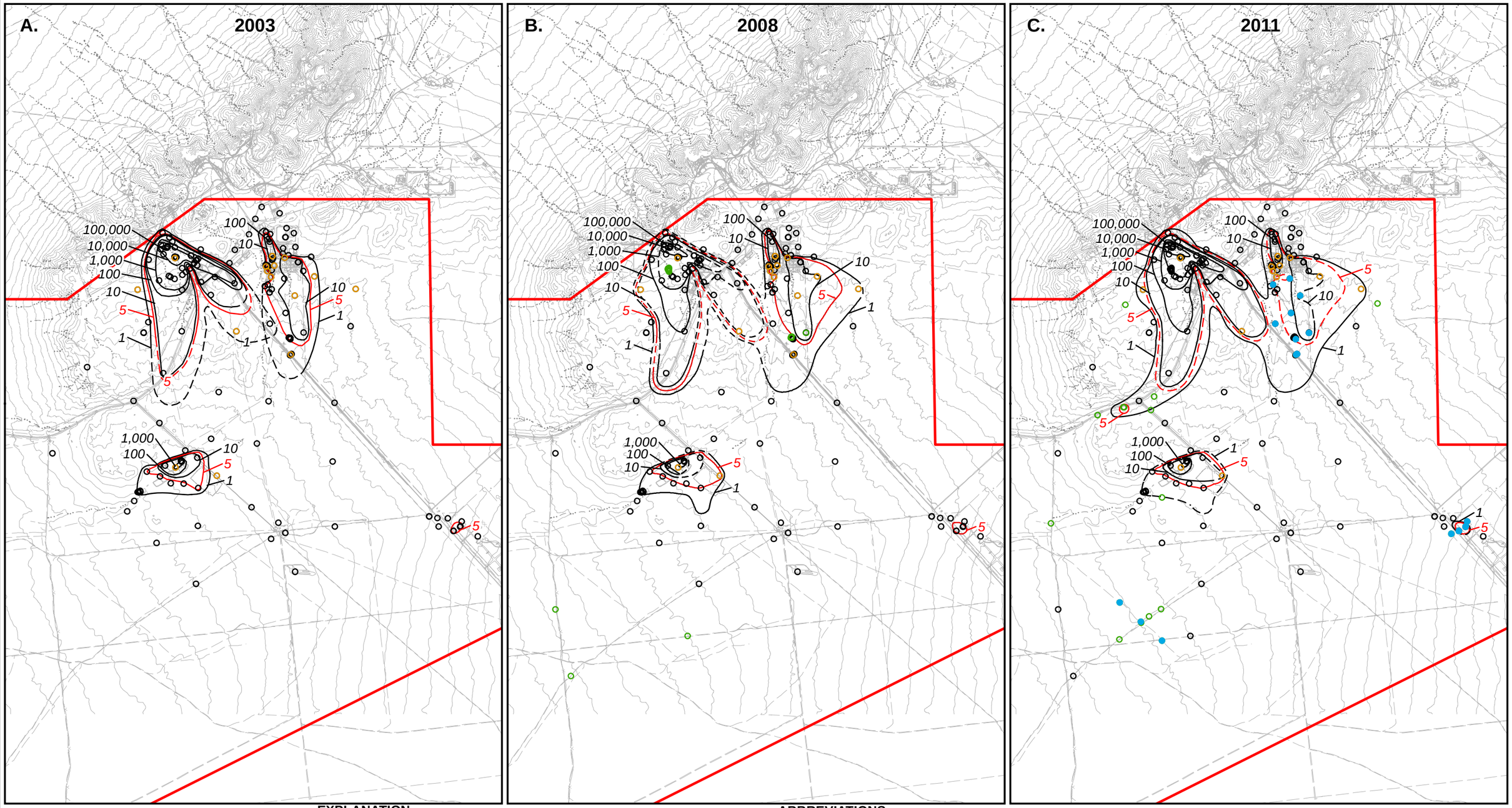
As of: [Fri 4/27/12]

First FYR for South AFRL

Submittal Dates for South AFRL Five-Year Report

Date 09-12	Edwards AFB	Figure
Project No. 60162823		**6.1-1**

6022-5193.10.07 First 5 yr Rpt - S. AFRL



EXPLANATION

- WELL SAMPLED IN 2011
- MONITORING/OBSERVATION WELL LOCATION
- MONITORING/OBSERVATION WELL DEPICTING A 10-FOLD INCREASE OR DECREASE IN CONCENTRATION DRIVING REVISIONS TO THE PLUME CONTOUR OUTLINE
- NEW MONITORING/OBSERVATION WELL LOCATION INSTALLED BETWEEN 2007 AND 2008 (FIGURE B.) AND BETWEEN 2008 AND 2011 (FIGURE C.)
- 1 — CONTOUR LINE OF PCE CONCENTRATION IN µg/L (DASHED WHERE INFERRED)
- 5 — MCL CONTOUR LINE OF PCE IN µg/L (DASHED WHERE INFERRED)
- SOUTH AFRL CONTAINMENT ZONE BOUNDARY
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- 2725 — TOPOGRAPHY ELEVATION (FEET ABOVE MEAN SEA LEVEL) (CONTOUR INTERVAL 25 FEET)
- FENCE LINE
- TOPOGRAPHY DRAINAGE

ABBREVIATIONS

µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
FYR	FIVE-YEAR REVIEW
MCL	MAXIMUM CONTAMINANT LEVEL (CALIFORNIA DEPARTMENT OF PUBLIC HEALTH 2011)
PCE	TETRACHLOROETHENE

NORTH

0 1,750 3,500 Feet

1 " = 3,500 '

First FYR for South AFRL

PCE Plume Contours
2003, 2008, and 2011

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		6.4-1

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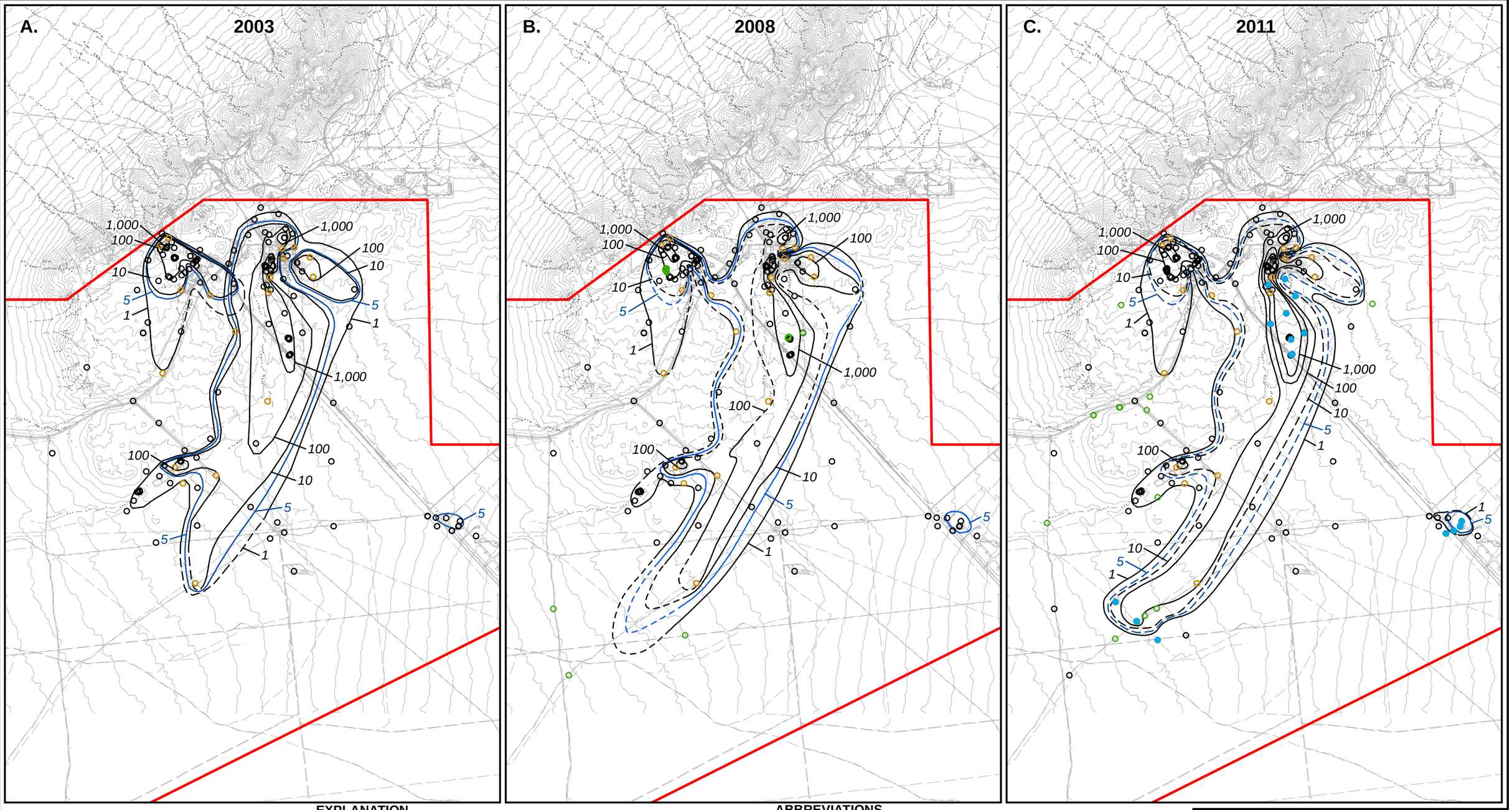

EXPLANATION

- WELL SAMPLED IN 2011
- MONITORING/OBSERVATION WELL LOCATION
- MONITORING/OBSERVATION WELL DEPICTING A 10-FOLD INCREASE OR DECREASE IN CONCENTRATION DRIVING REVISIONS TO THE PLUME CONTOUR OUTLINE
- NEW MONITORING/OBSERVATION WELL LOCATION INSTALLED BETWEEN 2007 AND 2008 (FIGURE B.) AND BETWEEN 2008 AND 2011 (FIGURE C.)
- 1 — CONTOUR LINE OF TCE CONCENTRATION IN µg/L (DASHED WHERE INFERRED)
- 5 — MCL CONTOUR LINE OF TCE IN µg/L (DASHED WHERE INFERRED)
- SOUTH AFRL CONTAINMENT ZONE BOUNDARY
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- 2725 — TOPOGRAPHY ELEVATION (FEET ABOVE MEAN SEA LEVEL) (CONTOUR INTERVAL 25 FEET)
- FENCE LINE
- TOPOGRAPHY DRAINAGE

ABBREVIATIONS

µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
FYR	FIVE-YEAR REVIEW
MCL	MAXIMUM CONTAMINANT LEVEL (CALIFORNIA DEPARTMENT OF PUBLIC HEALTH 2011)
TCE	TRICHLOROETHENE

NORTH

0 1,750 3,500 Feet

1 " = 3,500 '

