



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

September 28, 2009

Gregg Ikehara
36 CES/CEVR
Unit 14007
APO AP 96543-4007

Re: EPA Concurrence with the Air Force's Second Five-Year Review of Remedial Actions
Andersen Air Force Base, Guam, Dated August 2009.

Dear Mr. Ikehara,

EPA has reviewed the Second Five-Year Review of Remedial Actions, Andersen Air Force Base Guam. This Second Five-Year Review addresses completed remedial actions taken pursuant to the Record of Decision (ROD) for the MARBO Annex signed in July 1998. The remedies specified in the ROD included soil excavation at multiple sites, a cover and land use controls at Site 20 and monitored natural attenuation (MNA) with a contingency for wellhead treatment for groundwater.

The First Five-Year Review concluded that both the soil and groundwater remedies were protective. However, the Review noted that while no exposure pathways existed for the groundwater plume and that the plume was contained, MNA was not working as planned. The Review recommended that a focused feasibility study should be conducted to evaluate other groundwater remedy alternatives.

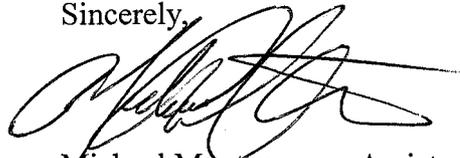
The Air Force, EPA and Guam EPA completed a review of groundwater treatment options and concluded that treatment of the deep karst aquifer was not practicable and that a technical impracticability waiver should be invoked to address the inability to achieve Safe Drinking Water Act Maximum Contaminant Levels within the aquifer in a reasonable timeframe. The Air Force is in the process of finalizing a ROD Amendment for groundwater at MARBO that specifies a remedy of Long Term Groundwater Monitoring with a Contingency for Wellhead Treatment. The Air Force, EPA and Guam EPA expect to sign the ROD Amendment by December 2009.

EPA agrees with the Air Force's protectiveness statement and conclusion in this Second Five-Year Review that the original remedy for both soil and groundwater are protective. We agree with the recommendation that the cover maintenance program at Site 20 can be changed from quarterly to semi-annually. We also agree that a TI Waiver for aquifer restoration will likely be appropriate and that protectiveness will be provided by groundwater monitoring and implementing the contingency of wellhead treatment if any nearby water supply wells are impacted.

Several RODs have been completed for other sites in the last three years at Andersen. As the current Second Five-Year Review only addresses the ROD for MARBO, the Air Force will be responsible for providing the next Five-Year Review in September 2012. This date is triggered by the ROD for Sites 6, 9, and 12, which included land use controls. Please address all sites requiring reviews in future Five-Year Reviews. This means that MARBO will be reviewed again in only three years, but it will save the Air Force from preparing separate reviews for the many sites at Andersen that will require Five-Year Reviews.

Please call Mark Ripperda of my staff if you have any questions regarding the Second Five-Year Review. He may be reached at 415-972-3028.

Sincerely,

A handwritten signature in black ink, appearing to read 'Michael Montgomery', written over a horizontal line.

Michael Montgomery, Assistant Director
Federal Facilities and Site Cleanup Branch
Superfund Division

cc: Lorilee Crisostomo, GEPA



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS, 36TH WING (PACAF)
UNIT 14007, APO AP 96543-4007

20 August 2009

36 CES/CEVR
Unit 14007
APO AP 96543-4007

Mr. Mark Ripperda
Project Manager
U.S. Environmental Protection Agency
75 Hawthorne St., H-9-4
San Francisco, CA 94105-3901

Dear Mr. Ripperda

Attached are two copies of the Final Second Five-Year Review of Record of Decision for MARBO Annex Operable Unit, Andersen Air Force Base, Guam.

Should you have any questions concerning these reports, please feel free to contact me at (671) 366-4692.

Sincerely

A handwritten signature in black ink, appearing to read "Gregg N. Ikehara".

GREGG N. IKEHARA
IRP Program Manager

Attachment:
ROD (2 copies)

cc:
Ms. Lorilee Crisostomo, GEPA
Mr. Rich Howard, Tech Law Inc.



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS, 36TH WING (PACAF)
Unit 14007, APO AP 96543-4007

36 CES/CEVR
Unit 14007
APO AP 96543-4007

Ms. Lorilee Crisostomo
Administrator
Guam Environmental Protection Agency
P.O. Box 22439 GMF
Barrigada, Guam 96921

Dear M. Crisostomo

Attached are two copies of the Final Second Five-Year Review of Record of Decision for MARBO Annex Operable Unit, Andersen Air Force Base, Guam.

Should you have any questions concerning these reports, please feel free to contact me at (671) 366-4692.

Sincerely

GREGG N. IKEHARA
IRP Program Manager

Attachment:
ROD (2 copies)

cc:
Mr. Mark Ripperda, USEPA Region IX
Mr. Rich Howard, Tech Law Inc.

RECEIVED

AUG 20 2009

Guam Environmental Protection Agency

GC
IRP

non-
agency

20 August 2009



21 August 2009

AFCEE/EXPG (Attn: Mr. Dean Blandford)
18001 Arc Light Blvd (Unit 14007)
Andersen AFB, Guam 96929

SUBJECT: Final Second Five-Year Review of Record of Decision for MARBO Annex Operable Unit, Andersen Air Force Base, Guam.

PROJECT: Andersen AFB, Contract No. FA8903-08-D-8776-005
Project No. AJJY20087002C1, Task Order 0005 (CDRL A001E)

Dear Mr. Blandford:

EA is pleased to forward one (1) electronic copy of the *Final Second Five-Year Review of Record of Decision for MARBO Annex Operable Unit, Andersen Air Force Base, Guam*. This document was prepared in accordance with the Statement of Work for the above referenced task order. Eight (8) copies for Andersen AFB; two (2) copies for USEPA; two (2) copies for Guam EPA; one (1) copy for Mr. Rich Howard are being hand-delivered to Mr. Gregg Ikehara. A copy of this transmittal (w/o enclosures) will also be forwarded to AFCEE/MSCD.

If you have any questions or comments, please contact me at your convenience. We appreciate the opportunity to provide these services to AFCEE.

Sincerely,

A handwritten signature in black ink, appearing to read 'Joel J. Lazzeri for', written in a cursive style.

Joel J. Lazzeri, P.G.
V.P. Federal Programs

cc: Mr. Gregg Ikehara, 36 CES/CEVR, Andersen AFB (8 copies)
Mr. Mark Ripperda, USEPA Region 9 (2 copies)
Mr. Rich Howard, TechLaw (1 copy)
Mr. Michael Cruz, Guam EPA (2 copies)
Mr. Joel Lazzeri, P.G., EA (1 electronic copy)
Mr. Scott Moncrief, P.G., EA (1 electronic copy)
Mr. Chip Brown, EA (1 electronic copy)
Ms. Barbara Wyskowski, AECOM (1 electronic copy)
AFCEE/MSCD (w/o enclosures)
AFCEE Project File, EA (1 electronic copy)

**THE UNITED STATES AIR FORCE
INSTALLATION RESTORATION PROGRAM**



FINAL

**SECOND
FIVE-YEAR REVIEW OF RECORD OF DECISION
FOR
MARBO ANNEX OPERABLE UNIT
ANDERSEN AIR FORCE BASE, GUAM**

August 2009

**THE UNITED STATES AIR FORCE
INSTALLATION RESTORATION PROGRAM**

FINAL

**SECOND
FIVE-YEAR REVIEW OF RECORD OF DECISION
FOR
MARBO ANNEX OPERABLE UNIT**

ANDERSEN AIR FORCE BASE, GUAM

August 2009

Approved By:

MICHAEL M. MONTGOMERY
Assistant Director, Federal Facilities and Site Cleanup Branch
U.S. Environmental Protection Agency, Region 9

Date

REPORT DOCUMENTATION PAGE

*Form Approved
OMB No. 0704-0188*

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to the Department of Defense, Executive Services and Communications Directorate (0704-0188). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION.

1. REPORT DATE (DD-MM-YYYY) 08-2009		2. REPORT TYPE Final		3. DATES COVERED (From - To) 02-03-2004 to 02-03-2009	
4. TITLE AND SUBTITLE Second Five-Year Review of Record of Decision for MARBO Annex Operable Unit, Andersen Air Force Base, Guam				5a. CONTRACT NUMBER FA8903-08-D-8776	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Toraj Ghofrani, P.E. and Scott Moncrief, P.G. (EA Engineering, Science, & Technology, Inc.)				5d. PROJECT NUMBER AJJY20087002C1	
				5e. TASK NUMBER Task Order 0005	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Metcalf & Eddy, Inc. 701 Edgewater Drive Wakefield, MA 01880-6236				8. PERFORMING ORGANIZATION REPORT NUMBER N/A	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Force Center for Engineering and the Environment Unit 14007 APO AP 96543-4007				10. SPONSOR/MONITOR'S ACRONYM(S) AFCEE	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) N/A	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT This second five-year review of the Record of Decision (ROD) for MARBO Annex Operable Unit presents the results of the implemented remedies for impacted soils and groundwater for MARBO Annex Operable Unit. This document includes a review of the latest available data since the ROD was signed in 1998 to determine the current and the future effectiveness of the implemented remedies in protecting the human health and the environment.					
15. SUBJECT TERMS - Andersen AFB - Installation Restoration Program - Public Involvement - Five-Year Review - Institutional Controls - Record of Decision					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER (Include area code)

TABLE OF CONTENTS

	Page
LIST OF TABLES	vi
LIST OF FIGURES	vii
LIST OF ACRONYMS AND ABBREVIATIONS	viii
 5-YEAR REVIEW SUMMARY FORM	
EXECUTIVE SUMMARY	ES-1
1.0 INTRODUCTION	1-1
1.1 Purpose of the Five-Year Review	1-1
1.2 Overview of the Five-Year Review Process.....	1-1
1.3 Role of OUs at Andersen AFB	1-2
1.3.1 Designation of OUs at Andersen AFB.....	1-2
1.3.2 Status of RODs for other Andersen AFB OUs	1-3
1.3.3 Sites Covered under the MARBO Annex OU ROD.....	1-5
2.0 SITE CHRONOLOGY	2-1
3.0 BACKGROUND	3-1
3.1 General Background	3-1
3.1.1 Overview of the First Five-Year Review	3-1
3.1.1.1 Evaluated Sites Referred for No Additional Five-Year Reviews.....	3-1
3.1.1.2 Evaluated Sites Subject to Additional Five-Year Reviews.....	3-1
3.1.1.3 Evaluated Sites Pending Final Remedy Selection	3-2
3.1.2 Environmental Setting of MARBO Annex.....	3-2
3.1.3 MARBO Annex Land and Resource Use	3-3
3.2 Background of Sites Included in this Five-Year Review.....	3-4
3.2.1 Background of Site 20	3-4
3.2.1.1 General Description of Site 20.....	3-4
3.2.1.2 Former, Current, and Future Land Use at Site 20.....	3-4
3.2.1.3 History of Contamination at Site 20	3-4
3.2.1.4 Initial Response at Site 20.....	3-5
3.2.1.5 Basis for Taking Action.....	3-5
3.2.2 Background of Site 41	3-5
3.2.2.1 General Description of Site 41.....	3-5

TABLE OF CONTENTS

	Page
3.2.2.2 Current and Future Land Use at Site 41.....	3-6
3.2.2.3 History of Contamination at Site 41	3-6
3.2.2.4 Initial Response at Site 41.....	3-6
3.2.2.5 Basis for Taking Action.....	3-6
3.2.3 Background of Site 42	3-7
3.2.3.1 General Description of Site 42.....	3-7
3.2.3.2 Current and Future Land Use at Site 42.....	3-7
3.2.3.3 History of Contamination at Site 42	3-7
3.2.3.4 Initial Response at Site 42.....	3-7
3.2.3.5 Basis for Taking Action at Site 42.....	3-8
3.2.4 Background of Site 43	3-8
3.2.4.1 General Description of Site 43.....	3-8
3.2.4.2 Current and Future Land Use at Site 43.....	3-8
3.2.4.3 History of Contamination at Site 43	3-8
3.2.4.4 Initial Response at Site 43.....	3-9
3.2.4.5 Basis for Taking Action at Site 43.....	3-9
3.2.5 Background of MARBO Annex Groundwater	3-9
3.2.5.1 Description for MARBO Annex Groundwater.....	3-9
3.2.5.2 Former, Current, and Future Land Use above MARBO Annex Groundwater.....	3-11
3.2.5.3 History of Contamination for MARBO Annex Groundwater	3-11
3.2.5.4 Initial Response for MARBO Annex Groundwater.....	3-11
3.2.5.5 Basis for Taking Action for MARBO Annex Groundwater...	3-12
4.0 REMEDIAL ACTIONS.....	4-1
4.1 Remedial Actions at Site 20.....	4-1
4.1.1 Remedial Action Description at Site 20.....	4-1
4.1.2 Remedy Implementation at Site 20.....	4-2
4.1.3 Systems Operations/Operation and Maintenance at Site 20	4-2
4.2 Remedial Actions at Site 41.....	4-3
4.2.1 Remedial Action Description at Site 41.....	4-3
4.2.2 Remedy Implementation at Site 41.....	4-3
4.3 Remedial Actions at Site 42.....	4-4
4.3.1 Remedial Action Description at Site 42.....	4-4

TABLE OF CONTENTS

	Page
4.3.2	Remedy Implementation at Site 42..... 4-4
4.4	Remedial Actions at Site 43..... 4-4
4.4.1	Remedial Action Description at Site 43..... 4-4
4.4.2	Remedy Implementation at Site 43..... 4-4
4.5	MARBO Annex Groundwater Remedial Actions 4-5
4.5.1	Original Remedial Action Description for MARBO Annex Groundwater 4-5
4.5.2	Remedy Implementation for MARBO Annex Groundwater..... 4-5
4.5.3	Systems Operations/Operation and Maintenance for MARBO Annex Groundwater 4-6
4.5.3.1	Performance of the LTGM Program..... 4-6
4.5.3.2	Modifications to the LTGM Program 4-7
5.0	PROGRESS SINCE THE LAST FIVE-YEAR REVIEW 5-1
5.1	Progress at Site 20..... 5-1
5.1.1	Protectiveness Statement from Last Five-Year Review at Site 20 5-1
5.1.2	Status of Recommendations and Follow-up Actions from Last Five-Year Review at Site 20 5-1
5.1.3	Results of Implemented Actions at Site 20..... 5-2
5.1.4	Status of Prior Issues at Site 20..... 5-2
5.2	Progress at Sites 41, 42, and 43 5-2
5.3	Progress on MARBO Annex Groundwater 5-2
5.3.1	Protectiveness Statement from Last Five-Year Review for MARBO Annex Groundwater..... 5-2
5.3.2	Status of Recommendations and Follow-up Actions from Last Five-Year Review of MARBO Annex Groundwater 5-3
5.3.3	Results of Implemented Actions for MARBO Annex Groundwater..... 5-4
5.3.4	Status of Prior Issues for MARBO Annex Groundwater..... 5-4
5.3.4.1	Follow-up Action on TI Waiver Recommendation 5-4
5.3.4.2	MARBO Annex OU ROD Amendment 5-5
5.3.4.3	Post ROD Amendment Remedial Design..... 5-6
6.0	FIVE-YEAR REVIEW PROCESS..... 6-1
6.1	Administrative Components 6-1
6.1.1	Community Involvement 6-1

TABLE OF CONTENTS

	Page
6.1.2 Other Community Involvement Activities.....	6-2
6.2 Document Review.....	6-3
6.3 Data Review.....	6-3
6.3.1 Discussion of the PCE/TCE Trends in the MARBO Annex OU LTGM Data Since 1998	6-3
6.3.1.1 Estimated Attenuation used in Developing Original Remedy..	6-4
6.3.1.2 LTGM Data Trends in Shallow and Deep Aquifer.....	6-4
6.3.1.3 LTGM Data Trends in Groundwater Production Wells at MARBO Annex OU	6-5
6.4 Site Inspections.....	6-6
6.5 Interviews.....	6-6
7.0 TECHNICAL ASSESSMENT OF SELECTED REMEDIES	7-1
7.1 Technical Assessment of Remedial Action at Site 20	7-1
7.1.1 Technical Assessment Summary of Site 20.....	7-2
7.2 Technical Assessment of Remedial Action for MARBO Annex Groundwater ..	7-2
7.2.1 Technical Assessment Summary of the MARBO Annex Groundwater..	7-3
8.0 ISSUES IDENTIFIED IN THE SECOND FIVE-YEAR REVIEW	8-1
8.1 Issues Identified at Site 20	8-1
8.1.1 Determination of Whether Issues Affect Protectiveness at Site 20	8-1
8.1.2 Unresolved Issues Raised by Regulatory Support or Community Groups at Site 20.....	8-1
8.2 Issues Identified for the MARBO Annex Groundwater Remedy.....	8-1
8.2.1 Issues Identified During Technical Assessment of MARBO Annex Groundwater	8-2
8.2.2 Determination of Whether Issues Affect Protectiveness of MARBO Annex Groundwater Remedy	8-2
8.2.3 Unresolved Issues Raised by Regulatory Support or Community Groups for MARBO Annex Groundwater Remedy	8-2
9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS.....	9-1
9.1 Recommendations and Follow-up Actions at Site 20.....	9-1

TABLE OF CONTENTS

	Page
9.2 MARBO Annex Groundwater Remedy Recommendations and Follow-up Actions	9-1
10.0 PROTECTIVENESS STATEMENTS	10-1
10.1 Protectiveness Statement for Site 20.....	10-1
10.2 Protectiveness Statement for MARBO Annex Groundwater	10-1
11.0 NEXT REVIEW	11-1
12.0 REFERENCES	12-1
Appendix A Andersen Air Force Base Administrative Record Index	
Appendix B Groundwater History at MARBO Annex	
Appendix C Operation and Maintenance Inspections	
Appendix D Post ROD Amendment Remedial Design LTGM Program Recommendations	
Appendix E Focused Feasibility Study Remedial Technology Screening Matrix	
Appendix F Second Five-Year Review Site Inspection Forms	
Appendix G Second Five-Year Review Site Inspection Photos	
Appendix H Second Five-Year Review Interviews	

LIST OF TABLES

Table

- 1-1 Operable Unit Designations for Andersen AFB, Guam.
- 1-2 Summary Status of Sites Covered Under Second Five-Year Review of MARBO Annex OU.

- 3-1 Comparison of Site 20 EPCs to 1995 Residential PRGs and BTVs used for the HHRA.
- 3-2 Comparison of Site 41 EPCs to Residential RSLs and BTVs.
- 3-3 Comparison of Site 42 EPCs to Residential RSLs and BTVs.
- 3-4 Comparison of Site 43 EPCs to Residential PRGs, Residential RSLs, and BTVs.

- 4-1 Annual System Operations/O&M Cost for Site 20.
- 4-2 Annual System Operations/O&M Cost for MARBO Annex Groundwater.

- 5-1 First Five-Year Review Issues, Recommendations, and Follow-up Actions for Site 20.
- 5-2 First Five-Year Review Issues, Recommendations, and Follow-up Actions for MARBO Annex Groundwater.

- 7-1 Comparison of Site 20 EPCs to 2009 Residential RSLs and BTVs.

- 8-1 Issues Identified at Site 20.
- 8-2 Issues Identified for the MARBO Annex Groundwater Remedy.

- 9-1 Second Five-Year Review Issues, Recommendations, and Follow-up Actions for Site 20.
- 9-2 Second Five-Year Review Issues, Recommendations, and Follow-up Actions for MARBO Annex Groundwater.

LIST OF FIGURES

Figure

- 1-1 Location Map of Andersen Air Force Base on Guam.
- 1-2 Installation Restoration Program Sites in MARBO Annex Operable Unit.
- 1-3 Location Map of Andersen Air Force Base Operable Units on Guam.

- 3-1 Volcanic Structure Contours.
- 3-2 MARBO Annex Operable Unit Land Use.
- 3-3 Before and After Remedial Action, IRP Site 20, MARBO Annex, Andersen AFB, Guam.
- 3-4 Proposed Soil Removal for Site 41 Unrestricted Land Use, MARBO Annex, Andersen AFB, Guam.
- 3-5 Proposed Soil Removal for Site 42 Unrestricted Land Use, MARBO Annex, Andersen AFB, Guam.
- 3-6 Proposed Soil Removal for Area A, Site 43, Unrestricted Land Use, MARBO Annex, Andersen AFB, Guam.
- 3-7 Proposed Soil Removal for Area B, Site 43, Unrestricted Land Use, MARBO Annex, Andersen AFB, Guam.
- 3-8 Proposed Soil Removal for Area C, Site 43, Unrestricted Land Use, MARBO Annex, Andersen AFB, Guam.
- 3-9 Proposed Soil Removal for Area D, Site 43, Unrestricted Land Use, MARBO Annex, Andersen AFB, Guam.
- 3-10 Historical Footprint of TCE and PCE Exceeding MCL in Groundwater at MARBO Annex Operable Unit, Andersen AFB, Guam.
- 3-11 Cross-Sectional View of Spatial Extent of Technical Impracticability Waiver Based on Historic Long Term Groundwater Monitoring Data, MARBO Annex Operable Unit, Andersen AFB, Guam.

LIST OF ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirement
AST	aboveground storage tank
bcy	bank cubic yards
bgs	below ground surface
BTV	Background Threshold Value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CES	Civil Engineer Squadron
CEVR	Civil Engineering Installation Restoration Program
COC	Contaminant of Concern
COPC	Contaminant of Potential Concern
CRP	Community Relations Plan
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethene
EA	EA Engineering, Science, and Technology, Inc.
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
FFA	Federal Facility Agreement
FFS	Focused Feasibility Study
FWENC	Foster Wheeler Environmental Corporation
GPZ	Groundwater Protection Zone
Guam EPA	Guam Environmental Protection Agency
GWA	Guam Waterworks Authority
HHRA	Human Health Risk Assessment
IC	Institutional Control
IEUBK	Integrated Exposure Uptake Biokinetic Model
IRP	Installation Restoration Program
lcy	loose cubic yard
LTGM	Long-Term Groundwater Monitoring
LUCMP	Land Use Control Management Plan
MARBO	Marianas Bonins Command
MCL	Maximum Contaminant Level
MEC	Munitions and Explosives of Concern

LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
mg/kg	milligram per kilogram
mg/L	milligrams per liter
mgd	million gallons per day
MMRP	Military Munitions Response Program
MNA	monitored natural attenuation
msl	mean sea level
NA	not applicable
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NGL	Northern Guam Lens
NPL	National Priorities List
O&M	Operation and Maintenance
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PRG	Preliminary Remediation Goal
RA	Remedial Action
RAB	Restoration Advisory Board
RAO	Remedial Action Objective
RD	Remedial Design
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPM	Remedial Project Manager
RPO	Remedial Process Optimization
RSL	Regional Screening Level
RVR	Remedial Verification Report
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act of 1986
TBD	to be determined
TCE	trichloroethene
TI	Technical Impracticability
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
USN	United States Navy
VOC	volatile organic compound
WERI	Water and Environmental Research Institute of the Pacific

This page is intentionally left blank

Second Five-Year Review Summary Form, Continued

Site 20

Issues

- Vehicle access, pig wallows, and small trees continue to threaten the structural integrity of the *Soil Cover*. The *Soil Cover* is subject to frequent island natural disasters such as typhoons and earthquakes that can damage the structural integrity of the *Soil Cover*.