First FYR for South AFRL

TCE Plume Contours 2003, 2008, and 2011

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		6.4-2

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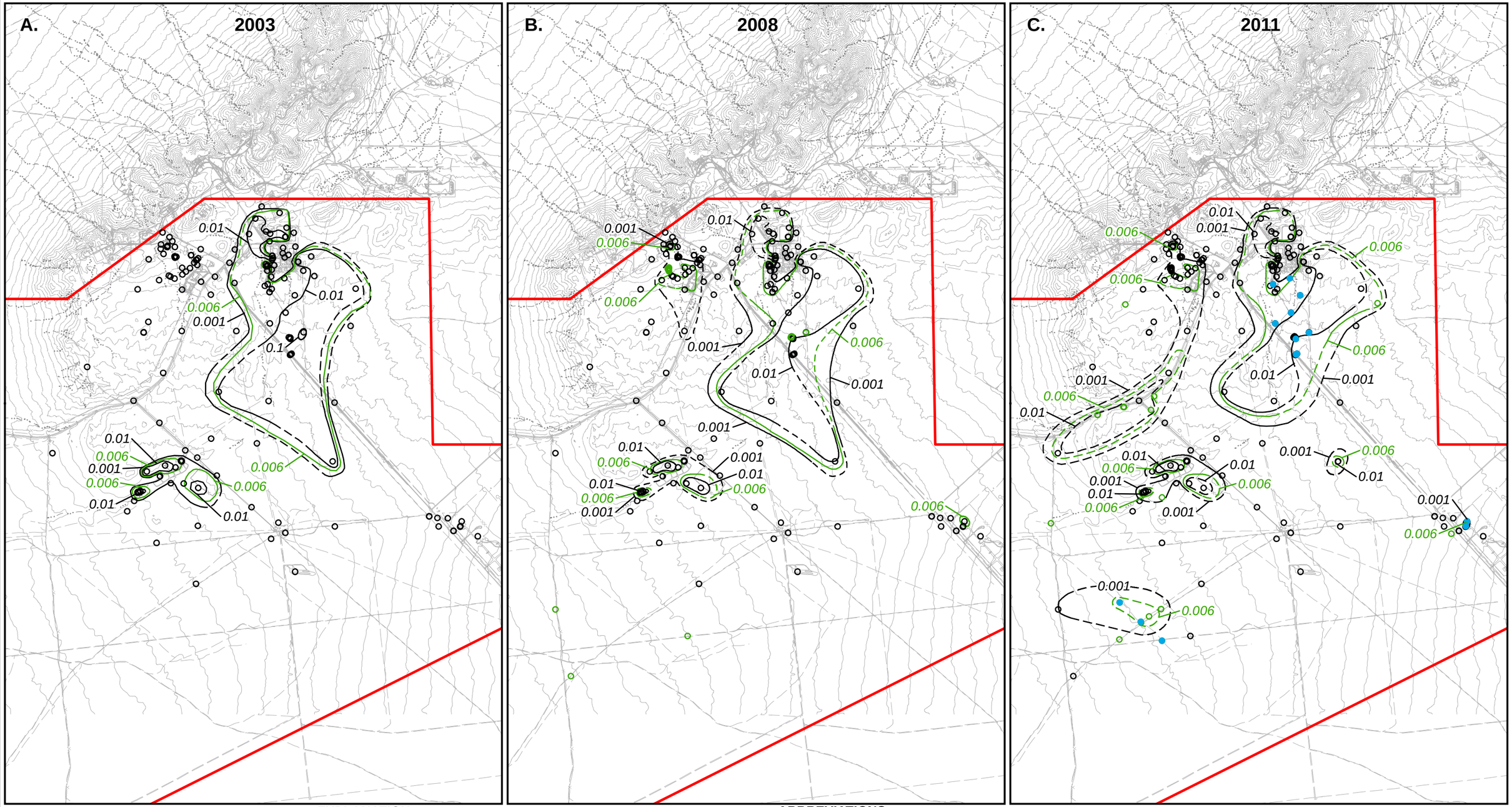

EXPLANATION

- WELL SAMPLED IN 2011
- MONITORING/OBSERVATION WELL LOCATION
- NEW MONITORING/OBSERVATION WELL LOCATION INSTALLED BETWEEN 2007 AND 2008 (FIGURE B.) AND BETWEEN 2008 AND 2011 (FIGURE C.)
- 1 — CONTOUR LINE OF PERCHLORATE CONCENTRATION IN mg/L (DASHED WHERE INFERRED)
- 0.006 — MCL CONTOUR LINE OF PERCHLORATE IN mg/L (DASHED WHERE INFERRED)
- SOUTH AFRL CONTAINMENT ZONE BOUNDARY
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- 2725 — TOPOGRAPHY ELEVATION (FEET ABOVE MEAN SEA LEVEL) (CONTOUR INTERVAL 25 FEET)
- FENCE LINE
- TOPOGRAPHY DRAINAGE

ABBREVIATIONS

mg/L	MILLIGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
FYR	FIVE-YEAR REVIEW
MCL	MAXIMUM CONTAMINANT LEVEL

NORTH

0 1,750 3,500 Feet

1 " = 3,500 '

First FYR for South AFRL

Perchlorate Plume Contours 2003, 2008, and 2011

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		6.4-3

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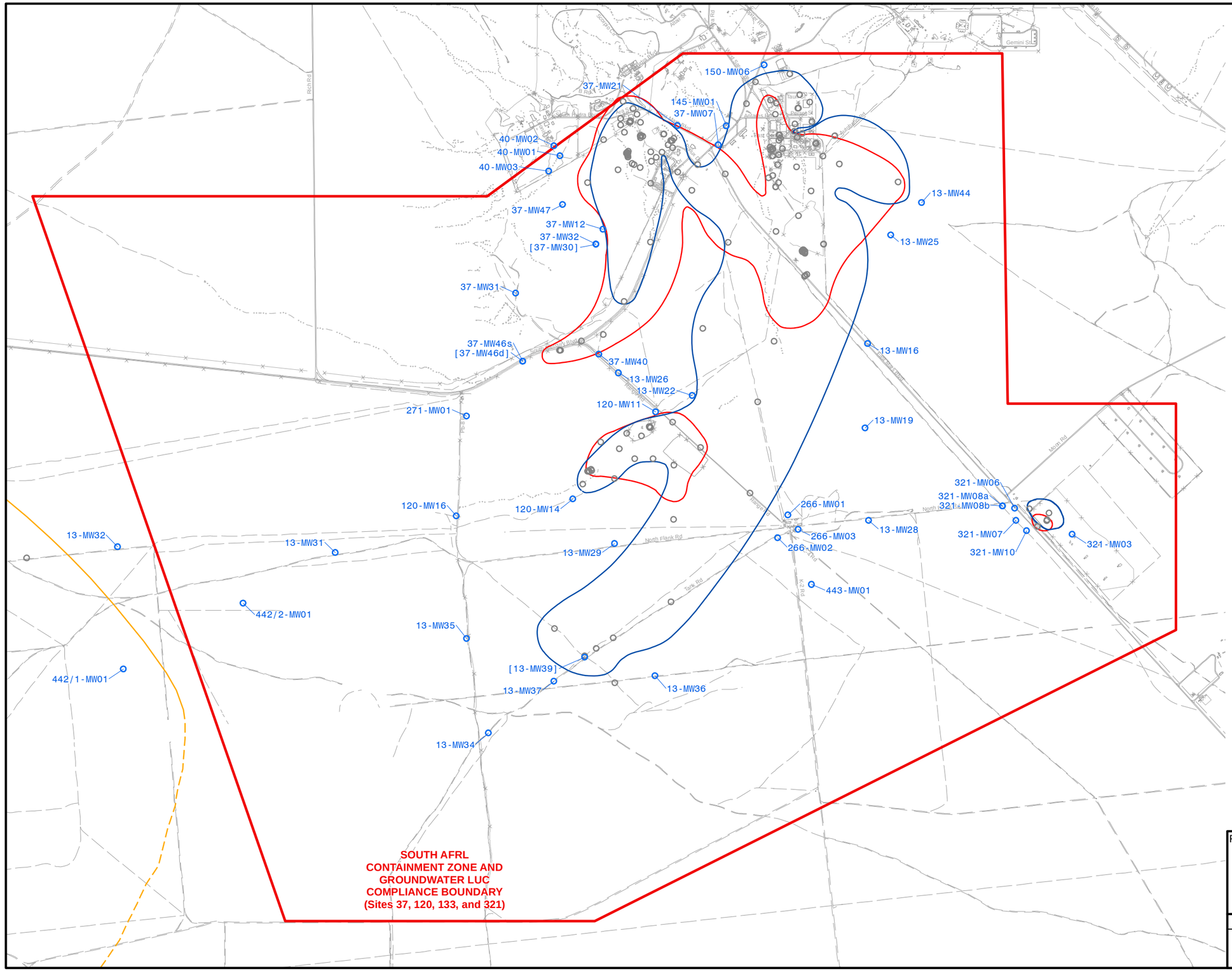

EXPLANATION

- EXTRACTION/INJECTION/MONITORING/OBSERVATION WELL LOCATION
- ESTIMATED BEDROCK TO ALLUVIAL AQUIFER TRANSITION (DASHED WHERE INFERRED)
- SOUTH AFRL CONTAINMENT ZONE AND GROUNDWATER LUC COMPLIANCE BOUNDARY
- CONTOUR LINE OF TCE CONCENTRATION IN 1 µg/L
- CONTOUR LINE OF PCE CONCENTRATION IN 1 µg/L
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- TOPOGRAPHY DRAINAGE
- [ ] VERTICAL EXTENT WELL. DATA NOT USED TO CONTOUR.

ABBREVIATIONS

µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
BLVD	BOULEVARD
CIR	CIRCLE
DR	DRIVE
FYR	FIVE-YEAR REVIEW
LUC	LAND USE CONTROL
PCE	TETRACHLOROETHENE
RD	ROAD
ST	STREET
TCE	TRICHLOROETHENE
VOC	VOLATILE ORGANIC COMPOUND

NOTES

1. PCE AND TCE RESULTS FROM WELLS SHOWN IN BLUE ARE NOT DETECTED ABOVE THE 1 µg/L REPORTING LIMIT.

NORTH

0 1,250 2,500 Feet

1 " = 2,500 '

First FYR for South AFRL

Non Detect Wells for VOCs at South AFRL

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		6.4-4

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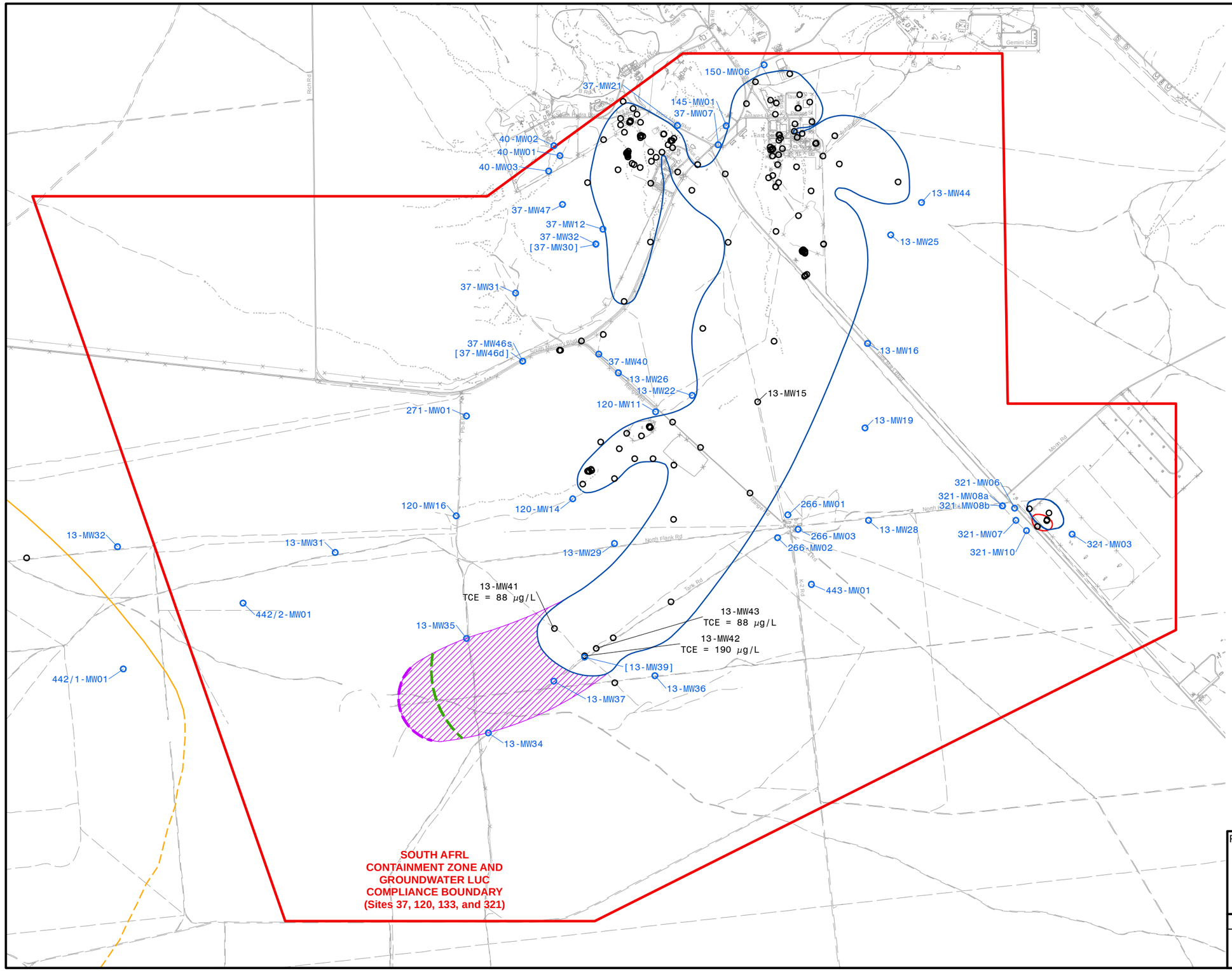

EXPLANATION

- EXTRACTION/INJECTION/MONITORING/OBSERVATION WELL LOCATION
- ESTIMATED BEDROCK TO ALLUVIAL AQUIFER TRANSITION (DASHED WHERE INFERRED)
- SOUTH AFRL CONTAINMENT ZONE AND GROUNDWATER LUC COMPLIANCE BOUNDARY
- ESTIMATED EXTENT OF TCE CONCENTRATION TO 1 µg/L
- ESTIMATED EXTENT BASED ON APPROXIMATE DISTANCE (4,000 FEET) BETWEEN THE 1-µg/L AND 100-µg/L SIMULATED TCE CONTOURS FROM THE 2012 GOUNDWATER MODELING REPORT FOR THE SOUTH AFRL
- ESTIMATED EXTENT BASED ON STRAIGHT LINEAR RELATIONSHIP BETWEEN CONCENTRATION AND DISTANCE USING SLOPE BETWEEN WELLS 13-MW15 AND 13-MW42
- ESTIMATED AREA COVERED BY TCE PLUME ASSUMING WELLS 13-MW37, 13-MW35, AND 13-MW34 DO NOT ENCOUNTER THE WATER-BEARING UNIT AT WELLS 13-MW41 AND 13-MW42, BASED ON 2011 DATA
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- TOPOGRAPHY DRAINAGE
- [ ] VERTICAL EXTENT WELL. DATA NOT USED TO CONTOUR.