Recommendations and Follow-up Actions

- Continue O&M program, with annual inspections to check the structural integrity of the *Soil Cover*, drainage channels, and the riprap. Maintenance should occur at least semi-annually to mow and control brush and trees. Sword grass at the site should not be mowed lower than four inches above the ground, as shorter grass cover are more susceptible to erosion.

Protectiveness Statement

Based on the review of existing data and site inspections, the remedy at Site 20 is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled.

Sites 22, 23, 24, 37, and 38

As recommended in the first five-year review for the MARBO Annex OU, Sites 22, 23, 24, 37, and 38 were not included in the second five-year review on the basis that no new source of contamination was found during the second five-year review period.

Sites 41, 42, 43

No interim removal actions have been implemented at Sites 41, 42, or 43, and the selection of the final remedies is pending a ROD. A RI/FS was completed for these sites in 2008 and identified *Soil Removal (Unrestricted Land Use)* as the preferred remedial alternative for all three sites. It is anticipated that the *Soil Removal* alternative would provide clean closure with minimal administrative effort and no associated long-term monitoring costs.

MARBO Annex Groundwater

Issues

- LTGM data indicates TCE concentration are increasing in production well MW-1.

Recommendations and Follow-up Actions

- Continue to monitor sampling data from this well and share with Andersen AFB potable water supply facility managers.

Protectiveness Statement

The remedy for MARBO Annex groundwater is protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled.

Other Comments

A ROD Amendment is planned to be completed for MARBO Annex groundwater by December 2009. The ROD Amendment will include a TI Waiver for the requirement of achieving MCLs in the aquifer. The amended remedy for MARBO Annex groundwater is *Long-Term Groundwater Monitoring with Contingency for Wellhead Treatment*. The ROD Amendment removes natural attenuation as a component of the remedy. The change in remedy will have no effect on the protectiveness.

EXECUTIVE SUMMARY

This is the second five-year review to evaluate if remedies that were implemented for the Record of Decision (ROD) for the Marianas Bonins Command (MARBO) Annex Operable Unit (OU) are still protective of human health and the environment. The five-year review has been completed in accordance with the United States Environmental Protection Agency (USEPA) Comprehensive Five-Year Review Guidance, June 2001, USEPA 540-R-01-007, and Office of Solid Waste and Emergency Response No. 9355.77-03B-P. To complete this second five-year review of the Final MARBO Annex OU ROD, dated July 1998, all relevant activities that have been performed and data and documents that have been generated since the implementation of remedial action have been reviewed.

The first five-year review recommended that, unless a new source of contamination was found during the second five-year review period, Sites 22, 23, 24, 37, and 38 should not be discussed in this second five-year review document. Based on a records search (Appendix A) and the site inspection in September 2008, no new source of contamination was found at Sites 22, 23, 24, 37, and 38. Accordingly, only a brief mention of these sites is included in this second five-year review of the MARBO Annex OU ROD.

Site 20 is classified as an *Operating Remedial Action* (RA), as the RA has been implemented but residual COCs have been left in place at concentrations that do not allow for unrestricted use of or unlimited access to the land. Since completion of the first five-year review, the quarterly inspection reports were the only data generated with regard to Site 20. The remedy at Site 20 is protective of human health and the environment since exposure pathways that could result in unacceptable risks are being controlled as intended by the ROD.

The land and resource use at Site 20 has not changed. With COC-impacted soil beneath the soil cover, the future land use at Site 20 remains restricted. The site and vicinity are still inactive and therefore the exposure assumptions for the human health risk assessment (HHRA) and ecological risk assessment (ERA) are still valid. No new human health or ecological exposure pathways or receptors have been identified. The toxicity data and USEPA residential Regional Screening Levels (RSLs) for Site 20 contaminants of concern remain unchanged or less stringent than the 1995 residential Preliminary Remediation Goals (PRGs) therefore rendering no changes in the 1995 HHRA results or the effectiveness of the selected remedy. Based on the site inspection, the integrity of the soil cover is still intact. However, as long as the site is accessible, the structural integrity of the soil cover may be compromised due to vehicle traffic, small trees, and pig wallows. Therefore, annual inspections and periodic maintenance of soil cover should be performed to ensure continued protection of human health or environment. Site 20 should be included in the next five-year review.

Based on human health and ecological risk assessments, MARBO Annex Groundwater is impacted by trichloroethene (TCE) and tetrachloroethene (PCE) in deep groundwater samples collected from monitoring wells IRP-29 and IRP-31 at concentrations above their respective MCLs (5 micrograms per Liter). Monitoring data indicate impacted groundwater zones exist between approximately 400 feet ground surface (bgs) to 470 feet bgs (TCE plume) and between 420 feet bgs and 490 feet bgs (PCE plume). The exact source of TCE and PCE remains unknown. The 1998

ROD selected remedial action for MARBO Annex Groundwater was *Natural Attenuation with Wellhead Treatment*, which was to eliminate the risk of direct exposure to TCE and PCE. Institutional controls (ICs) were a component of the remedy and consisted of Land Use Restrictions and Long-Term Groundwater Monitoring.

During the first five-year review, the remedy was found to be functioning as intended in the 1998 ROD and was still protective of human health and the environment. The remedy for MARBO Annex groundwater is protective of human health and the environment since exposure pathways that could result in unacceptable risks are being controlled.

During the second five-year review period, natural attenuation was determined to be ineffective in remediating the TCE and PCE in MARBO Annex Groundwater. Monitoring data suggested that neither physical (e.g., dilution) nor biological processes (e.g., reductive dehalogenation) were operating to significantly attenuate TCE or PCE in the deep part of the freshwater lens. As a result, a ROD Amendment was prepared for MARBO Annex Groundwater which included a Technical Impracticability Waiver which waives the Applicable or Relevant and Appropriate Requirement of meeting the MCL in the aquifer. The ROD Amendment is planned to be signed by December 2009. The change in remedy has no effect on the site protectiveness. MARBO Annex Groundwater should be included in the next five-year review.

Sites 41, 42, and 43 are located in the MARBO Annex; however, they are included in the Site-wide OU. The Remedial Investigation/Feasibility Study (RI/FS) document for these sites is currently under agency review. All three sites contain COCs, for which the FS indicates *Soil Removal* as the preferred remedial alternative (RA). Under this RA the COCs would be cleaned up and there would be no restrictions on future land use at any of the three sites (including residential land use). A ROD for these sites has not yet been completed. Sites 41, 42, and 43 should be included in the next five year review.

The next and third five-year review of the MARBO Annex OU ROD is due five years from the USEPA's approval of this review, and should include review of the remedies for Sites 20, 41, 42, and 43, and for MARBO Annex Groundwater. The related review period will be from 02 March 2009 to 02 March 2014.

1.0 INTRODUCTION

On 14 October 1992, the United States Environmental Protection Agency (USEPA) Region 9 formally listed Andersen Air Force Base (AFB) on the National Priorities List (NPL) with a Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) identification number of GU6571999519. By 30 March 1993, the United States Air Force (USAF) entered into a Federal Facility Agreement (FFA) with the USEPA and the Guam Environmental Protection Agency (Guam EPA) and began its Superfund clean-up program in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

Under the CERCLA, Andersen AFB is required to conduct a Record of Decision (ROD) review every five years. This second five-year ROD review has been prepared for the Marianas Bonins Command (MARBO) Annex Operable Unit (OU) in accordance with the USEPA Comprehensive Five-Year Review Guidance, June 2001, USEPA 540-R-01-007, and Office of Solid Waste and Emergency Response (OSWER) No. 9355.7-03B-P.

1.1 Purpose of the Five-Year Review

Recurring five-year reviews of RODs are designed to evaluate the remedies that are implemented by RODs to ensure that the remedies are still protective of human health and the environment. During each five-year review, all relevant activities that have been performed and data and documents that have been generated since the previous five-year review are evaluated. Recommendations are provided to close any data gaps and improve the effectiveness of the remedial action in protecting human health and the environment (USEPA, 2001).

1.2 Overview of the Five-Year Review Process

This five-year review of the MARBO Annex OU ROD is mandated as part of the Superfund Amendments and Reauthorization Act of 1986 (SARA), which amended the CERCLA. A five-year review is applicable to sites for which a ROD, or a Decision Document, was signed on or after 17 October 1986; the effective date of the SARA. According to CERCLA §121(c), as amended:

“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 action taken as a result of such reviews.”

This requirement is further defined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations Part 300.430(f)(4)(ii), and states that:

“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 initiation of the remedial action.”

The USAF is the lead agency conducting this five-year review. Through Metcalf and Eddy, EA Engineering, Science, and Technology, Inc. (EA) has been contracted by the USAF to conduct the site inspections and prepare this five-year review for the MARBO Annex OU ROD, which was finalized in May 1998. The review team includes the USAF, USEPA Region 9, and Guam EPA. This five-year ROD review was initiated in November 2008 and was completed in June 2009.

This is the second five-year review for the MARBO Annex OU ROD. The triggering action for this statutory review is the USEPA approval of the first five-year review on 06 July 2004. The triggering action for the first five-year review was the initial mobilization of the cleanup at Installation Restoration Program (IRP) Site 20, where residual contaminants were left at the site above concentrations that would allow for unlimited use and unrestricted exposure (Figures 1-1 and 1-2).

1.3 Role of OUs at Andersen AFB

Andersen AFB elected to use an OU approach to manage the remedial investigations under their IRP. As with many large sites, the environmental problems at Andersen AFB, Guam, are complex. As a result, the USAF, with concurrence from USEPA Region 9 and Guam EPA, has organized the environmental restoration work at Andersen AFB into six OUs. A discussion of the OUs is presented in the following sections.

1.3.1 Designation of OUs at Andersen AFB

According to the 1993 FFA, the OUs were formed to 1) expedite the completion of environmental activities, 2) evaluate sites with similar locations and potentially similar requirements as unique groups, 3) complete remedial design investigations at sites where closure decisions have been previously reached with the Government of Guam, and 4) provide a screening mechanism for evaluating newly or tentatively identified sites for inclusion in the Remedial Investigation/Feasibility Study (RI/FS).

Prior to 1996, the original OUs were designated numerically, as follows (Table 1-1):

- OU-1 was designated for soils and potential contaminant sources associated with IRP sites within the Main Base Landfill Complex,
- OU-2 was designated for groundwater basewide (MARBO Annex, Main Base, Harmon Annex, and Northwest Field),
- OU-3 was designated for soils and potential contaminant sources associated with IRP sites within the MARBO Annex,

- OU-4 was designated for soils and potential contaminant sources associated with IRP sites within the Harmon Annex, Northwest Field, and the Main Base, that lie inside the Groundwater Protection Zone (GPZ),
- OU-5 was designated for soils and potential contaminant sources associated with IRP sites within the Harmon Annex, Northwest Field, and the Main Base, that lie outside the GPZ, and
- OU-6 was designated for Basewide (later termed Site-wide) documents and any IRP sites added to the IRP subsequent to execution of the FFA in 1994 (ICF, 1994).

In 1996 the USAF, USEPA, and Guam EPA agreed that to effectively respond to projected property transfers (Harmon and MARBO Annexes) the criteria used to develop the original numerical OU designations were impractical for effective management of the IRP (Table 1-1). The increased focus on property transfers created the need for grouping sites into geographically distinct OUs that combined soil, potential contaminant sources, and groundwater (Andersen AFB, 2003). The re-designated OUs are presented in Table 1-1 and are illustrated in Figure 1-3:

- Harmon OU,
- MARBO Annex OU,
- Main Base OU,
- Northwest Field OU,
- Urunao OU, and
- Site-wide OU (formerly Basewide OU).

1.3.2 Status of RODs for other Andersen AFB OUs

Although Andersen AFB IRP is still in the process of completing RI/FS for several sites, RODs have been completed for the majority of the IRP sites in the last two of years. The status of the RODs, with respect to sites comprising each of the other five OUs, is presented in Table 1-1 and briefly discussed below:

- Harmon Annex OU (Sites 18, 19, and 39) – A final ROD addressing the Harmon Annex OU was completed in July 2002. A *No Further Action* ROD was approved for the Harmon OU (Foster Wheeler Environmental Corporation and EA [FWENC/EA], 2002) As the ROD resulted in site conditions that allowed for unlimited use and unrestricted exposure, no subsequent five-year review is required.
- Main Base OU (Sites 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 25, 26, 27, 28, 29, 34, and 35) – RODs addressing the Main Base OU are either completed or in the process of completion. The following sites were grouped into separate ROD documents:
 - Sites 6, 9, and 12 (Group 1)
 - Sites 5 and 8 (Group 2)
 - Sites 4, 11, 25, 28, and 34 (Group 3)
 - Sites 3, 10, 13, and 27 (Group 4)

- Sites 29 and 35
- Sites 2, 14, 15, and 26 (Grouping not yet assigned)

By August 2007, RODs were completed for 11 Main Base OU sites (Groups 1, 2, and 3) (EA, 2006; EA, 2007a; EA, 2007b). As presented in Table 1-1, the RODs for seven of these sites resulted in site conditions that allowed for unlimited use and unrestricted exposure and *No Action* was required. However, at four sites (Sites 5, 6, 8, and 12), *Institutional Controls* were selected as the remedial action in the RODs to mitigate on-site contamination posing unacceptable risk to human health. For the remaining Main Base OU sites, RI and remedial action (RA) activities are ongoing and RODs for these sites are currently under development.

- Northwest Field OU (Sites 7, 16, 17, 21, 30, 31, and 36) – A final ROD addressing Sites 7, 16, 17, 31, and 36 was completed in August 2007 (EA, 2007c). As presented in Table 1-1, the ROD for all five of these sites resulted in site conditions that allowed for unlimited use and unrestricted exposure and *No Action* was required. RI activities are ongoing at the remaining two Northwest Field OU sites (Sites 21 and 30). A ROD for Site 21 is currently under development.

Site 30 was transferred to the USAF's Military Munitions Response Program (MMRP) due the presence of munitions and explosives of concern (MEC) being identified onsite during the RI activities. Under the MMRP, a ROD will be completed for Site 30 after a remedial investigation/feasibility study, with respect to the MEC, is completed. The ROD for this site is currently under development.

- Urunao OU (Site 40) – A final ROD addressing the Urunao OU was completed in December 2003. The selected remedy, *Soil Removal*, is currently being implemented by the USAF.
- Site-wide OU (Sites 41 through 78) – The Site-wide OU consists of former Areas of Concern (AOCs) that have been formally redesignated as IRP sites. This OU consists of sites dispersed across the Main Base, Northwest Field, MARBO Annex, and Tumon Tank Farm. The ROD documents for 19 of these sites were completed in November 2008, and grouped as follows:
 - Sites 45, 49, 59, 61, 67, 68, and 69 (Group A)
 - Sites 48, 56, 58, 70, and 73 (Group B)
 - Sites 47, 50, 51, 53, and 55 (Group C)
 - Sites 44 and 46 (Group F)

The ROD documents for sites in Groups A, B, and F resulted in site conditions that allowed for unlimited use and unrestricted exposure and *No Action* was required. Therefore no five-year review is required for these sites. The ROD for sites in Group C selected *Soil Removal* to address unacceptable risk posed by onsite contamination. The implementation of the RA is expected for completion by 2012.

RODs for the remaining sites in the Site-wide OU are currently under development, and will be grouped in the four following documents:

- Sites 63, 64, 65, 66, 72, and 77 (Group D)
- Sites 57, 71, 74, 75, 76, and 78 (Group E)
- Sites 41, 42, 43 (Group G)
- Site 54

Due to presence of MEC, Sites 52 and 60 were transferred to the USAF's MMRP. Also due to the presence of MEC, Site 62 is expected to be transferred to the MMRP in the near future. Under the MMRP, RODs will be completed for these sites after further investigations/feasibility studies are completed with respect to the MEC.

1.3.3 Sites Covered under the MARBO Annex OU ROD

The MARBO Annex OU includes the following six IRP sites, along with the groundwater beneath them (Figure 1-2):

- Site 20/Waste Pile 7 (Site 20),
- Site 22/Waste Pile 6 (Site 22),
- Site 23/Waste Pile 5 (Site 23),
- Site 24/Landfill 29 (Site 24),
- Site 37/War Dog Borrow Pit (Site 37), and
- Site 38/MARBO Laundry (Site 38).

At the time of the ROD, there were no contaminants of concern (COCs) identified at Sites 23 or 37 that posed unacceptable risks to human health or the environment (EA, 1998a). Subsequently the ROD recommended *No Further Action* for these sites. These sites were evaluated in the first five-year review, and will not be addressed in this review. Additionally, during the first five-year review, Sites 22, 24, and 38 were identified as *Completed RAs* where cleanup levels had been achieved since the ROD and there were no longer COCs present at concentrations that pose unacceptable risks to human health or the environment (EA, 2004). The first five-year review evaluated these sites and recommended that they not be addressed in subsequent five-year reviews. As such, these sites are not evaluated in this review.

The RAs for Site 20 and the MARBO Annex Groundwater are considered *Operating RAs*, where the RA has been initiated but the cleanup levels have not been achieved. In the case of Site 20, cleanup levels will never be achieved, as protectiveness depends on implementation of engineering controls (soil cover) and land use controls unless a need to implement a future remedial action arises such as for encroachment of property or a change in future land use.

Additionally, at the time of the MARBO Annex OU ROD, three AOCs (AOCs 54, 55, and 56) located in the MARBO Annex were recommended for further investigation under the Phase II Environmental Baseline Survey (EA, 1998b). These AOCs were not part of the MARBO Annex OU and were not included in the MARBO Annex OU ROD. They have subsequently been re-designated as Sites 41, 42, and 43, respectively, and though they are located within the MARBO Annex, they are included in the Site-wide OU. Consequently, this five-year review evaluates the MARBO Annex OU ROD and related actions, as well as Sites 41, 42, and 43. Under the ROD currently in progress for these three sites the preferred remedial alternative is *Soil Removal*, which when implemented, would clean-up on site contaminants and result in no restrictions on future land use.

Table 1-2 presents a summary of the status of sites covered under the second five-year review for MARBO Annex OU. This includes a list of all sites under review, their contaminants of potential concern (COPCs) or COCs, their original selected RA, status of the RA, current protectiveness status, and any recommendations for action or future review.

TABLE 1-1. OPERABLE UNIT DESIGNATIONS FOR ANDERSEN AFB, GUAM.

Original OU Designation	Site Number	Former Site Name	Revised OU Designation	ROD Date	Present RA Status	Selected RA
OU-1	1	Landfill 1	Main Base (Landfill Complex)		Transferred to Compliance	--
	2	Landfills 2, 4, & 5	Main Base (Landfill Complex)		Pending ROD	TBD
	3	Waste Pile 3	Main Base (Landfill Complex)		Pending ROD	TBD
	29	Waste Pile 2	Main Base (Landfill Complex)		Pending ROD	TBD
	35	Waste Pile 1	Main Base (Landfill Complex)		Pending ROD	TBD
OU-2	Groundwater underlying the OUs		MARBO Annex	March-98	Institutional Controls	Institutional Controls
			Main Base		TBD	TBD
OU-3	20	Waste Pile 7	MARBO Annex	March-98	Institutional Controls	Institutional Controls
	22	Waste Pile 6	MARBO Annex	March-98	NFA	NFA
	23	Waste Pile 5	MARBO Annex	March-98	NFA	NFA
	24	Landfill 29	MARBO Annex	March-98	NFA	NFA
	37	War Dog Borrow Pit	MARBO Annex	March-98	NFA	NFA
	38	MARBO Laundry	MARBO Annex	March-98	NFA	NFA
OU-4	4	Landfill 6	Main Base	August-07	NFA	NA
	5	Landfill 7	Main Base	August-07	Institutional Controls	Institutional Controls
	7	Landfill 9	Northwest Field	August-07	NFA	NA
	16	Landfill 21	Northwest Field	August-07	NFA	NA
	17	Landfill 22	Northwest Field	August-07	NFA	NA
	18	Landfill 23	Harmon Annex	December-01	NFA	NA
	19	Landfill 24	Harmon Annex	December-01	NFA	NFA - RA Completed
	21	Landfill 26	Northwest Field		Pending ROD	TBD
	26	Firefighter Training Area 2	Main Base		Pending ROD	TBD
	27	Hazardous Waste Storage Area 1	Main Base		Pending ROD	TBD
	28	Chemical Storage Area 1	Main Base	August-07	NFA	NA
	30	Waste Pile 4	Northwest Field		Transferred to MMRP	TBD
	31	Chemical Storage Area 4	Northwest Field	August-07	NFA	NA
	32	Drum Storage Area 1	Main Base		Transferred to Compliance	--
39	Harmon Substation	Harmon Annex	December-01	NFA	NFA - RA Completed	

TABLE 1-1. OPERABLE UNIT DESIGNATIONS FOR ANDERSEN AFB, GUAM.

Original OU Designation	Site Number	Former Site Name	Revised OU Designation	ROD Date	Present RA Status	Selected RA
OU-5	6	Landfill 8	Main Base	September-06	Institutional Controls	Institutional Controls
	8	Landfill 10a (formerly Landfill 10)	Main Base	August-07	Institutional Controls	Institutional Controls
		Landfill 10b (formerly Landfill 11)				
		Landfill 10c (formerly Landfill 12)				
	9	Landfill 13	Main Base	September-06	Institutional Controls	Institutional Controls
	10	Landfill 14	Main Base		Pending ROD	NA
	11	Landfill 15a (formerly Landfill 15)	Main Base	August-07	NFA	NA
		Landfill 15b (formerly Landfill 16)				
	12	Landfill 17	Main Base	September-06	Institutional Controls	Institutional Controls
		Pati Point Dump Site				
	13	Landfill 18	Main Base		Pending ROD	TBD
	14	Landfill 19	Main Base		Pending ROD	TBD
	15	Landfill 20	Main Base		Pending ROD	TBD
	25	Firefighter Training Area 1	Main Base	August-07	NFA	NA
33	Drum Storage Area 2	Main Base		Transferred to Compliance	--	
34	PCB Storage Area	Main Base	August-07	NFA	NFA - RA Completed	
36	Ritidian Point Dump Site	Northwest Field	August-07	NFA	NFA - RA Completed	
No OU designation	40	Urunao Dumpsites 1 & 2	Urunao	December-03	RA In Progress	RA In Progress
	41	AOC-54	Site-wide		Pending ROD	TBD
	42	AOC-55	Site-wide		Pending ROD	TBD
	43	AOC-56	Site-wide		Pending ROD	TBD
	44	AOC-65	Site-wide	November-08	NFA	NA
	45	AOC-67	Site-wide	November-08	NFA	NA
	46	AOC-69	Site-wide	November-08	NFA	NA
	47	AOC-80	Site-wide	November-08	RA Pending Completion	Soil Removal
	48	AOC-83	Site-wide	November-08	NFA	NA
	49	AOC-84	Site-wide	November-08	NFA	NA
	50	AOC-85	Site-wide	November-08	RA Pending Completion	Soil Removal
	51	AOC-93	Site-wide	November-08	RA Pending Completion	Soil Removal
	52	AOC-94	Site-wide		MMRP ROD Pending	TBD
	53	AOC-99	Site-wide	November-08	RA Pending Completion	Soil Removal
	54	AOC-105	Site-wide		Pending ROD	TBD
	55-A	Site 55 (formerly AOC-106)	Site-wide	November-08	RA Pending Completion	Soil Removal
	55-B	Site 55 (formerly AOC-106)	Site-wide		Transferred to Range Program	--
56	ESI AOC-10 & 11	Site-wide	November-08	NFA	NA	
57	ESI AOC-12	Site-wide		Pending ROD	TBD	

TABLE 1-1. OPERABLE UNIT DESIGNATIONS FOR ANDERSEN AFB, GUAM.