ABBREVIATIONS

µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
BLVD	BOULEVARD
CIR	CIRCLE
CSM	CONCEPTUAL SITE MODEL
DR	DRIVE
FYR	FIVE-YEAR REVIEW
LUC	LAND USE CONTROL
PCE	TETRACHLOROETHENE
RD	ROAD
ST	STREET
TCE	TRICHLOROETHENE
USEPA	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
VOC	VOLATILE ORGANIC COMPOUND

NOTES

1. PCE AND TCE RESULTS FROM WELLS SHOWN IN BLUE ARE NOT DETECTED ABOVE THE 1 µg/L REPORTING LIMIT.
2. ALTERNATE ESTIMATES OF PLUME EXTENT TO REFLECT USEPA CSM OF FRACTURE FLOW (SEE SECTION 6.4.2.2).

NORTH

0 1,250 2,500 Feet

1 " = 2,500 '

First FYR for South AFRL

Estimated TCE Plume Extents Based on Alternative Methods to Depict USEPA Hypothesis

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		6.4-5

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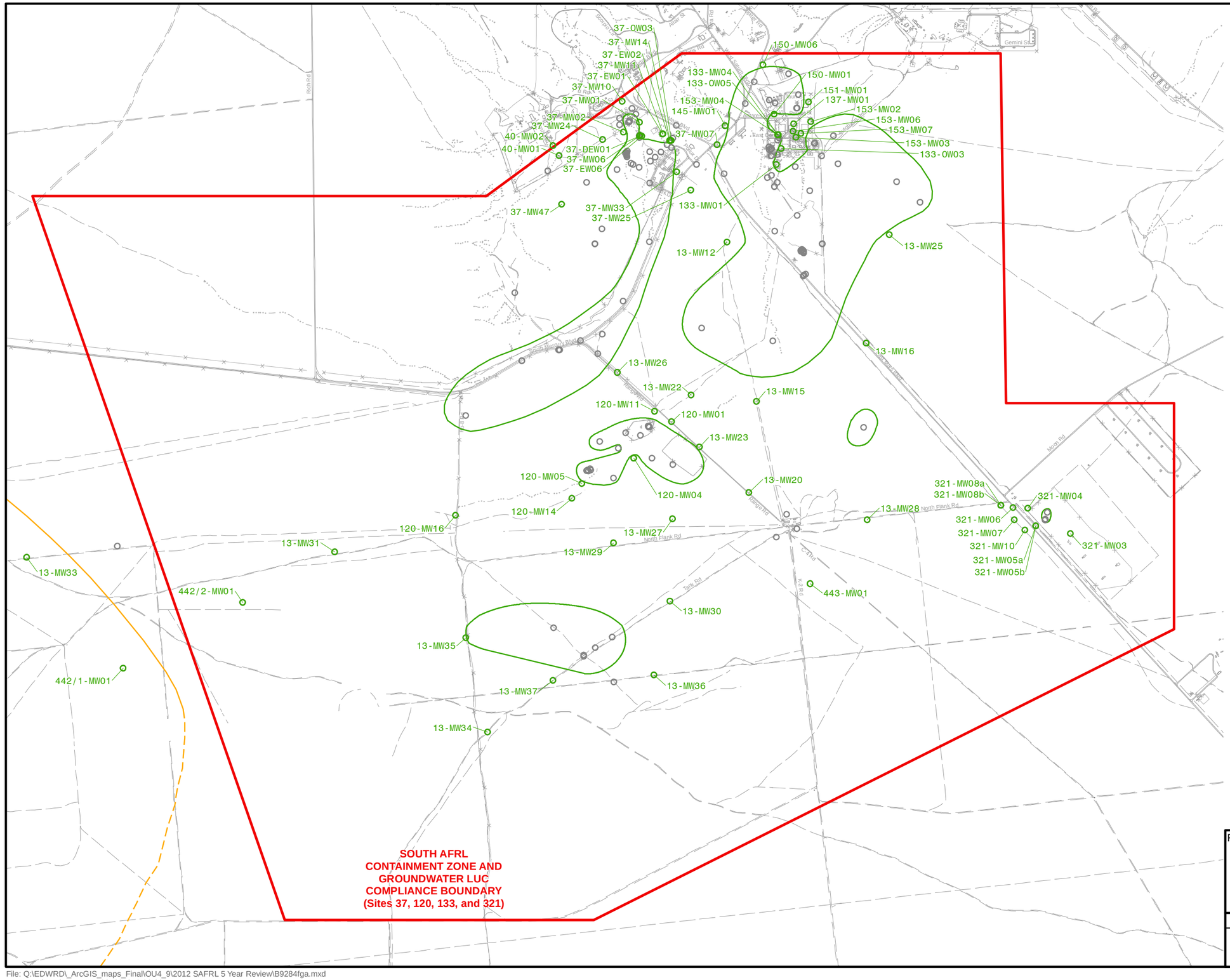

EXPLANATION

- EXTRACTION/INJECTION/MONITORING/OBSERVATION WELL LOCATION
- ESTIMATED BEDROCK TO ALLUVIAL AQUIFER TRANSITION (DASHED WHERE INFERRED)
- SOUTH AFRL CONTAINMENT ZONE AND GROUNDWATER LUC COMPLIANCE BOUNDARY
- CONTOUR LINE OF PERCHLORATE CONCENTRATION IN 0.001 mg/L
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- TOPOGRAPHY DRAINAGE
- [ ] VERTICAL EXTENT WELL. DATA NOT USED TO CONTOUR.

ABBREVIATIONS

mg/L	MILLIGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
BLVD	BOULEVARD
CIR	CIRCLE
DR	DRIVE
FYR	FIVE-YEAR REVIEW
LUC	LAND USE CONTROL
RD	ROAD
ST	STREET

NOTES

1. PERCHLORATE RESULTS FROM WELLS SHOWN IN GREEN ARE NOT DETECTED ABOVE 0.001 mg/L. WELLS SHOWN IN GRAY SHADE LOCATED OUTSIDE THE 0.001 mg/L CONTOUR WERE NOT SAMPLED FOR PERCHLORATE.

NORTH

0 1,250 2,500 Feet

1 " = 2,500 '

First FYR for South AFRL

Non Detect Wells for Perchlorate at South AFRL

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		6.4-6

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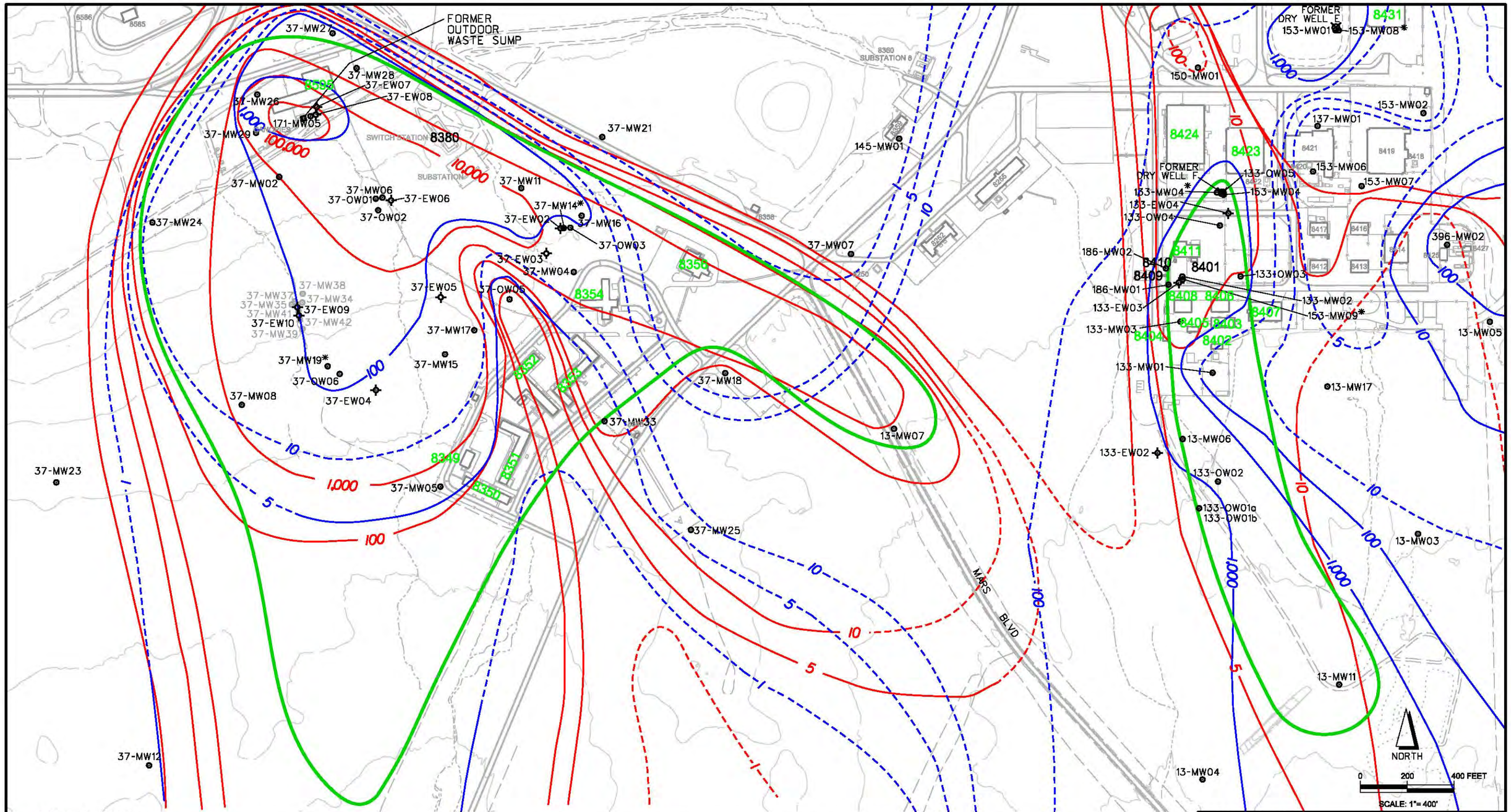

EXPLANATION

- CONTOUR LINE OF GWVCL–IND BASED ON THE 2005 EXTENT OF TCE AND PCE AT A 10^{-6} RISK LEVEL FOR INDUSTRIAL EXPOSURE
- 5 — CONTAMINANT LEVEL CONTOUR LINE OF PCE IN µg/L (DASHED WHERE INFERRED)
- 5 — CONTAMINANT LEVEL CONTOUR LINE OF TCE IN µg/L (DASHED WHERE INFERRED)
- MONITORING WELL LOCATION
- EXTRACTION WELL LOCATION
- * VERTICAL EXTENT WELL
- SURFACE DRAINAGE

µg/L MICROGRAMS PER LITER
AFB AIR FORCE BASE
AFRL AIR FORCE RESEARCH LABORATORY
BLVD BOULEVARD
FYR FIVE–YEAR REVIEW
GWVCL–IND GROUNDWATER VAPOR COMPLIANCE LEVEL FOR INDUSTRIAL EXPOSURE
PCE TETRACHLOROETHENE
TCE TRICHLOROETHENE
VI VAPOR INTRUSION
VIP VAPOR INTRUSION PATHWAY

NOTES

1. BUILDING NUMBERS SHOWN IN GREEN ARE OCCUPIED BUILDINGS INCLUDED IN VIP EVALUATION.
2. ADAPTED FROM FIGURE 1.5–1 OF THE SOUTH AFRL VI REPORT (AECOM 2012c)