Original OU Designation	Site Number	Former Site Name	Revised OU Designation	ROD Date	Present RA Status	Selected RA
No OU designation	58	ESI AOC-14	Site-wide	November-08	NFA	NA
	59	AOC-I01	Site-wide	November-08	NFA	NA
	60	AOC-I02	Site-wide		MMRP ROD Pending	TBD
	61	AOC-I03	Site-wide	November-08	NFA	NA
	62	AOC-I04	Site-wide		MMRP ROD Pending	TBD
	63	AOC-I05	Site-wide		Pending ROD	TBD
	64	AOC-I06	Site-wide		Pending ROD	TBD
	65	AOC-I07	Site-wide		Pending ROD	TBD
	66	AOC-I08	Site-wide		Pending ROD	TBD
	67	AOC-I09	Site-wide	November-08	NFA	NA
	68	AOC-I10	Site-wide	November-08	NFA	NA
	69	AOC-68	Site-wide	November-08	NFA	NA
	70	ESI AOC-17 & 19	Site-wide	November-08	NFA	NA
	71	ESI AOC-18	Site-wide		Pending ROD	TBD
	72	ESI AOC-21 & 22	Site-wide		Pending ROD	TBD
	73	ESI AOC-28	Site-wide	November-08	NFA	NA
	74	ESI AOC-13	Site-wide		Pending ROD	TBD
	75	ESI AOC-15, 16, & 20	Site-wide		Pending ROD	TBD
76	ESI AOC-23, 24, 25 & 26	Site-wide		Pending ROD	TBD	
77	AOC -5	Site-wide		Pending ROD	TBD	
78	AOC -8	Site-wide		Pending ROD	TBD	

Notes: -- = not applicable

MMRP = Military Munitions Response Program

NA = Selected Remedy was No Action

NFA = No Further Action

RA = Remedial Action

ROD = Record of Decision

TBD = Selected Remedy To Be Determined

TABLE 1-2. SUMMARY STATUS OF SITES COVERED UNDER SECOND FIVE-YEAR REVIEW OF MARBO ANNEX OU.

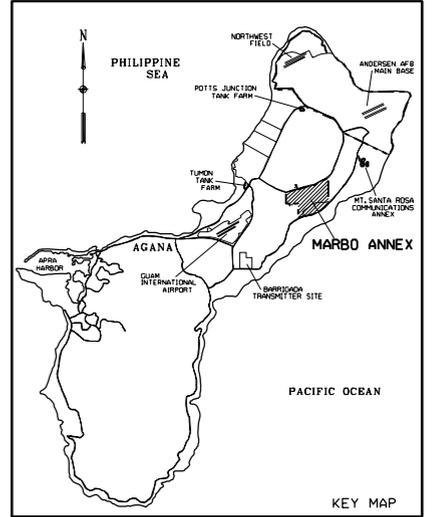
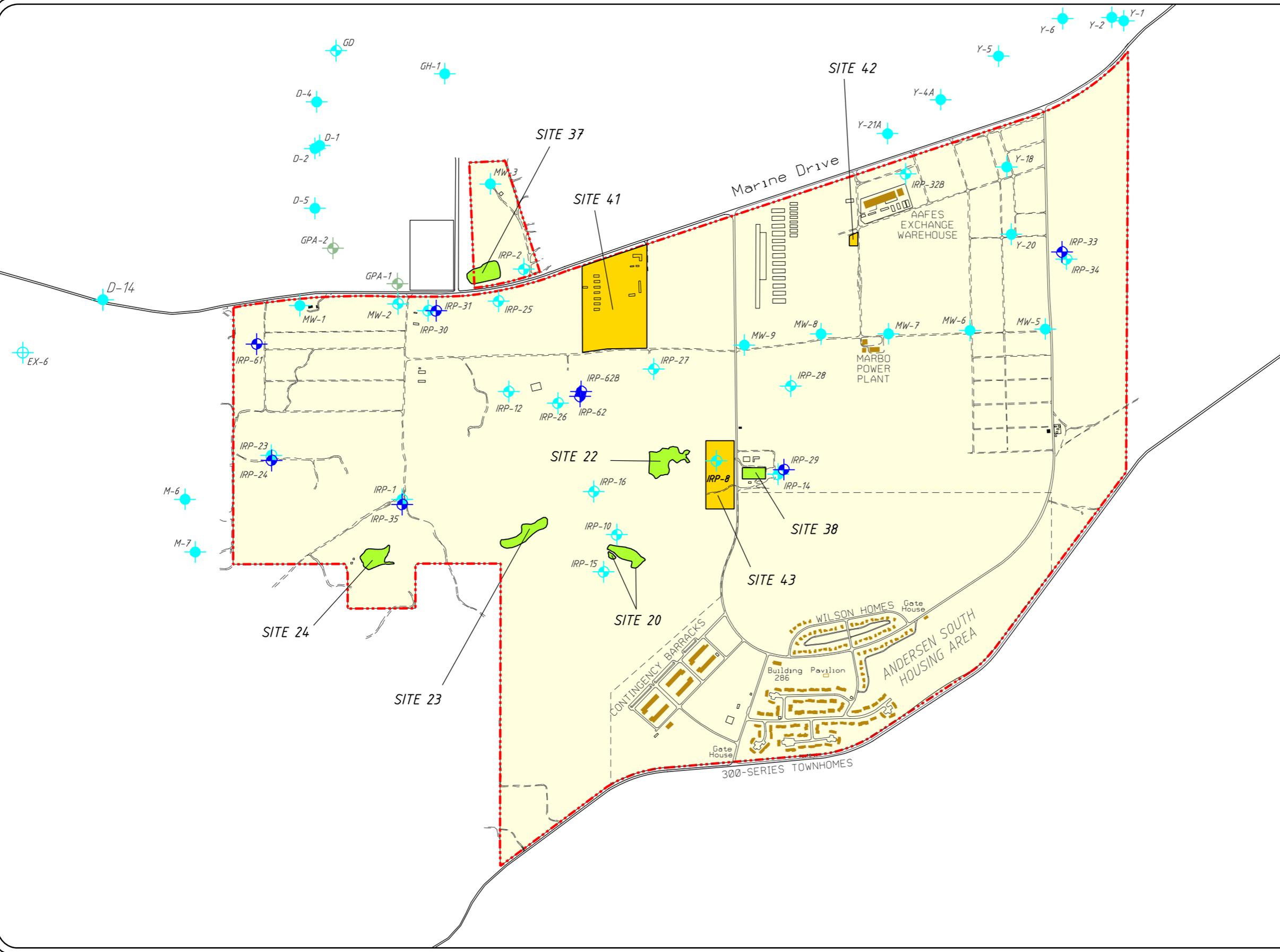
Site Name, COPCs, or COCs	Selected RA	RA Status	Issues	Recommendations and Milestone Date	RA Protectiveness? Yes/No	
					Current	Future
<p>Site 20 COCs = 4,4'-DDE, 4,4'-DDT, Dieldrin, Alpha chlordane, Gamma chlordane, Aroclor 1260, and Lead, based on human health and ecological risk assessment results.</p>	<p><i>Soil Cover</i></p>	<p>Completed on 25 May 1999</p>	<p>Several issues = Pig wallow and small trees are present at the site, which have damaged small area of the <i>Soil Cover</i>.</p>	<p>Recommendations = Continue annual Operation and Maintenance (O&M) and event driven O&M are recommended. Maintain posted signage on periphery of the site to restrict any activities that may jeopardize the structural integrity of the <i>Soil Cover</i>.</p>	<p>Y</p>	<p>Y</p>
<p>MARBO Annex Groundwater COCs = PCE and TCE, based on human health and ecological risk assessment results.</p>	<p>Original Remedy: <i>Natural Attenuation</i> plus 3 three institutional controls (ICs): 1) <i>Land Use Restrictions</i> 2) <i>Groundwater Monitoring</i> 3) <i>Existing Wellhead Treatment</i></p>	<p>Amended Remedy: <i>Institutional controls (ICs):</i> 1) <i>Land Use Restrictions</i> 2) <i>Groundwater Monitoring</i> 3) <i>Contingency for Wellhead Treatment</i></p>	<p>Several Issues = Lack of information to compare groundwater conditions in MARBO Annex with Harmon; Freshwater, transition and marine zones are poorly defined; PCE and TCE sources in MARBO Annex have not been identified; Fate and transport of TCE and PCE within MARBO in depth are poorly understood.</p> <p>A ROD Amendment was completed for MARBO Annex groundwater during the second five-year review period. The ROD Amendment included a TI Waiver that was invoked for the CERCLA requirement of achieving MCLs in the aquifer. The amended remedy for MARBO Annex groundwater is <i>Institutional Controls with Contingency for Wellhead Treatment</i>. The ROD Amendment removes natural attenuation as a component of the remedy.</p>	<p>Recommendations = Continue to perform long term monitoring in accordance with Post ROD Remedial Design. Continue to monitor sampling data from this well and share with Andersen AFB potable water supply facility managers.</p>	<p>Y</p>	<p>Y</p>

TABLE 1-2. SUMMARY STATUS OF SITES COVERED UNDER SECOND FIVE-YEAR REVIEW OF MARBO ANNEX OU.

Site Name, COPCs, or COCs	Selected RA	RA Status	Issues	Recommendations and Milestone Date	RA Protectiveness? Yes/No	
					Current	Future
Site 41 COCs = Lead, based on human health and ecological risk assessment results.	NA	Remedy Selection Pending	Status reviewed in this second five-year review. Final RAOs have not been determined. RA pending ROD completion.	None	NA	NA
Site 42 COCs = Lead, based on human health and ecological risk assessment results.	NA	Remedy Selection Pending	Status reviewed in this second five-year review. Final RAOs have not been determined. RA pending ROD completion.	None	NA	NA
Site 43 COCs = Arsenic, Cadmium, Lead, Aroclor 1254, Benzo(a)pyrene, (in surface soil) and Arsenic and Vanadium (in subsurface soi), based on human health and ecological risk assessment results.	NA	Remedy Selection Pending	Status reviewed in this second five-year review. Final RAOs have not been determined. RA pending ROD completion.	None	NA	NA



Figure 1-1. Location Map of Andersen Air Force Base on Guam.



- LEGEND:**
- EXISTING AIR FORCE PROPERTY LINE
 - EXISTING ROADS
 - EXISTING UNIMPROVED ROADS
 - FORMER BUILDING OR PAD
 - EXISTING BUILDING NOT INCLUDED IN THE FIRST FIVE-YEAR REVIEW OF THE MARBO ANNEX OPERABLE UNIT RECORD OF DECISION.
 - INSTALLATION RESTORATION PROGRAM (IRP) SITES, INCLUDING GROUNDWATER BENEATH THE SITES, THAT ARE INCLUDED IN THE MARBO ANNEX OPERABLE UNIT.
 - NEWLY INVESTIGATED SITES.
 - + IRP-33 DEEP MONITORING WELL
 - + IRP-34 SHALLOW MONITORING WELL
 - + GPA-1 FULL SCREENED MONITORING WELL ACROSS THE WATER TABLE
 - + MW-5 PRODUCTION WELL
 - + EX-6 EXPLORATORY BOREHOLE

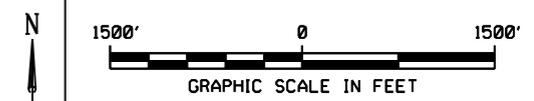


Figure 1-2.
Installation Restoration Program Sites in MARBO Annex Operable Unit.

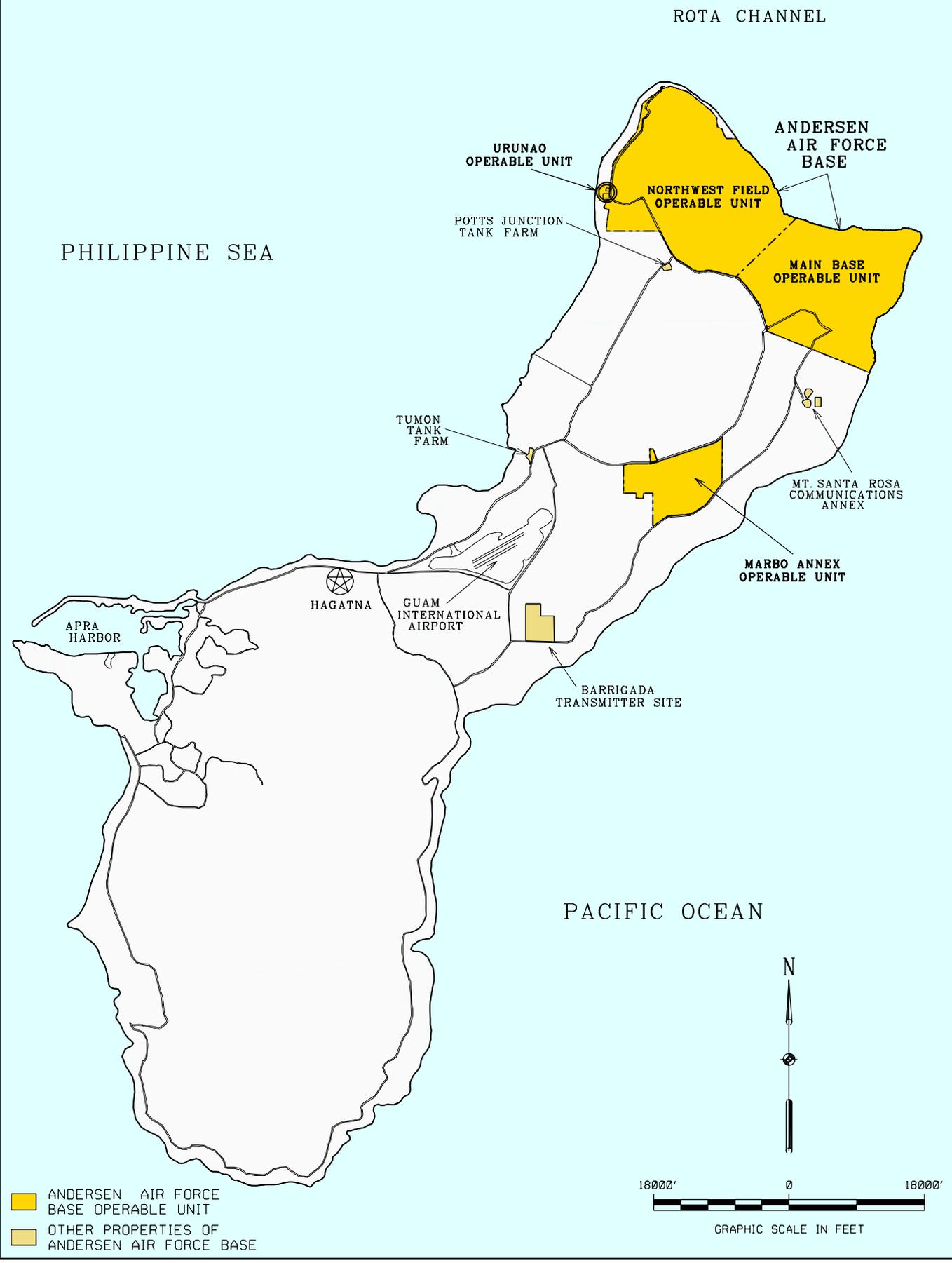


Figure 1-3. Location Map of Andersen Air Force Base Operable Units on Guam.

2.0 SITE CHRONOLOGY

Andersen AFB began investigating the MARBO Annex as early as 1985. A chronology of documents related to the MARBO Annex is highlighted and presented in the Andersen AFB Administrative Record Index from 1985 to 2009 (Appendix A). These documents include work plans, quality assurance project plans, environmental investigation reports, groundwater monitoring reports, and the record of public involvement.

The chronology of events and documents leading up to the first five-year review that are most directly related to site cleanup at the MARBO Annex are presented below:

10 March 1985	Phase I Record Search designated IRP sites at MARBO Annex
14 October 1992	FFA; Andersen AFB was included on the USEPA NPL
February 1994	Sampling and Analysis Plan (SAP) Addendum to OU 6 for OU3 (for soil)
February 1994	Work Plan Addendum to OU 6 for OU3 (for soil)
March 1994	SAP Addendum to OU 6 for OU 2 (for groundwater)
March 1994	Work Plan Addendum to OU 6 for OU 2 (for soil)
December 1996	Final OU3 RI (for soil)
January 1997	Final OU3 Focused Feasibility Study (FFS) (for soil)
March 1997	Final OU2 RI (for groundwater)
October 1997	Final OU2 FFS (for groundwater)
October 1997	Final MARBO Annex Proposed Plan (for soil and groundwater)
24 October 1997	Public Meeting held for MARBO Annex Proposed Plan
17 July 1998	Final MARBO Annex OU ROD (for soil and groundwater)
31 October 1998	Final Quality Program Plan and RA document, MARBO Annex OU
31 October 1998	Final Environmental Cleanup Plan and RA document, MARBO Annex OU
16 February 1999	Remedial mobilization began at Site 38/MARBO Laundry
23 February 1999	Remedial mobilization began at Site 22/Waste Pile 6
02 March 1999	Remedial mobilization began at Site 20/Waste Pile 7
10 May 1999	RA completed at Site 38/MARBO Laundry
25 May 1999	Completed soil cover at Site 20/Waste Pile 7
31 May 1999	Completed phase 1 of RA at Site 22/Waste Pile 6
13 November 1999	Commenced phase 2 of RA at Site 22/Waste Pile 6
15 September 2000	Final Site 24/Landfill 29 Quality Program Plans
30 November 2000	Final Site 24/Landfill 29 Environmental Cleanup Plan

30 November 2000	Remedial mobilization began at Site 24/Landfill 29
31 October 2000	Final Site 20/Waste Pile 7 Remedial Verification Report (RVR)
31 October 2000	Final Site 38/MARBO Laundry RVR
26 February 2001	Completed phase 2 RA at Site 22/Waste Pile 6
26 March 2001	Completed RA at Site 24/Landfill 29
04 May 2001	Interim Site 22/Waste Pile 6 RVR
02 October 2001	Final Site 24/Landfill 29 RVR
24 January 2003	Final Environmental Cleanup Plan, MARBO Annex OU
24 January 2003	Final Addendum to Quality Program Plan, MARBO Annex OU
24 January 2003	Interim Site 22/Waste Pile 6 Environmental Cleanup Plan
28 April 2003	Phase 3 Remedial Mobilization began at Site 22/Waste Pile 6
23 January 2004	Completed RA at Site 22/Waste Pile 6
25 June 2004	Final Site 22/Waste Pile 6 RVR
25 July 2004	Final First Five-Year Review of ROD for MARBO Annex OU

The chronology of events and documents compiled since the first five-year review that are most directly related to site cleanup at the MARBO Annex are presented below:

02 December 2004	Quarterly Inspection for Site 20
01 April 2006	Quarterly Inspection for Site 20
06 April 2006¹	EPA Concurrence with Agency Draft Workplan for RI/FS at Sites 41, 42, and 43 (Site-wide OU)
17 May 2006¹	Final Work Plan for RI/FS at Sites 41, 42, and 43 (Site-wide OU)
02 February 2007	Quarterly Inspection for Site 20
19 July 2007	Quarterly Inspection for Site 20
11 January 2008¹	Agency Draft RI/FS for Sites 41, 42, and 43
28 February 2008	Quarterly Inspection for Site 20
21 November 2008¹	Final FFS to Support a ROD Amendment with a Technical Impracticability (TI) Waiver for the MARBO Annex OU (for groundwater)
By December 2009	ROD Amendment for MARBO Annex OU (for groundwater)
By December 2009¹	Post-ROD Amendment Remedial Design (RD) for MARBO Annex OU (for groundwater)

¹ This document has not yet been filed in the Andersen AFB Administrative Record.

3.0 BACKGROUND

3.1 General Background

3.1.1 Overview of the First Five-Year Review

The first five-year review of the MARBO Annex OU ROD included an evaluation of the post-ROD status of six IRP sites (Sites 20, 22, 23, 24, 37, and 38), and the groundwater beneath the MARBO Annex (Figure 1-2). The ROD review also evaluated the status of three additional IRP sites pending final remedy selection that were part of another OU but were located within the boundaries of the MARBO Annex. The review organized the evaluated sites with respect to their media of concern, i.e. soil-related COCs and groundwater-related COCs.

3.1.1.1 Evaluated Sites Referred for No Additional Five-Year Reviews

As no new sources of contamination were identified during the document review and site inspection conducted for the first five-year review of Sites 22, 23, 24, 37, and 38, future five-year reviews were not recommended.

3.1.1.2 Evaluated Sites Subject to Additional Five-Year Reviews

Five-year reviews must be performed for Site 20 and the MARBO Annex groundwater because their selected remedies are considered *Operating RAs*, as they have been implemented but leave residual COCs in place at concentrations that do not allow for unrestricted use or unlimited access.

The selected remedy for Site 20 consisted of a *Soil Cover with Institutional Controls (ICs)*. During the first five-year review site inspection of Site 20, there were concerns regarding pig wallowing activity and small tree roots at the site that jeopardized the integrity of the *Soil Cover* in protecting the human health and the environment (EA, 2004). A regular quarterly Operations and Maintenance (O&M) program was therefore recommended to verify and maintain the integrity of the *Soil Cover* at Site 20. As part of the quarterly O&M program, “event driven” inspections were recommended to verify the integrity of the *Soil Cover* after natural disasters, such as typhoons or earthquakes. Furthermore it was recommended that signs be posted at the boundaries of the site restricting intrusive activities that would damage the *Soil Cover*, such as driving trucks, trenching, or excavating (EA, 2004). The integrity of the soil cover at Site 20 has been evaluated during the second five-year review through site inspection and the review of quarterly O&M records, and the findings are presented in this document.