First FYR for South AFRL

Site 37 PCE Plume and Site 133 TCE Plume Contours within the GWVCLs-ind Compliance Boundary

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		6.4-7

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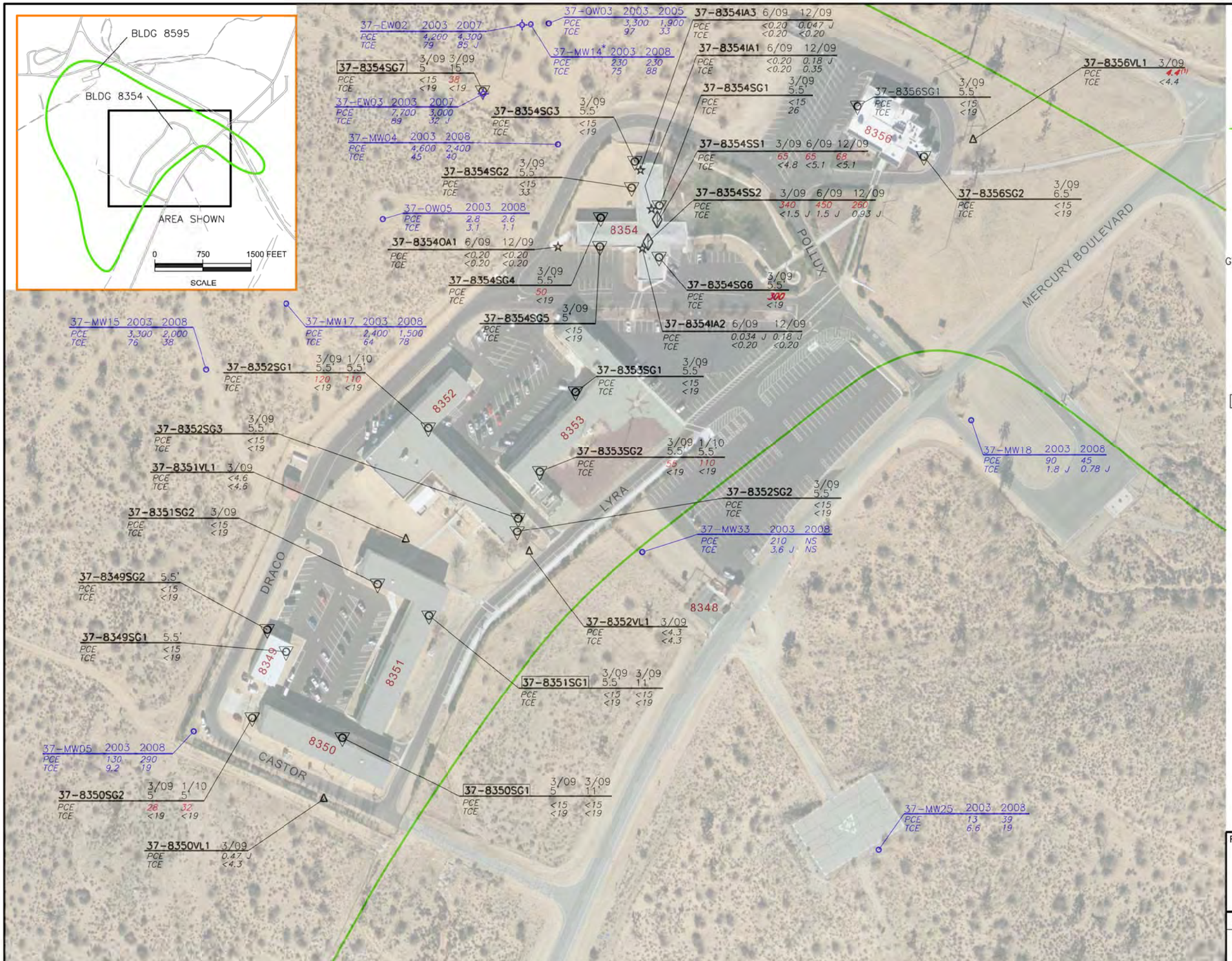

EXPLANATION

- VAPOR MONITORING WELL
- INDOOR/OUTDOOR AIR SAMPLE LOCATIONS (8-HOUR SAMPLE PERIOD)
- SUB-SLAB VAPOR MONITORING WELL
- GROUNDWATER MONITORING WELL
- GROUNDWATER EXTRACTION WELL
- UNDERGROUND COMMUNICATION/ELECTRICAL VAULT
- CONTOUR LINE OF GWVCL-IND BASED ON THE 2005 EXTENT OF TCE AND PCE AT A 10^{-6} RISK LEVEL FOR INDUSTRIAL EXPOSURE

*	VERTICAL EXTENT GROUNDWATER MONITORING WELL
%	PERCENT
<	LESS THAN
µg/L	MICROGRAMS PER LITER
ppb[v]	PARTS PER BILLION BY VOLUME
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
BLDG	BUILDING
FYR	FIVE-YEAR REVIEW
GW	GROUNDWATER
GWVCL-IND	GROUND WATER VAPOR COMPLIANCE LEVEL FOR INDUSTRIAL EXPOSURE
ID	IDENTIFICATION
NS	NOT SAMPLED
PCE	TETRACHLOROETHENE
ROD	RECORD OF DECISION
SN	SCREENING NUMBER (REFER TO TABLE 4.3-4)
TCE	TRICHLOROETHENE
VI	VAPOR INTRUSION
(1)	VAPOR RESULTS EXCEEDS THE SCREENING NUMBER FOR PCE IN VAULT SAMPLES OF 2.5 PPB[V], REFER TO TABLE 4.3-4.

LOCATION ID — WELLS SHOWN WITH A BOX AROUND THE ID INDICATE A NESTED VAPOR WELL

LOCATION ID	SAMPLE DEPTH AND/OR DATE
ANALYTE	*VAPOR CONCENTRATION IN ppb[v] (SHOWN IN BLACK)* *GW CONCENTRATION IN µg/L (SHOWN IN BLUE)*

LABORATORY-ASSIGNED DATA QUALIFIER

J — ESTIMATED VALUE, VALUE IS BELOW THE REPORTING LIMIT BUT ABOVE THE METHOD DETECTION LIMIT.

NOTES

1. VAPOR CONCENTRATIONS EXCEEDING SN SHOWN IN **RED BOLD**; RESULTS EXCEEDING 10% SN SHOWN IN RED
2. HIGHEST CONCENTRATION VALUE DETECTED ARE SHOWN IF DUPLICATE OR CONFIRMATION SAMPLES WERE TAKEN.
3. ADAPTED FROM FIGURE 2.2-1 OF THE SOUTH AFRL VI REPORT (AECOM 2012c).

NORTH

0 75 150 FEET

SCALE: 1"= 150'

First FYR for South AFRL

Site 37 Vapor Sampling Locations and Results

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		6.4-8

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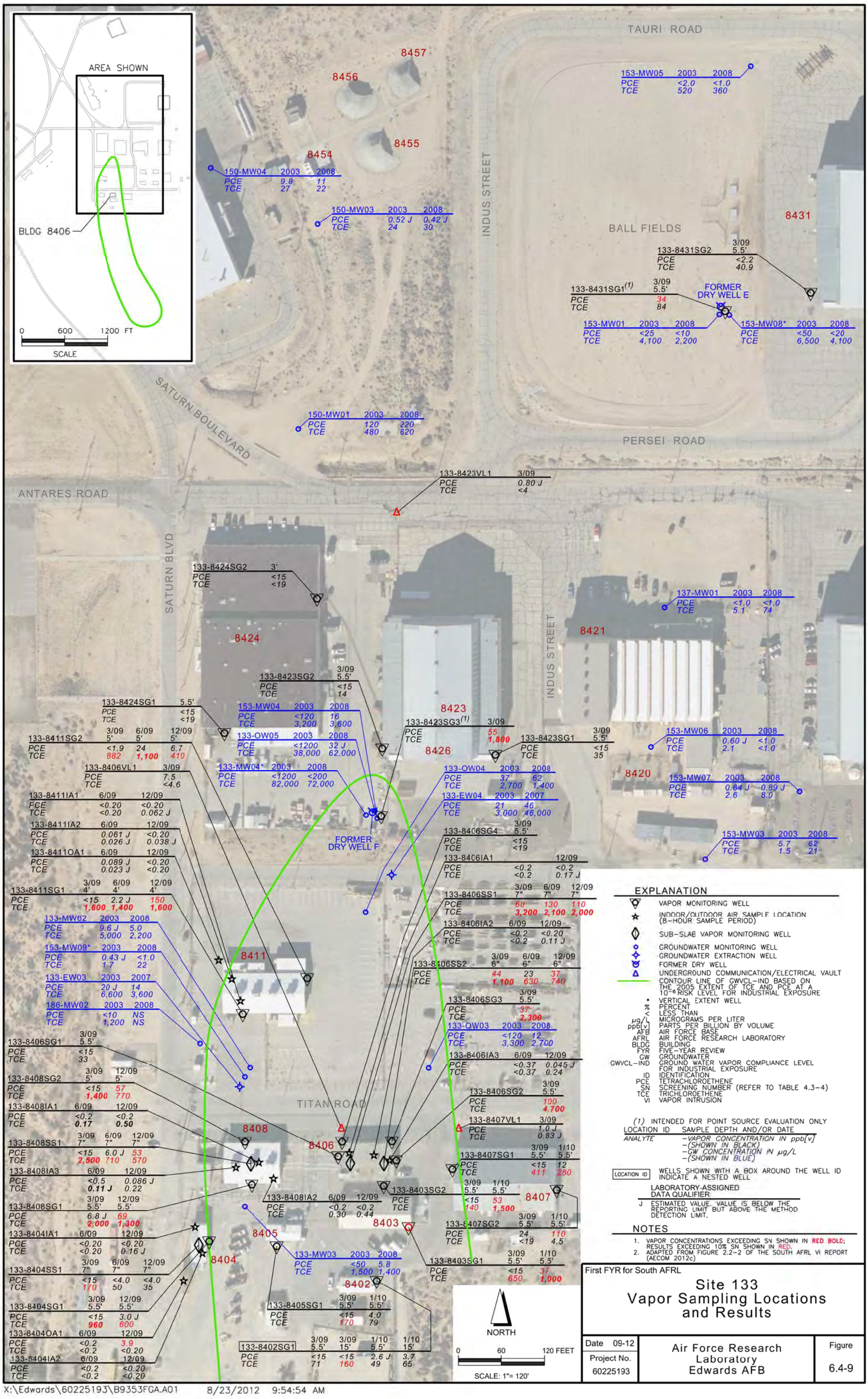

EXPLANATION

- VAPOR MONITORING WELL
- INDOOR/OUTDOOR AIR SAMPLE LOCATION (8-HOUR SAMPLE PERIOD)
- SUB-SLAB VAPOR MONITORING WELL
- GROUNDWATER MONITORING WELL
- GROUNDWATER EXTRACTION WELL
- FORMER DRY WELL
- UNDERGROUND COMMUNICATION/ELECTRICAL VAULT
- CONTOUR LINE OF GWVCL-IND BASED ON THE 2005 EXTENT OF TCE AND PCE AT A 10^{-6} RISK LEVEL FOR INDUSTRIAL EXPOSURE

*	VERTICAL EXTENT WELL
%	PERCENT
<	LESS THAN
µg/L	MICROGRAMS PER LITER
ppb[v]	PARTS PER BILLION BY VOLUME
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
BLDG	BUILDING
FYR	FIVE-YEAR REVIEW
GW	GROUNDWATER
GWVCL-IND	GROUND WATER VAPOR COMPLIANCE LEVEL FOR INDUSTRIAL EXPOSURE
ID	IDENTIFICATION
PCE	TETRACHLOROETHENE
SN	SCREENING NUMBER (REFER TO TABLE 4.3-4)
TCE	TRICHLOROETHENE
VI	VAPOR INTRUSION

(1) INTENDED FOR POINT SOURCE EVALUATION ONLY

LOCATION ID — SAMPLE DEPTH AND/OR DATE

ANALYTE — -VAPOR CONCENTRATION IN ppb[v] -(SHOWN IN BLACK) -GW CONCENTRATION IN µg/L -(SHOWN IN BLUE)

LOCATION ID — WELLS SHOWN WITH A BOX AROUND THE WELL ID INDICATE A NESTED WELL

LABORATORY-ASSIGNED DATA QUALIFIER

J — ESTIMATED VALUE. VALUE IS BELOW THE REPORTING LIMIT BUT ABOVE THE METHOD DETECTION LIMIT.