The 1998 ROD selected remedy for the MARBO Annex groundwater consisted of *Natural Attenuation with Institutional Controls* to achieve the remediation goal of decreasing trichloroethene (TCE) and tetrachloroethene (PCE) concentrations in the aquifer to levels below Maximum Contaminant Level (MCL). Through physical processes of dispersion and dilution, the timeframe to achieve cleanup goals (MCLs) was estimated at 10 to 40 years, assuming a continued source of PCE and TCE did not exist (EA, 1998a). Supplemental to the natural attenuation were three ICs that included:

- **Land Use Restrictions** to monitor and restrict groundwater access in areas impacted by TCE/PCE,
- **Groundwater Monitoring** to monitor TCE/PCE and confirm the stability of TCE/PCE plumes in the MARBO Annex, and
- **Existing Wellhead Treatment** to ensure public health risk is within the acceptable range at existing USAF production wells.

During the first five-year review of the MARBO Annex OU ROD, it was determined that the overall timeframe for the groundwater remedy to effectively reduce the concentrations of the TCE/PCE to below MCLs, may take longer than 40 years (EA, 2004). At the conclusion of the first five-year review, it was recommended that if, during the second five-year review period, monitored natural attenuation (MNA) did not appear to be effectively reducing TCE and PCE concentrations in MARBO Annex Groundwater, the MARBO Annex OU ROD would be amended to either specify an active remediation method or a TI waiver to achieve the applicable or relevant and appropriate requirement (ARAR) of meeting the drinking water MCL in the aquifer (EA, 2004).

A ROD Amendment for the MARBO Annex groundwater remedy will be completed by December 2009 (EA and Metcalf & Eddy [EA/M&E], 2009a). The amended remedy is *Long-Term Groundwater Monitoring with Contingency for Wellhead Treatment*, with a TI Waiver which waives the requirement of achieving MCLs in the aquifer.

3.1.1.3 Evaluated Sites Pending Final Remedy Selection

Sites 41, 42, and 43 (formerly AOCs 54, 55, and 56, respectively) located in the MARBO Annex were designated as part of the Site-wide OU (previously referred to as the Basewide OU) and were not included in the MARBO Annex OU ROD. These sites were evaluated in the first five-year review because they are located within the MARBO Annex; however, a final remedy was not selected. A ROD is currently under development. Because a final remedy has still not been selected under the Site-wide OU, an update of the status of these sites is included in this review.

3.1.2 Environmental Setting of MARBO Annex

MARBO Annex OU is located on a broad, uplifted limestone plateau that is underlain by volcanic rocks (Figure 3-1). The limestone plateau includes numerous sinkholes and ranges in elevation from 300 to over 500 feet above mean sea level (msl). The sinkholes are very porous and provide rapid infiltration of surface water to the underlying fresh water aquifer, rendering no permanent surface water bodies at the MARBO Annex.

The surface of the limestone plateau is interrupted by two volcanic peaks, Mount Santa Rosa and Mataguac Hill, which are located northeast and north of the MARBO Annex, respectively (Figure 3-1). These low-permeability volcanic outcrops extend into the subsurface to form a lateral barrier that directs the groundwater flow towards the Tumon Bay (Figure 3-1). According to groundwater monitoring data (EA, 2008b), the groundwater at the MARBO Annex is encountered at approximately 281 to 400 feet below ground surface (bgs). Based on the 2001

Guam Water Quality Standards, the fresh or saline groundwater at the MARBO Annex is categorized as a G-1 Resource Zone for potable water (Guam EPA, 2001). Consequently, any wastewater discharges within the G-1 Resource Zone is regarded as tributary to the potential potable groundwater supply and must be free of pollutants.

Water extracted from production wells in the MARBO Annex supplies Andersen AFB. Currently, seven of the nine Andersen AFB production wells (MW-series wells) located on the MARBO Annex (Figure 1-2) are used for water production, and they can yield upwards of approximately 3.0 million gallons per day (mgd), to meet the average Base consumption of 2.0 mgd (EA, 2008c).

Although there are housing developments (Wilson Homes, Contingency Barracks, and the Andersen South Housing Area) within the MARBO Annex, they have been unoccupied since 1996 (Figure 1-2). The nearest populated areas are in the nearby villages of Dededo located approximately 50 feet west, Yigo located approximately 150 feet north, and Mangilao located approximately 25 feet east of the MARBO Annex. As of 2000, the combined population of Dededo and Yigo was approximately 62,000, which comprises approximately 40 percent of the island's population (United States Census Bureau, 2001). Dispersed, low-density populations characterize the area between these villages and the MARBO Annex.

MARBO Annex is located in the interior of Guam, away from the coastal cliff line and marine environments. Therefore, the MARBO Annex is not within the range of the critical habitats of threatened or endangered species such as the Mariana crow (*Corvus kubaryi*), the Mariana fruit bat (*Pteropus mariannus*), the Fire tree (*Serianthes nelsonii*), and the Ufa-Halomtano tree (*Heritiera longipetiolata*) (Department of Aquatic and Wildlife Resources, 1988).

3.1.3 MARBO Annex Land and Resource Use

Presently, MARBO Annex properties are inactive. According to the Andersen AFB archives, the MARBO Annex was developed for military housing, warehouses, industrial support facilities, and operational facilities. From 1944 through 1950, MARBO Annex was under the jurisdiction of the Naval Government of Guam. Following the Organic Act of 1950, the United States Government took control of the MARBO Annex and administration was transferred to the United States Navy (USN). By 1956 all operations at the MARBO Annex had ceased, except for the USN Power Plant and the water production wells. On 25 June 1958, the USAF assumed control of the MARBO Annex. Based on review of available Real Estate Property records at Andersen AFB, all temporary buildings on the MARBO Annex were removed prior to June 1960 (EA, 2004).

Subsequent to finalizing the MARBO Annex OU ROD in 1998, various land parcels have been transferred or have been proposed for transfer to other Federal or territorial agencies (EA, 1998a). Two parcels, covering 81 acres and 395 acres, respectively, have been transferred to the Government of Guam (Figure 3-2). The 81-acre parcel contains an active Guam Waterworks Authority (GWA) production well (Y-20) and included the planned construction of a high school. The 231-acre parcel contains a fire station and an active GWA production well (Y-19), and future land use plans include construction of a police station. Another 1,569-acre parcel was

offered to the United States Marines, for training facilities, however in 2003 the Marines indicated that they were no longer interested in acquiring the property. The USAF is currently considering alternate plans for future disposition of this parcel. Another 224-acre parcel is being retained by the USAF for a variety of purposes. An area near Site 20 is being retained to ensure ICs are maintained in compliance with the MARBO Annex OU ROD. Several linked areas are being retained to support the USAF groundwater production and distribution system at the MARBO Annex. Two areas (the MARBO Laundry and the Army and Air Force Exchange Service Warehouse) are being retained for USAF warehousing activities. Currently, the MARBO Annex consists of approximately 2,010 acres of land.

3.2 Background of Sites Included in this Five-Year Review

3.2.1 Background of Site 20

3.2.1.1 General Description of Site 20

Site 20 is classified as an *Operating RA*, as the RA has been implemented but residual COCs have been left in place at concentrations that do not allow for unrestricted use of or unlimited access to the land. An *Operating RA* may require management in perpetuity.

Site 20 is located in the south-central portion of the MARBO Annex (Figure 1-2). Site 20 is an abandoned quarry that was partially filled with waste and covered with soil and vegetation. The site was divided into two broad areas of concern with respect to the potential for contamination. Area A included the *Buried Waste Area* and consisted of approximately 1.84 acres of fill, averaging 10.8 feet in thickness, and a small area covered with 10 empty, deteriorated drum remnants. Area B included numerous mounds of soil, some of which were covered with construction debris, municipal trash, and metal debris (EA, 1998b).

3.2.1.2 Former, Current, and Future Land Use at Site 20

As previously discussed, Site 20 was formerly used as quarry and was subsequently an area where waste materials were disposed. Access is currently restricted and ICs have been placed on the site to restrict future use because COCs at the site pose potentially unacceptable risks to human health. There are currently no plans to modify existing land use; however, any future land use at Site 20 must include provisions for mitigating exposure of future human receptors to COCs remaining onsite.

3.2.1.3 History of Contamination at Site 20

According to the Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA), Area A had surface soil contamination that required a RA. The COCs identified at Site 20 included lead, pesticides (4,4'-dichlorodiphenyldichloroethene [4,4-DDE], 4,4-dichlorodiphenyltrichloroethene [4,4-DDT], dieldrin, alpha chlordane, and gamma chlordane), and the polychlorinated biphenyl (PCB) Aroclor 1260, as shown in Table 3-1 (EA, 1997). The calculated exposure point concentrations (EPCs) that were used for the HHRA in the MARBO Annex RI/FS (ICF, 1996) are presented in Table 3-1 along with their respective

Background Threshold Value (BTV) and the 1995 residential Preliminary Remediation Goal (PRG) (USEPA, 1995):

Table 3-1. Comparison of Site 20 EPCs to 1995 Residential PRGs and BTVs used for the HHRA.

COC	EPC (mg/kg)	1995 Residential PRG (mg/kg)	BTV (mg/kg)
4,4'-DDE	6.7	1.3	NA
4,4'-DDT	6.2	1.3	NA
Dieldrin	0.12	0.028	NA
Alpha chlordane	0.44	0.34	NA
Gamma chlordane	0.38	0.34	NA
Aroclor 1260	4.4	0.066*	NA
Lead	3,604	400	166

* = PRG is based on total PCB concentration; prior to 2000 there was no PRG for Aroclor 1260.
 BTV = Background Threshold Value
 COC = contaminant of concern
 EPC = Exposure Point Concentration
 mg/kg = milligrams per kilogram
 NA = not applicable; BTV is applicable only for inorganic compounds (metals).
 PRG = Preliminary Remediation Goal

3.2.1.4 Initial Response at Site 20

The COCs detected in Site 20 soils were determined to be relatively stable and immobile; therefore, no immediate response was required.

3.2.1.5 Basis for Taking Action

The basis for taking action at Site 20 was excessive cancer to residential receptors (2×10^{-4}) and non-cancer (HI=4) risks associated with elevated concentrations of Aroclor 1260, pesticides, and lead in surface and subsurface soils in the *Buried Waste Area* (Figure 3-3). Though the condition of the COC-impacted soil did not require an immediate initial response, an RA was proposed for the site to protect the future human and ecological receptors.

3.2.2 Background of Site 41

3.2.2.1 General Description of Site 41

Site 41 is located adjacent to Marine Drive (Figure 1-2), covers approximately 8 acres, and is flat to gently sloping. Site 41 includes the foundations (concrete pads) of former operational support buildings such as a tool shop, a carpenter shop, a generator shop, a heavy vehicle shop, and vehicle maintenance shops. In addition, a vehicle maintenance pit associated with the former heavy vehicle shop was located at the site. Due to past operations at the former shops, potentially hazardous materials were suspected to have been discharged to the soils.

3.2.2.2 Current and Future Land Use at Site 41

Currently, the site is inactive and there are no plans to modify existing land use, however, redevelopment of this area is likely at some future date given the limited available land on Guam.

3.2.2.3 History of Contamination at Site 41

Based on the analysis of 105 surface soil samples (including 10 duplicate samples), lead was detected at concentrations ranging from 19.6 to 53,300 milligrams per kilogram (mg/kg) (EA, 2008a). At the time the HHRA was performed, 2004 USEPA Region 9 PRGs were used to conduct the risk screening; however, they have since been superseded by 2009 USEPA Regional Screening Levels (RSLs) (USEPA, 2004; USEPA, 2009). For lead, the residential and industrial RSLs are equivalent to the corresponding PRGs; 400 mg/kg and 800 mg/kg, respectively. The average concentration of lead in surface soil samples (1,257 mg/kg) exceeds both residential and industrial RSLs, as shown in Table 3-2. Therefore, lead in surface soil was identified as a COC, posing potentially unacceptable risks to future residential receptors and current industrial workers at the site.