NOTES

1. VAPOR CONCENTRATIONS EXCEEDING SN SHOWN IN **RED BOLD**; RESULTS EXCEEDING 10% SN SHOWN IN RED.
2. ADAPTED FROM FIGURE 2.2-2 OF THE SOUTH AFRL VI REPORT (AECOM 2012c)

First FYR for South AFRL

Site 133 Vapor Sampling Locations and Results

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		6.4-9

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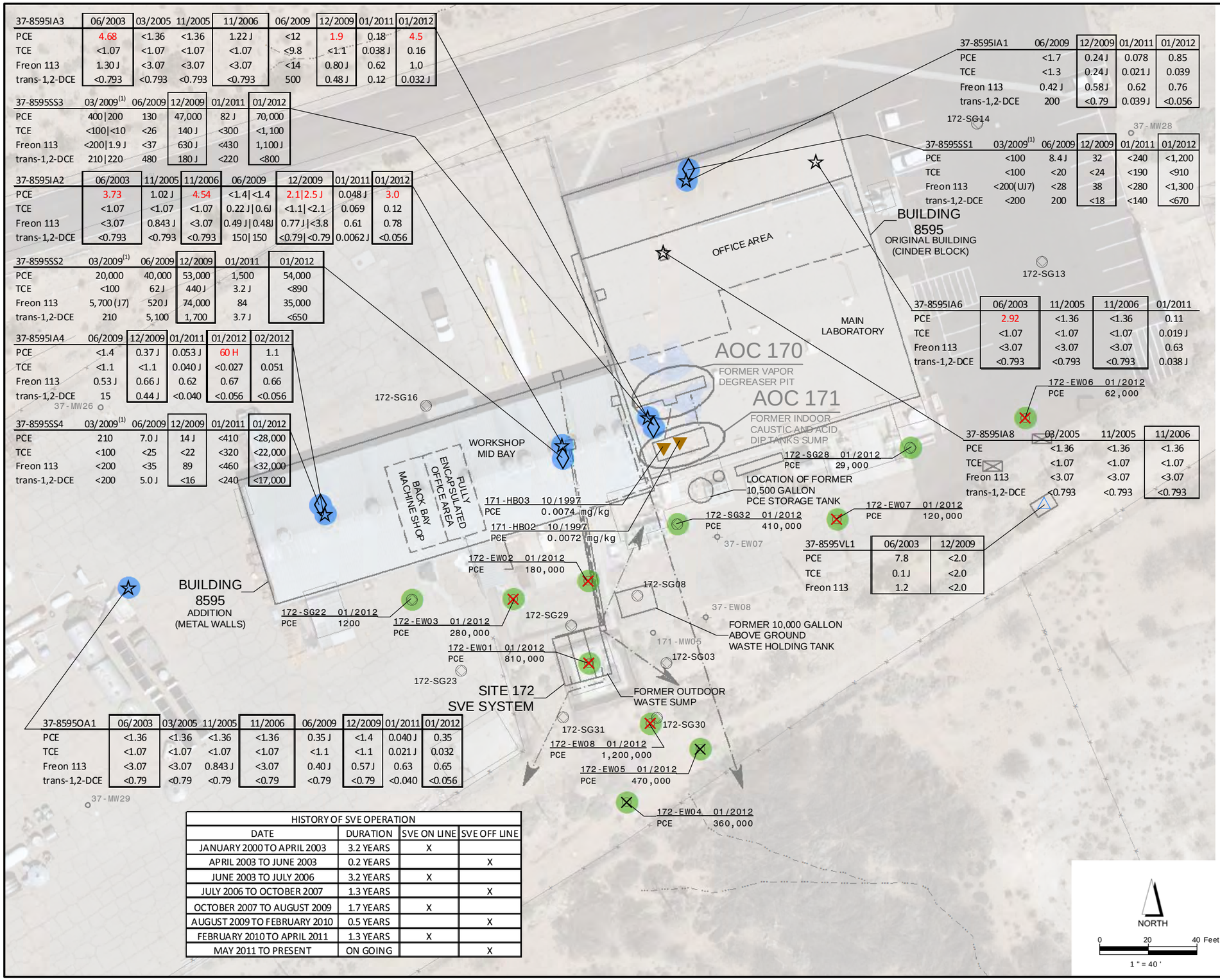

37-8595IA3	06/2003	03/2005	11/2005	11/2006	06/2009	12/2009	01/2011	01/2012
PCE	4.68	<1.36	<1.36	1.22 J	<12	1.9	0.18	4.5
TCE	<1.07	<1.07	<1.07	<1.07	<9.8	<1.1	0.038 J	0.16
Freon 113	1.30 J	<3.07	<3.07	<3.07	<14	0.80 J	0.62	1.0
trans-1,2-DCE	<0.793	<0.793	<0.793	<0.793	500	0.48 J	0.12	0.032 J

37-8595SS3	03/2009(1)	06/2009	12/2009	01/2011	01/2012
PCE	400|200	130	47,000	82 J	70,000
TCE	<100|<10	<26	140 J	<300	<1,100
Freon 113	<200|1.9 J	<37	630 J	<430	1,100 J
trans-1,2-DCE	210|220	480	180 J	<220	<800

37-8595IA2	06/2003	11/2005	11/2006	06/2009	12/2009	01/2011	01/2012
PCE	3.73	1.02 J	4.54	<1.4|<1.4	2.1|2.5 J	0.048 J	3.0
TCE	<1.07	<1.07	<1.07	0.22 J|0.6J	<1.1|<2.1	0.069	0.12
Freon 113	<3.07	0.843 J	<3.07	0.49 J|0.48J	0.77 J|<3.8	0.61	0.78
trans-1,2-DCE	<0.793	<0.793	<0.793	150|150	<0.79|<0.79	0.0062 J	<0.056

37-8595SS2	03/2009(1)	06/2009	12/2009	01/2011	01/2012
PCE	20,000	40,000	53,000	1,500	54,000
TCE	<100	62 J	440 J	3.2 J	<890
Freon 113	5,700 (J7)	520 J	74,000	84	35,000
trans-1,2-DCE	210	5,100	1,700	3.7 J	<650

37-8595IA4	06/2009	12/2009	01/2011	01/2012	02/2012
PCE	<1.4	0.37 J	0.053 J	60 H	1.1
TCE	<1.1	<1.1	0.040 J	<0.027	0.051
Freon 113	0.53 J	0.66 J	0.62	0.67	0.66
trans-1,2-DCE	15	0.44 J	<0.040	<0.056	<0.056

37-8595SS4	03/2009(1)	06/2009	12/2009	01/2011	01/2012
PCE	210	7.0 J	14 J	<410	<28,000
TCE	<100	<25	<22	<320	<22,000
Freon 113	<200	<35	89	<460	<32,000
trans-1,2-DCE	<200	5.0 J	<16	<240	<17,000

37-8595OA1	06/2003	03/2005	11/2005	11/2006	06/2009	12/2009	01/2011	01/2012
PCE	<1.36	<1.36	<1.36	<1.36	0.35 J	<1.4	0.040 J	0.35
TCE	<1.07	<1.07	<1.07	<1.07	<1.1	<1.1	0.021 J	0.032
Freon 113	<3.07	<3.07	0.843 J	<3.07	0.40 J	0.57 J	0.63	0.65
trans-1,2-DCE	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.040	<0.056

37-8595IA1	06/2009	12/2009	01/2011	01/2012
PCE	<1.7	0.24 J	0.078	0.85
TCE	<1.3	0.24 J	0.021 J	0.039
Freon 113	0.42 J	0.58 J	0.62	0.76
trans-1,2-DCE	200	<0.79	0.039 J	<0.056

37-8595SS1	03/2009(1)	06/2009	12/2009	01/2011	01/2012
PCE	<100	8.4 J	32	<240	<1,200
TCE	<100	<20	<24	<190	<910
Freon 113	<200(UJ7)	<28	38	<280	<1,300
trans-1,2-DCE	<200	200	<18	<140	<670

37-8595IA6	06/2003	11/2005	11/2006	01/2011
PCE	2.92	<1.36	<1.36	0.11
TCE	<1.07	<1.07	<1.07	0.019 J
Freon 113	<3.07	<3.07	<3.07	0.63
trans-1,2-DCE	<0.793	<0.793	<0.793	0.038 J

37-8595IA8	03/2005	11/2005	11/2006
PCE	<1.36	<1.36	<1.36
TCE	<1.07	<1.07	<1.07
Freon 113	<3.07	<3.07	<3.07
trans-1,2-DCE	<0.793	<0.793	<0.793

37-8595VL1	06/2003	12/2009
PCE	7.8	<2.0
TCE	0.1 J	<2.0
Freon 113	1.2	<2.0

HISTORY OF SVE OPERATION			
DATE	DURATION	SVE ON LINE	SVE OFF LINE
JANUARY 2000 TO APRIL 2003	3.2 YEARS	X	
APRIL 2003 TO JUNE 2003	0.2 YEARS		X
JUNE 2003 TO JULY 2006	3.2 YEARS	X	
JULY 2006 TO OCTOBER 2007	1.3 YEARS		X
OCTOBER 2007 TO AUGUST 2009	1.7 YEARS	X	
AUGUST 2009 TO FEBRUARY 2010	0.5 YEARS		X
FEBRUARY 2010 TO APRIL 2011	1.3 YEARS	X	
MAY 2011 TO PRESENT	ON GOING		X

EXPLANATION

- SUB-SLAB VAPOR MONITORING WELL
- SOIL VAPOR OBSERVATION WELL
- SOIL VAPOR EXTRACTION WELL (EXTRACTION WELLS SHOWN IN RED WILL BE ONLINE WHEN SVE IS REACTIVATED)
- INDOOR/OUTDOOR AIR SAMPLE LOCATION (8-HOUR SAMPLE PERIOD) (RESULTS SHOWN IN RED EXCEED IAVML-IND FOR PCE OF 1.7 µg/m^3 ESTABLISHED IN THE SOUTH AFRL ROD [USAF 2007])
- UNDERGROUND COMMUNICATION/ELECTRICAL VAULT
- FORMER INDOOR SUMP SOIL SAMPLE (CITED IN SECTION 3.3.1.3)
- GROUNDWATER MONITORING WELL
- GROUNDWATER EXTRACTION WELL
- INDOOR AIR/SUB-SLAB SAMPLE LOCATIONS (ALL AVAILABLE SAMPLE RESULTS SHOWN)
- EXTRACTION/VAPOR MONITORING WELL SAMPLE LOCATIONS (ONLY MOST RECENT SAMPLING RESULTS SHOWN)
- PIPING (ABOVE GROUND)
- PIPING (BELOW GROUND)

LOCATION ID SAMPLE DATE
ANALYTE VAPOR CONCENTRATION IN µg/m^3

RESULTS IN BOX WERE COLLECTED WHEN SVE WAS NOT OPERATING

ABBREVIATIONS

<	LESS THAN
µg/m^3	MICROGRAMS PER CUBIC METER
mg/kg	MILLIGRAMS PER KILOGRAM
AFRL	AIR FORCE RESEARCH LABORATORY
AOC	AREA OF CONCERN
DCE	DICHLOROETHENE
FYR	FIVE-YEAR REVIEW
IAVML-IND	INDOOR AIR VAPOR MITIGATION LEVEL FOR INDUSTRIAL EXPOSURE
PCE	TETRACHLOROETHENE
ROD	RECORD OF DECISION
SIM	SELECTIVE ION MONITORING
SVE	SOIL VAPOR EXTRACTION SYSTEM
TCE	TRICHLOROETHENE
USAF	UNITED STATES AIR FORCE
VIP	VAPOR INTRUSION PATHWAY
VOC	VOLATILE ORGANIC COMPOUND

LABORATORY-ASSIGNED DATA QUALIFIER

J	ESTIMATED VALUE. VALUE IS BELOW THE REPORTING LIMIT BUT ABOVE THE METHOD DETECTION LIMIT.
H	SAMPLE WAS PREPPED OR ANALYZED OUTSIDE THE HOLDING TIME.

DATA VALIDATION QUALIFIER

(J7)	ESTIMATED VALUE. INITIAL OR CALIBRATION WAS OUTSIDE OF CRITERIA.
(UJ7)	ESTIMATED REPORTING LIMIT. INITIAL OR CONTINUING CALIBRATION WAS OUTSIDE OF CRITERIA.

NOTES

I. VAPOR MONITORING WELLS WERE ANALYZED FOR VOCs BY METHOD TO14 (BETWEEN 06/2003 AND 12/2009) AND TO15 (BETWEEN 01/2011 AND 01/2012). SAMPLES FROM INDOOR AND OUTDOOR AIR WERE ANALYZED FOR VOCs BY METHOD TO15 SIM.

II. INDOOR, OUTDOOR, AND SUB-SLAB LOCATION. ONLY CONCENTRATIONS OF PCE, TCE, FREON 113, AND TRANS-1,2-DCE ARE LISTED (WHERE DETECTED).

III. OUTSIDE VAPOR WELLS. ONLY CONCENTRATION OF PCE ARE LISTED.

(1) GRAB SAMPLES FROM SUB-SLAB WELLS ANALYZED BY MODIFIED 8260B FROM ONSITE MOBILE LABORATORY.

(2) ADAPTED FROM FIGURE 4.5-1 OF THE SOUTH AFRL VI REPORT (AECOM 2012c)

First FYR for South AFRL

Building 8595 Indoor Air and Extraction Well Sampling Results

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		6.4-10

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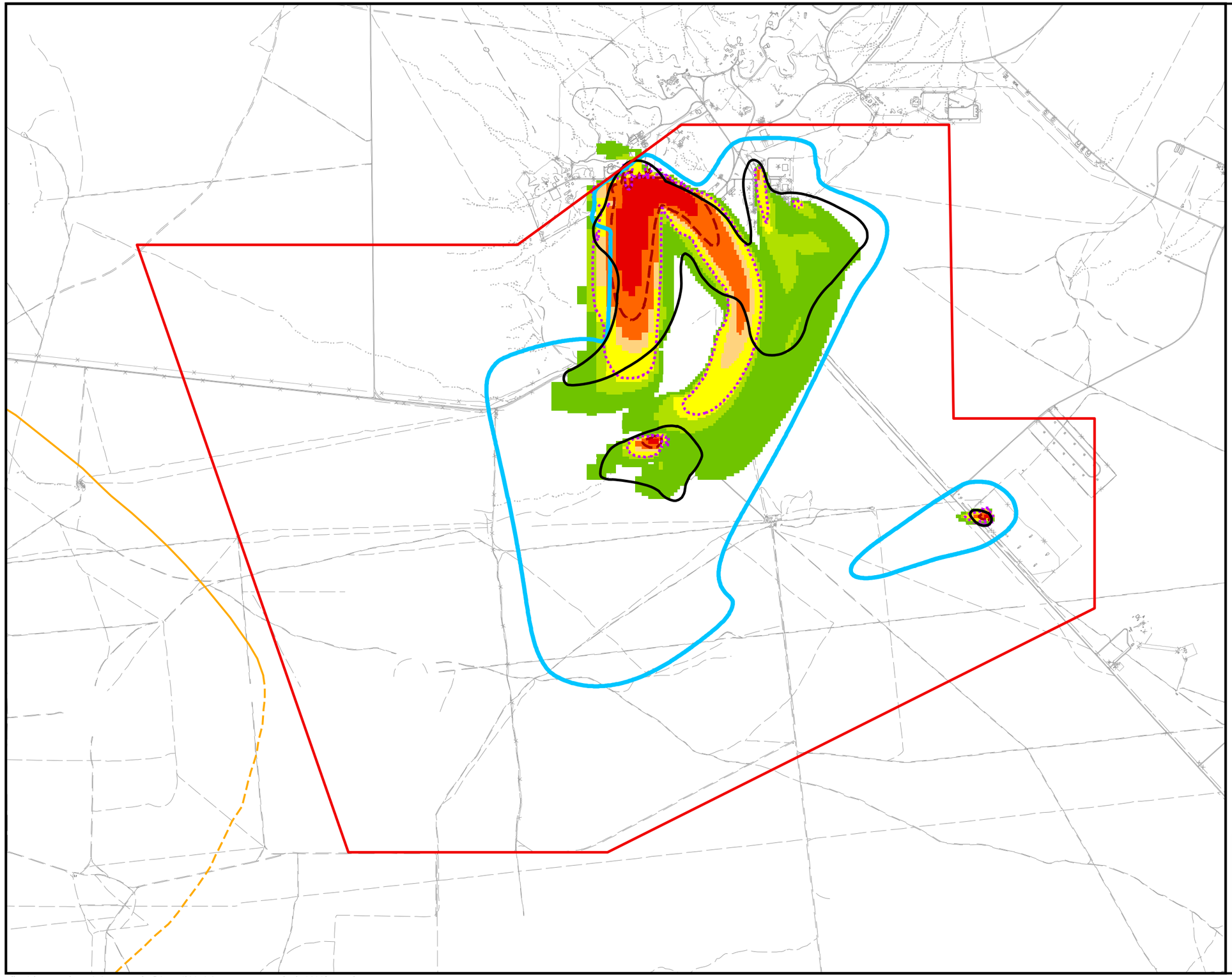

EXPLANATION

- SOUTH AFRL CZ
- ESTIMATED LOCATION OF BEDROCK ALLUVIAL AQUIFER CONTACT (DASHED WHERE INFERRED)
- VICB FROM 2007 SOUTH AFRL ROD BASED ON THE 30-YEAR PROJECTED EXTENT OF THE GWCVLs-RES FOR TCE AND PCE AT A 10^{-6} RISK LEVEL FOR RESIDENTIAL USE (ESTABLISHED USING 2005 GROUNDWATER MODEL)
- CONTOUR LINE OF 13 µg/L (GWVCL-RES AT A 10^{-6} RISK LEVEL ESTABLISHED USING OEHHA TOXICITY CRITERIA FOR PCE) – 30-YEAR PROJECTED EXTENT USING 2012 GROUNDWATER MODEL
- CONTOUR LINE OF 300 µg/L (CONCENTRATION AT A 10^{-6} RISK LEVEL ESTABLISHED USING IRIS TOXICITY CRITERIA FOR PCE) – 30-YEAR PROJECTED EXTENT USING 2012 GROUNDWATER MODEL
- ESTIMATED EXTENT OF THE SOUTH AFRL PCE PLUME USING MOST CURRENT DATA AVAILABLE THROUGH 2011

ABBREVIATIONS

µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
CZ	CONTAINMENT ZONE
FYR	FIVE-YEAR REVIEW
GWVCL-RES	GROUNDWATER VAPOR COMPLIANCE LEVEL AT A 10^{-6} RISK LEVEL FOR RESIDENTIAL USE
IRIS	INTEGRATED RISK INFORMATION SYSTEM
OEHHA	OFFICE OF HEALTH HAZARD ASSESMENT
PCE	TETRACHLOROETHENE
ROD	RECORD OF DECISION
TCE	TRICHLOROETHENE
VICB	VAPOR INSTRUSION COMPLIANCE BOUNDARY

CONCENTRATIONS (µg/L) - 30-YEAR PROJECTED EXTENT

- 1-5
- 5-10
- 10-50
- 50-100
- 100-1,000
- 1,000+

NOTES

1. 300 µg/L WOULD BE THE GWVCL-RES ESTABLISHED USING 2011 REVISED IRIS TOXICITY CRITERIA AT A 10^{-6} RISK LEVEL FOR RESIDENTIAL USE.
2. 13 µg/L IS THE GWVCL-RES ESTABLISHED IN THE 2007 ROD USING OEHHA TOXICITY CRETERION AT A 10^{-6} RISK LEVEL FOR RESIDENTIAL USE.

NORTH

0 1,500 3,000 Feet

1 " = 3,000 '

First FYR for South AFRL

Projected Extent of PCE Contours at 13 µg/L and 300 µg/L (Using the 2012 Groundwater Model)

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		6.4-11

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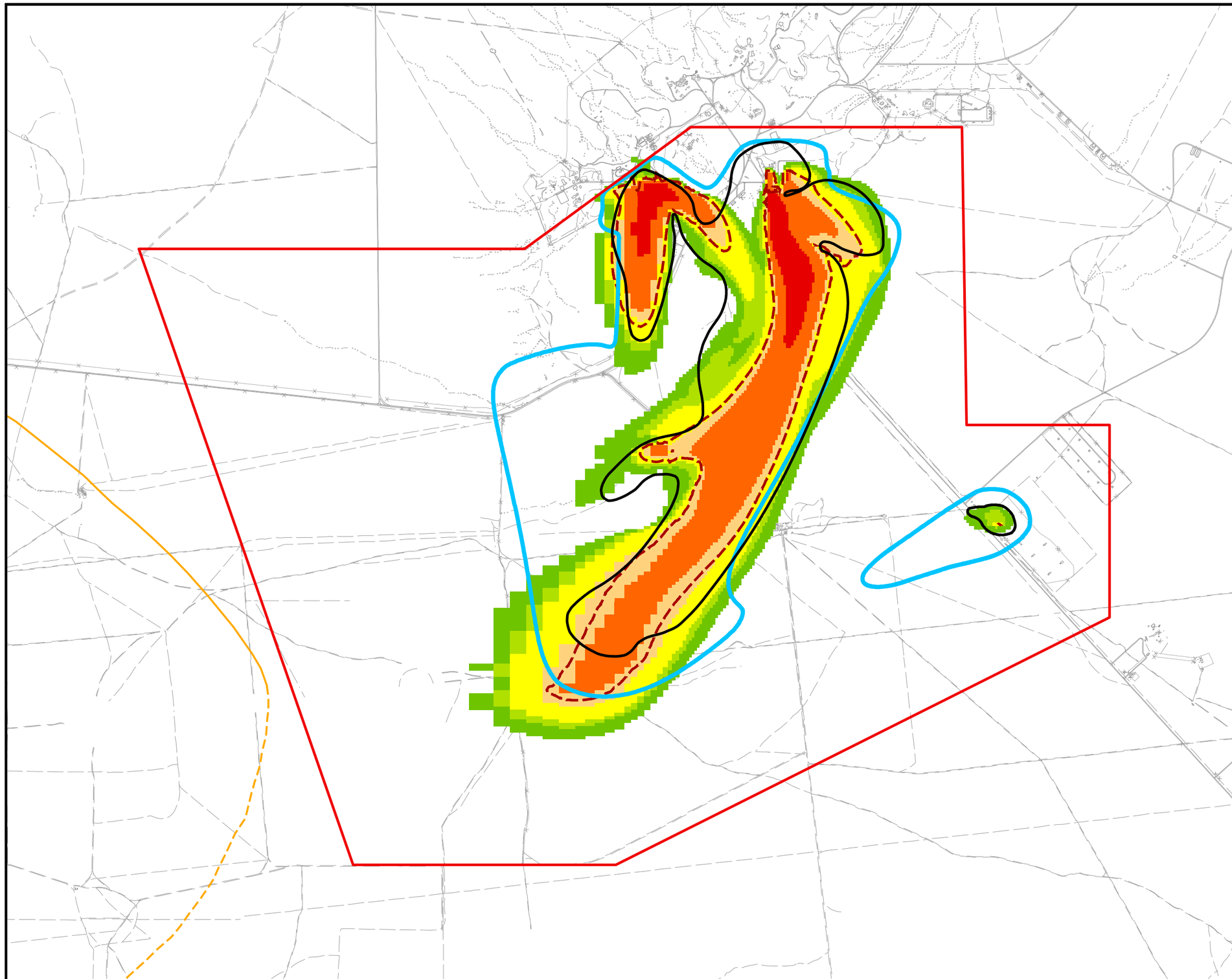

EXPLANATION

- SOUTH AFRL CZ
- ESTIMATED LOCATION OF BEDROCK ALLUVIAL AQUIFER CONTACT (DASHED WHERE INFERRED)
- VICB FROM 2007 SOUTH AFRL ROD BASED ON THE 30-YEAR PROJECTED EXTENT OF THE GWCVLs-RES FOR TCE AND PCE AT A 10^{-6} RISK LEVEL FOR RESIDENTIAL USE
- CONTOUR LINE OF 30 µg/L TCE – 30-YEAR PROJECTED EXTENT USING 2012 GROUNDWATER MODEL
- ESTIMATED EXTENT OF THE SOUTH AFRL TCE PLUME USING MOST CURRENT DATA AVAILABLE THROUGH 2011

ABBREVIATIONS

µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
CZ	CONTAINMENT ZONE
FYR	FIVE-YEAR REVIEW
GWVCL-RES	GROUNDWATER VAPOR COMPLIANCE LEVEL AT A 10^{-6} RISK LEVEL FOR RESIDENTIAL USE
IRIS	INTEGRATED RISK INFORMATION SYSTEM
PCE	TETRACHLOROETHENE
ROD	RECORD OF DECISION
TCE	TRICHLOROETHENE
VICB	VAPOR INSTRUSION COMPLIANCE BOUNDARY

CONCENTRATIONS (µg/L) - 30-YEAR PROJECTED EXTENT

- 1-5
- 5-10
- 10-50
- 50-100
- 100-1,000
- 1,000+

NOTE

1. 30 µg/L WOULD BE THE GWVCL-RES ESTABLISHED USING 2011 REVISED IRIS TOXICITY CRITERION AT A 10^{-6} RISK LEVEL FOR RESIDENTIAL USE.
2. THE VICB ESTABLISHED IN THE 2007 ROD IS BASED ON THE 30-YEAR PROJECTED EXTENT (USING 2005 MODEL) OF TCE AT A CONCENTRATION OF 60 µg/L AND PCE AT A CONCENTRATION OF 13 µg/L.

NORTH

0 1,500 3,000 Feet

1 " = 3,000 '

First FYR for South AFRL

Projected Extent of TCE Contours at 30 µg/L (Using the 2012 Groundwater Model)

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		6.4-12

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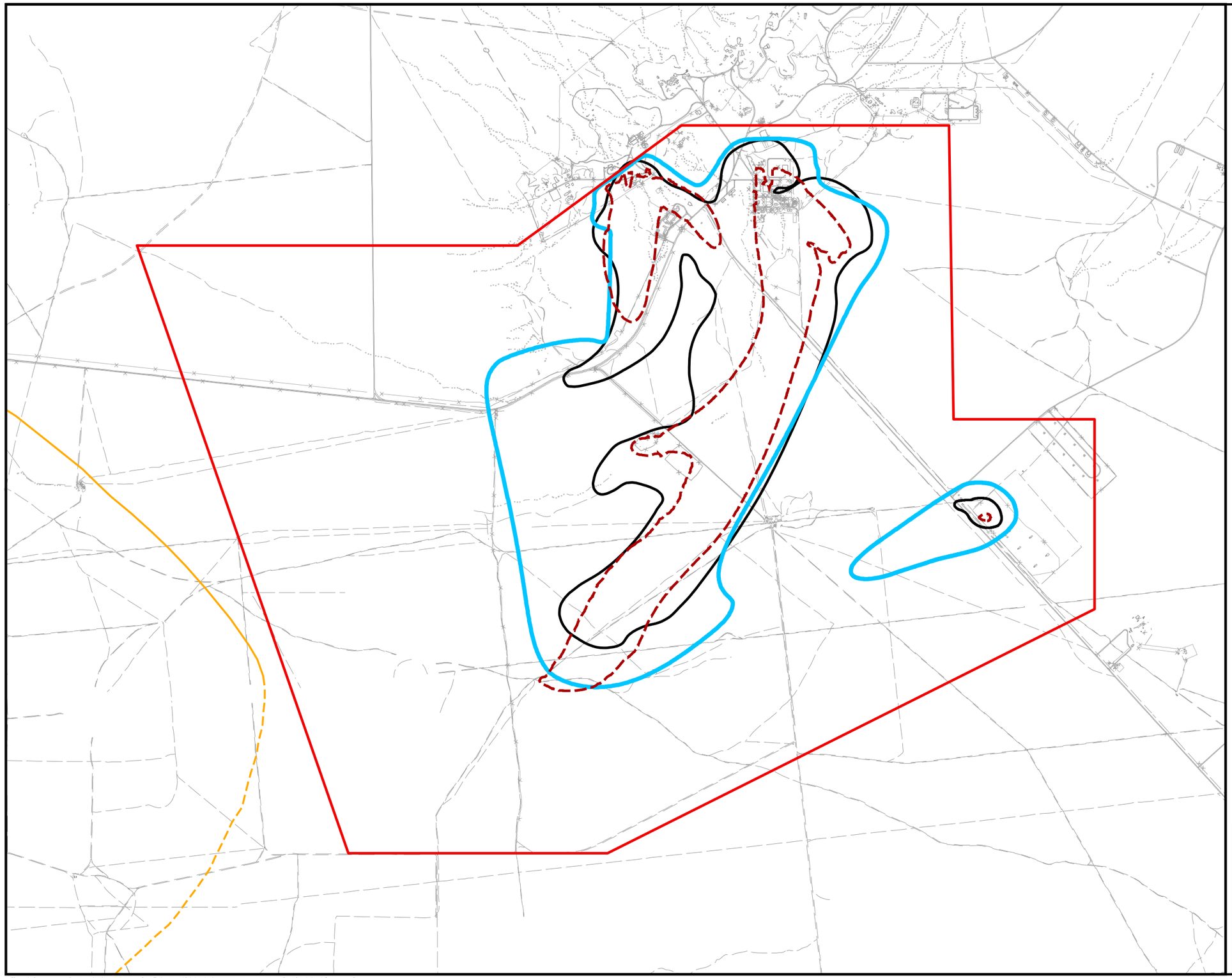

EXPLANATION

- SOUTH AFRL CONTAINMENT ZONE AND GROUNDWATER LUC COMPLIANCE BOUNDARY
- ESTIMATED LOCATION OF BEDROCK ALLUVIAL AQUIFER CONTACT (DASHED WHERE INFERRED)
- VICB FROM 2007 SOUTH AFRL ROD BASED ON THE 30 YEAR PROJECTED EXTENT OF THE GWCVLs-RES FOR TCE AND PCE AT A 10^{-6} RISK LEVEL FOR RESIDENTIAL USE (ESTABLISHED USING 2005 GROUNDWATER MODEL)
- 30-YEAR PROJECTED EXTENT OF THE COMBINED 300 µg/L PCE AND 30 µg/L TCE CONTOURS USING 2012 GROUNDWATER MODEL
- ESTIMATED EXTENT OF THE 1 µg/L COMBINED SOUTH AFRL PCE AND TCE PLUME USING MOST CURRENT DATA AVAILABLE THROUGH 2011

ABBREVIATIONS

µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
FYR	FIVE-YEAR REVIEW
GW	GROUNDWATER
GWVCL-RES	GROUNDWATER VAPOR COMPLIANCE LEVEL AT A 10^{-6} RISK LEVEL FOR RESIDENTIAL USE
LUC	LAND USE CONTROL
PCE	TETRACHLOROETHENE
ROD	RECORD OF DECISION
TCE	TRICHLOROETHENE
VICB	VAPOR INTRUSION COMPLIANCE BOUNDARY

NORTH

0 1,500 3,000 Feet

1 " = 3,000 '

First FYR for South AFRL

Comparison of the 2007 ROD VICB to the 30-Year Projected Extent of the Combined 300 µg/L PCE and 30 µg/L TCE Contours (Using the 2012 Groundwater Model)

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60133607		6.4-13

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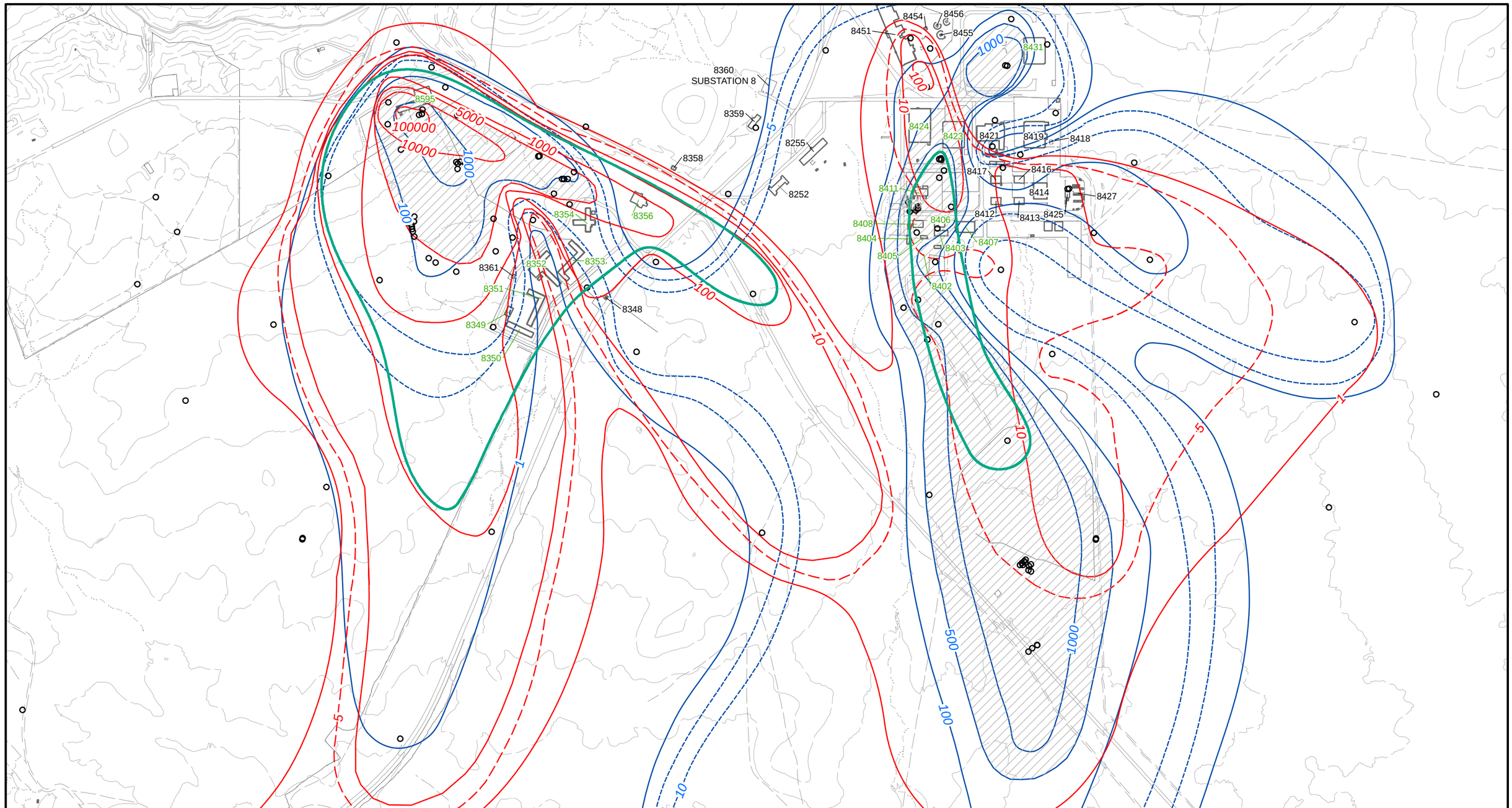

EXPLANATION

- AREA WHERE GROUNDWATER CONCENTRATIONS EXCEED GWVCL-IND BASED ON CURRENT EXTENT OF TCE AND PCE AT A 10^{-6} RISK LEVEL FOR INDUSTRIAL EXPOSURE USING TOXICITY CRITERIA UPDATED THRU 2012
- CONTAMINANT LEVEL CONTOUR LINE OF PCE IN µg/L (DASHED WHERE INFERRED)
- CONTAMINANT LEVEL CONTOUR LINE OF TCE IN µg/L (DASHED WHERE INFERRED)
- MONITORING WELL LOCATION
- SURFACE DRAINAGE
- CONTOUR LINE OF GWVCL-IND PRESENTED IN THE 2007 SOUTH AFRL ROD AND BASED ON THE 2005 EXTENT OF TCE AND PCE AT A 10^{-6} RISK LEVEL FOR INDUSTRIAL EXPOSURE

BUILDING NUMBERS SHOWN IN GREEN ARE OCCUPIED BUILDINGS INCLUDED IN VIP EVALUATION.

µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
BLVD	BOULEVARD
GWVCL-IND	GROUNDWATER VAPOR COMPLIANCE LEVEL FOR INDUSTRIAL EXPOSURE
PCE	TETRACHLOROETHENE
TCE	TRICHLOROETHENE
VIP	VAPOR INTRUSION PATHWAY

NORTH

0 350 700 Feet

1 " = 700 '

First FYR for South AFRL

Site 37 PCE Plume and Site 133 TCE Plume Contours within the Revised GWVCLs-ind Compliance Boundary Calculated using Updated Toxicity Criteria

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		6.4-14

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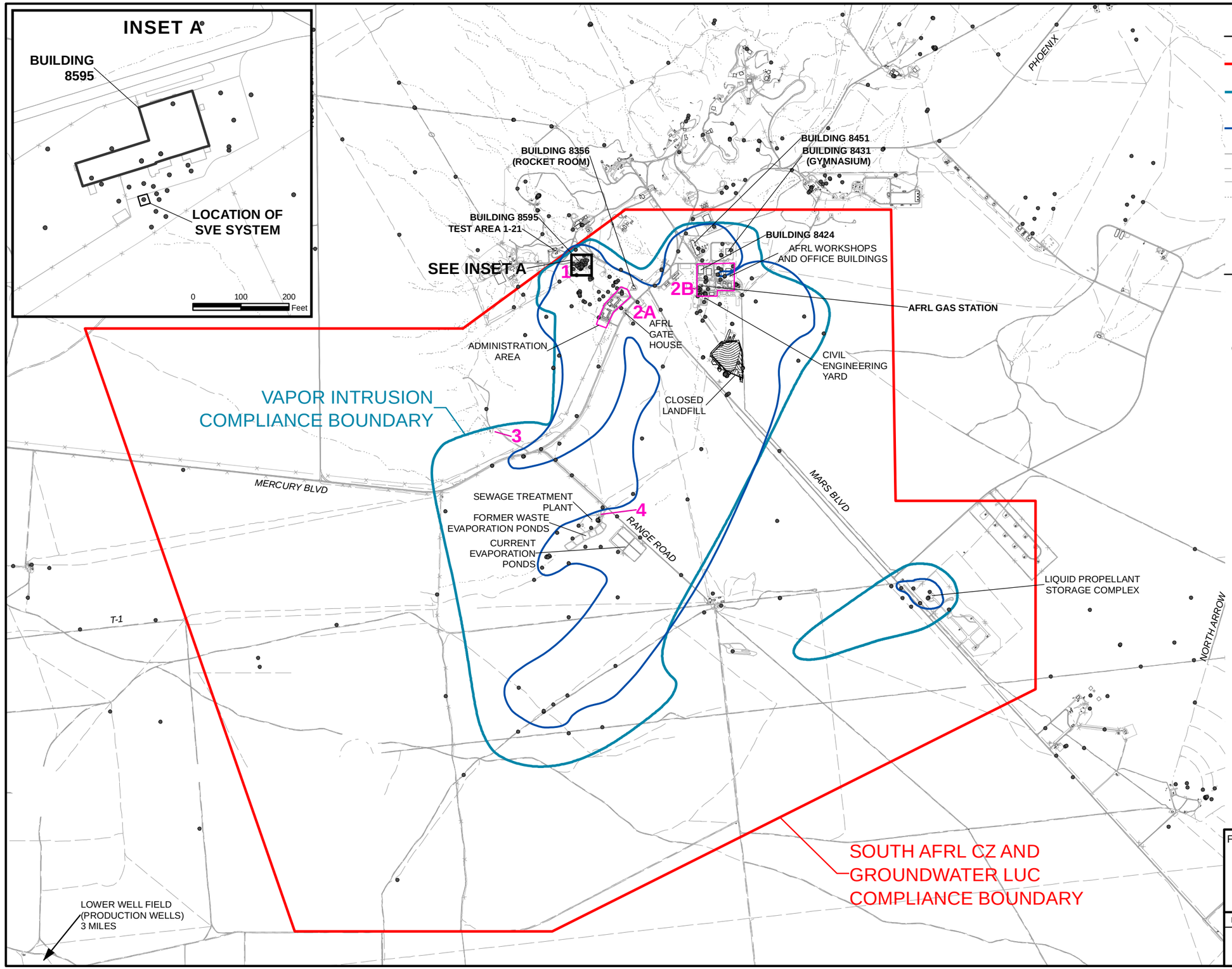

EXPLANATION

- SOIL GAS OR GROUNDWATER WELL LOCATION
- SOUTH AFRL CZ BOUNDARY
- VICB BASED ON THE 30-YEAR PROJECTED EXTENT OF THE GWVCLs-RES FOR TCE AND PCE AT A 10^{-6} RISK LEVEL FOR RESIDENTIAL USE.
- ESTIMATED EXTENT OF THE 1 µg/L SOUTH AFRL PCE AND TCE PLUME USING MOST CURRENT DATA AVALABLE THROUGH 2011.
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- TOPOGRAPHY DRAINAGE
- 1 SITE INSPECTION TOUR STOP

ABBREVIATIONS

µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
BLVD	BOULEVARD
CZ	CONTAINMENT ZONE
FYR	FIVE-YEAR REVIEW
GWVCLs-RES	RESIDENTIAL GROUNDWATER VAPOR COMPLIANCE LEVEL
LUC	LAND USE CONTROL
PCE	TETRACHLOROETHENE
SVE	SOIL VAPOR EXTRACTION
TCE	TRICHLOROETHENE
VICB	VAPOR INTRUSION COMPLIANCE BOUNDARY

First FYR for South AFRL

South AFRL
Site Inspection Tour Stops

Date 09-12	Air Force Research Laboratory Edwards AFB	Figure
Project No. 60225193		6.5-1

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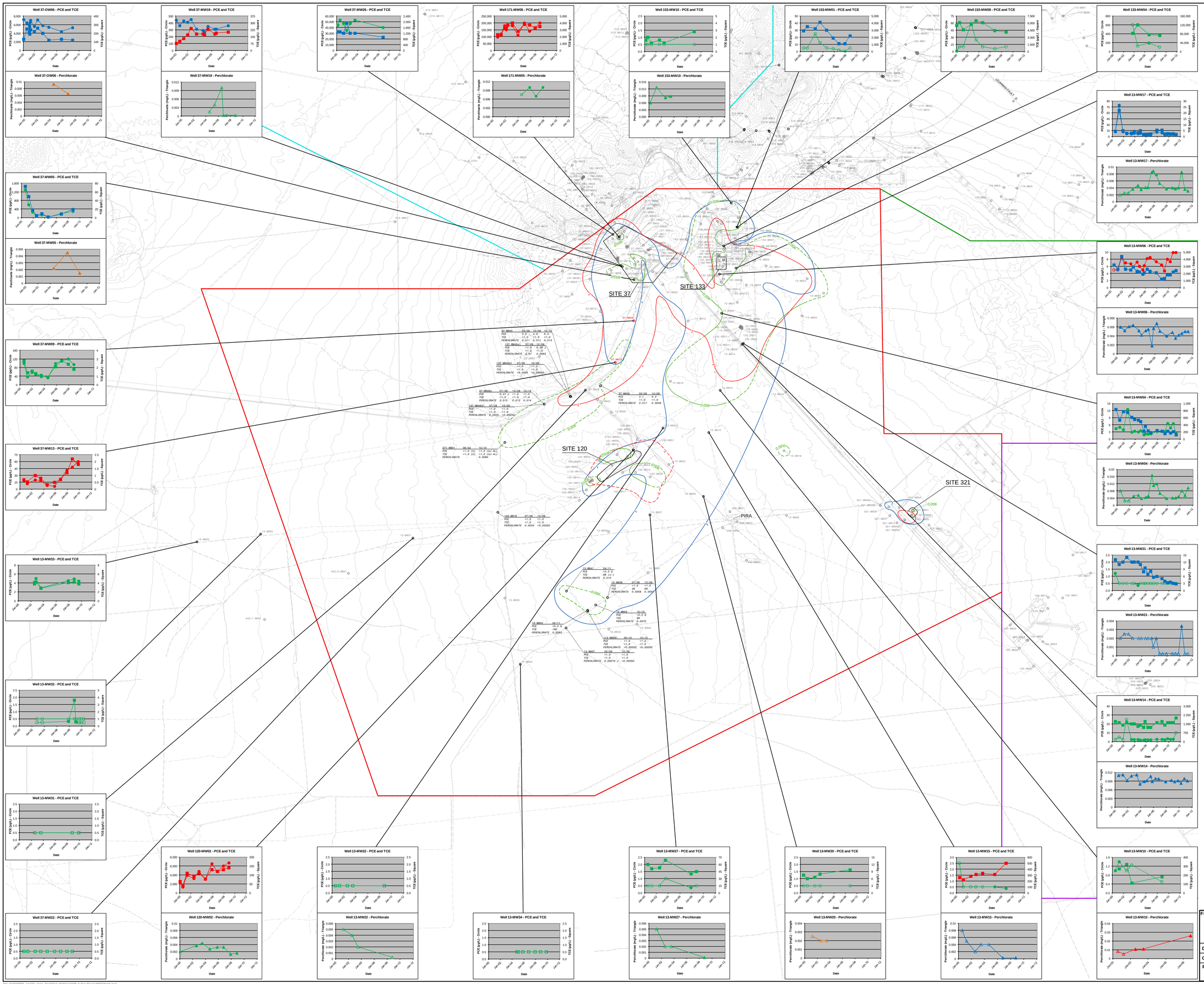
PLATE

SOUTH AFRL 2011 ESTIMATED PCE, TCE, AND PERCHLORATE CONTOURS AND TRENDS



EXPLANATION

- MONITORING/OBSERVATION/EXTRACTION WELL LOCATION
- PCE (OPEN SYMBOLS ON PLOTS DENOTE NON-DETECT RESULTS. SYMBOL IS PLACED AT HALF THE REPORTING LIMIT.)
- TCE (OPEN SYMBOLS ON PLOTS DENOTE NON-DETECT RESULTS. SYMBOL IS PLACED AT HALF THE REPORTING LIMIT.)
- PERCHLORATE (OPEN SYMBOLS ON PLOTS DENOTE NON-DETECT RESULTS. SYMBOL IS PLACED AT HALF THE REPORTING LIMIT.)
- CONTOUR LINE OF PCE CONCENTRATION IN µg/L. (DASHED WHERE INFERRED)
- CONTOUR LINE OF TCE CONCENTRATION IN µg/L. (DASHED WHERE INFERRED)
- 0.006 — MCL CONTOUR LINE OF PERCHLORATE CONCENTRATION IN mg/L (DASHED WHERE INFERRED)
- SOUTH AFRL CONTAINMENT ZONE BOUNDARY
- AFRL ARROYOS GROUNDWATER AREA
- NORTHEAST AFRL GROUNDWATER AREA
- MARS BLVD GROUNDWATER AREA
- PAVED ROAD
- UNPAVED ROAD
- TRAIL
- 2700 — TOPOGRAPHY ELEVATION (FEET ABOVE MEAN SEA LEVEL) (CONTOUR INTERVAL 25 FEET)
- FENCE LINE
- TOPOGRAPHY DRAINAGE
- U / D — FAULT LINE (DASHED WHERE APPROXIMATED, DOTTED WHERE INFERRED) U - UPTHROWN SIDE D - DOWNTHROWN SIDE
- [ ] VERTICAL EXTENT WELL. DATA NOT USED TO CONTOUR.
- ( ) LARGE SCREENED INTERVAL. DATA NOT USED TO CONTOUR.

WELL LOCATION DATE
PARAMETER VALUE (µg/L)
(PERCHLORATE PRESENTED IN mg/L)

ABBREVIATION

µg/L	MICROGRAMS PER LITER
AFB	AIR FORCE BASE
AFRL	AIR FORCE RESEARCH LABORATORY
BLVD	BOULEVARD
JAN	JANUARY
MAROS	MONITORING AND REMEDIATION OPTIMIZATION SYSTEM
MCL	MAXIMUM CONTAMINANT LEVEL
mg/L	MILLIGRAMS PER LITER
PCE	TETRACHLOROETHENE
PIRA	PRECISION IMPACT RANGE AREA
QC	QUALITY CONTROL
TCE	TRICHLOROETHENE

LABORATORY-ASSIGNED DATA QUALIFIERS

J	ESTIMATED RESULT. RESULT IS LESS THAN THE REPORTING LIMIT.
Q	ELEVATED REPORTING LIMIT. THE REPORTING LIMIT IS ELEVATED DUE TO HIGH ANALYTE LEVELS.

DATA VALIDATION QUALIFIERS

(J-)	INDICATES AN ESTIMATED VALUE WITH A NEGATIVE BIAS.
(U)	INDICATES THE COMPOUND OR ANALYTE WAS ANALYZED FOR BUT NOT DETECTED AT OR ABOVE THE STATED LIMIT.
(UJ-4L)	REPORTING LIMIT ESTIMATED. RECOVERIES FOR ONE OR MORE SURROGATES ARE BELOW THE QC LIMITS. INDICATES POSSIBLE LOW BIAS.

NOTE

1. PLUMES ARE DRAWN BASED ON LATEST SAMPLING (2008-2011).
2. CONTAMINANT PLOTS SHOWN IN RED DENOTE INCREASING OR PROBABLY INCREASING CONCENTRATION IN MAROS.
3. CONTAMINANT PLOTS SHOWN IN BLUE DENOTE DECREASING OR PROBABLY DECREASING CONCENTRATION IN MAROS.
4. CONTAMINANT PLOTS SHOWN IN GREEN DENOTE STABLE OR NO TRENDS EVALUATED IN MAROS.
5. CONTAMINANT PLOTS SHOWN IN ORANGE DENOTE TOO FEW SAMPLING RESULTS AVAILABLE TO EVALUATE A TREND IN MAROS.

First FYR for South AFRL

Plate 1
South AFRL 2011 Estimated PCE, TCE, and Perchlorate Contours and Trends

DRAWN BY: TT	DESIGNED BY: MB	SCALE: 1" = 1,250'
CHECKED BY: MB	APPROVED BY: MB	DATE: 09-2012
PROJECT NUMBER: 60222994	MAP SHEET NUMBER: SHEET 1 OF 1	REV NO.: A01

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