Table 3-2. Comparison of Site 41 EPCs to Residential RSLs and BTVs.

COC	EPC (mg/kg)	2009 Residential RSL (mg/kg)	2009 Industrial RSL (mg/kg)	BTV (mg/kg)
Lead	1,257	400	800	166
BTV = Background Threshold Value EPC = Exposure Point Concentration mg/kg = milligrams per kilogram RSL = Regional Screening Level				

Lead was not detected in any subsurface soil samples at concentrations exceeding the residential PRG (400 mg/kg).

3.2.2.4 Initial Response at Site 41

The COC detected in Site 41 soils (lead) was determined to be relatively stable and immobile in the weathered limestone soils; therefore, no immediate response was required.

3.2.2.5 Basis for Taking Action at Site 41

The future use of Site 41 is undetermined; therefore, the site may be potentially developed for future residential or commercial use. The basis for taking action at Site 41 was related to elevated concentrations of lead in surface soil (Figure 3-4). There are no toxicity values published by USEPA to quantify cancer risks from lead using the standard HHRA methodologies; therefore, no HHRA was conducted for Site 41. The USEPA Region 9 residential PRG and RSL were based on the output of the Integrated Exposure Uptake Biokinetic (IEUBK) Lead Model for residential exposures. According to USEPA guidance, lead is assessed through the use of the blood-lead model, which uses the average concentration of lead in soil.

Though the condition of the lead-impacted soil did not require an immediate initial response, an RA has been proposed for the site to protect future human and ecological receptors.

3.2.3 Background of Site 42

3.2.3.1 General Description of Site 42

Site 42 is located approximately 900 feet south of Marine drive (Figure 1-2), covers approximately 1.5 acres, and is flat to gently sloping. Site 42 is a former gas station with two associated rusted aboveground storage tanks (ASTs). Due to past operations, discharge of fuel constituents to the soil may have occurred.

3.2.3.2 Current and Future Land Use at Site 42

Currently, the site is inactive and there are no plans to modify existing land use; however, redevelopment of this area is likely at some future date given the limited available land on Guam.

3.2.3.3 History of Contamination at Site 42

Based on the analysis of 26 surface soil samples (including two duplicate samples), lead was detected at concentrations ranging from 25.6 to 3,370 mg/kg (EA, 2008a). At the time the HHRA was performed, 2004 USEPA Region 9 PRGs were used to conduct the risk screening; however, they have since been superseded by 2009 USEPA RSLs. For lead, the residential and industrial RSLs are equivalent to the corresponding PRGs; 400 mg/kg and 800 mg/kg, respectively. The average concentration of lead in surface soil samples (485 mg/kg) exceeds the residential RSL, as shown in Table 3-3. Therefore, lead in surface soil was identified as a COC, posing potentially unacceptable risks to future residential receptors at the site.

Table 3-3. Comparison of Site 42 EPCs to Residential RSLs and BTVs.

COC	EPC (mg/kg)	2009 Residential RSL (mg/kg)	BTV (mg/kg)
Lead	485	400	166
BTV = Background Threshold Value EPC = Exposure Point Concentration mg/kg = milligrams per kilogram RSL = Regional Screening Level			

Lead was not detected in any of the subsurface soil samples at concentrations exceeding the residential RSL (400 mg/kg).

3.2.3.4 Initial Response at Site 42

The COC detected in Site 42 soils were determined to be relatively stable and immobile in the weathered limestone soils; therefore, no immediate response was required.

3.2.3.5 Basis for Taking Action at Site 42

The future use of Site 42 is undetermined; therefore, the site may be potentially developed for future residential or commercial use. The basis for taking action at Site 42 was related to elevated concentrations of lead in surface soil (Figure 3-5). There are no toxicity values published by USEPA to quantify cancer risks from lead using the standard HHRA methodologies. As previously discussed, lead is assessed through the use of the blood-lead model, which uses the average concentration of lead in soil compared to the results of the IEUBK Lead Model for residential exposures. Though the condition of the lead-impacted soil did not require an immediate initial response, an RA has been proposed for the site to protect future human and ecological receptors.

3.2.4 Background of Site 43

3.2.4.1 General Description of Site 43

Site 43 is located west of the former MARBO Laundry (Figure 1-2), covers approximately 35 acres, and is flat to gently sloping. Site 43 includes the foundations (concrete pads) of former operational support buildings including a welding shop, battery shop, concrete vault, machine shop, carpenter shop, motor pool garage, paint shop, warehouses, generator shed, grease stand, steam shop, supply shed, preventative maintenance shop, sign paint shop, refrigerator shop, plumbing shop, and electric shop. Due to past operations at the shops, potentially hazardous materials were suspected to have been discharged at the site.

3.2.4.2 Current and Future Land Use at Site 43

Currently, the site is inactive and there are no plans to modify existing land use; however, redevelopment of this area is likely at some future date given the limited available land on Guam.

3.2.4.3 History of Contamination at Site 43

Based on the analysis of 173 surface soil samples (including 5 duplicates) and 33 subsurface soil samples (including 4 duplicates), arsenic, cadmium, lead, Aroclor 1254, and benzo(a)pyrene, in surface soil, and arsenic and vanadium, in subsurface soil, were identified as COCs (Table 3-4) (EA, 2008a). These COCs were detected at concentrations exceeding the residential PRGs, and or BTVs, posing potentially unacceptable risks to future residential receptors and current industrial workers at the site.

At the time the HHRA was performed, 2004 USEPA Region 9 PRGs were used to conduct the risk screening; however, they have since been superseded by 2009 USEPA RSLs. The residential RSL for benzo(a)pyrene is more stringent (0.015 mg/kg) than the residential PRG, and the residential RSLs for cadmium and vanadium are less stringent (70 and 390 mg/kg, respectively) than their respective residential PRGs (Table 3-4). These changes are not significant enough to alter the conclusions of the RI/FS for Site 43, as most of these COCs are collocated with other COCs that are targeted for removal.

Table 3-4. Comparison of Site 43 EPCs to Residential PRGs, Residential RSLs, and BTVs.

COC	EPC (mg/kg)	2004 Residential PRG (mg/kg)	2009 Residential RSL (mg/kg)	BTV (mg/kg)
Surface Soil				
Arsenic	116	0.39	0.39	62
Cadmium	226	37	70	6.5
Lead	9,390	400	400	166
Aroclor 1254	31	0.22	0.22	NA
Benzo(a)pyrene	83	0.06	0.015	NA
Subsurface Soil				
Arsenic	64	0.39	0.39	62
Vanadium	225	78	390	206
BTV = Background Threshold Value EPC = Exposure Point Concentration mg/kg = milligrams per kilogram NA = not applicable; BTV is applicable only for inorganic compounds (metals). PRG = Preliminary Remediation Goal RSL = Regional Screening Level				

3.2.4.4 Initial Response at Site 43

The COCs detected in Site 43 soil samples were determined to be relatively stable and immobile in the weathered limestone soils; therefore, no immediate response was required.

3.2.4.5 Basis for Taking Action at Site 43

The future use of Site 43 is undetermined; therefore, the site may be potentially developed for future residential or commercial use. The basis for taking action at Site 43 was related to arsenic, cadmium, Aroclor 1254, and benzo(a)pyrene in surface soil, and arsenic and vanadium in subsurface soil. These COCs posed either potentially unacceptable non-cancer and/or cancer risks to current industrial workers and future residential receptors (Figures 3-6 through 3-9). Lead in surface soil also posed potentially unacceptable risks to current industrial workers and future residential receptors.

3.2.5 Background of MARBO Annex Groundwater

3.2.5.1 Description for MARBO Annex Groundwater

Since 1989, the quality of the MARBO Annex groundwater has been evaluated at least semi-annually through a network of groundwater monitoring points (EA, 2008b). The Long-Term Groundwater Monitoring (LTGM) Program for Andersen AFB was initiated in October 1995 to ensure compliance with CERCLA, RCRA, Clean Water Act, Safe Drinking Water Act, and all ARARs, with the goals of:

- establishing baseline groundwater elevation and water quality data at monitoring and production wells,
- evaluating the baseline data and identifying critical sampling locations,

- installing new monitoring wells in those critical sampling locations, and
- determining modifications to monitoring points, monitoring frequency, and analytical methods.

Since the LTGM Program was initiated in 1995, 26 rounds of groundwater sampling have been conducted at the MARBO Annex. Currently, 18 monitoring and three production wells are sampled as part of the LTGM Program at the MARBO OU. Nine of the monitoring wells and the three production wells are “shallow” wells that are screened across the top of the freshwater lens. Five of the monitoring wells are “deep” wells that are screened near the base of the freshwater lens. The “deep” wells are screened at depths approximately 90 to 100 feet lower than the screened intervals of the nearby “shallow” wells, to monitor water quality near the base of the freshwater lens. Two of the monitoring wells are open-boreholes that fully penetrate the freshwater lens. The two Guam Power Authority monitoring wells are fully screened across the freshwater lens. The analytical results for monitoring points in the LTGM Program are provided in Appendix B.

The northern half of Guam exhibits characteristics of a Simple Carbonate Island, a Carbonate-Cover Island, and a Composite Island according to the type of Carbonate Island Karst Model (Mylroie et al., 2001). As presented in Figure 3-1, the two volcanic peaks of Mount Santa Rosa and Mataguac Hill create a channel that directs the groundwater flow toward Tumon Bay.

Groundwater is the principal source of drinking water for Guam and is the source of freshwater for other uses. Currently, the karst limestone of the Northern Guam Lens (NGL) produces approximately 40 million gallons of freshwater per day for public use (EA, 2008c). Even though Guam receives approximately 100 inches of rainfall per year, surface water does not exist on northern Guam due to the highly permeable, eogenetic, karst limestone.

The hydrogeology model of the NGL is complex due to 400 feet of karstic geologic features with secondary dissolution channelization and water production pumping. Groundwater velocities can vary significantly and hydraulic conductivities of up to 20,000 feet per day have been observed at MARBO Annex (ICF, 1997). The vast majority of rainfall percolates through the vadose zone and creates a freshwater lens that floats atop a transition zone underlain by marine water due to density effects. The freshwater lens is approximately 100 feet thick and subject to highly conductive groundwater flow. A brackish transition zone (mixing zone) of approximately 20 feet thick exists between the freshwater lens and the underlying marine water (EA, 2008c).

The rapid infiltrating recharge to the upper portion of the freshwater lens propagates quickly (within weeks to months) to coastal discharge areas via seeps and/or large-scale dissolution features (EA, 2008c). The rapidly infiltrating recharge has created strongly oxidized groundwater conditions throughout the fresh water lens, as evidenced by shallow and deep dissolved oxygen concentrations generally ranging from 5 to 8 milligrams per Liter (mg/L) and oxidation-reduction potential ranging from 100 to 500 millivolts (EA, 2008c). The strong lateral flow component that is observed in the upper portion of the freshwater lens is not evident in the basal portion of the lens, based on contaminant trends.

Based on the extensive data-set collected over the course of the MARBO Annex LTGM Program, it is apparent that the elevation and thickness of the freshwater lens vary in response to rapid flush of short-term rainfall events, moderate-term seasonal rainfall and monsoonal wind effects on sea level, and long-term fluctuations due to El Nino/Southern Oscillation events and eustatic sea level rise. The short- and long-term rainfall events have lead to cyclic variation on the thickness of the groundwater lens, based on cyclical chloride level observations (20 and 200 mg/L) in deep groundwater monitoring wells (EA, 2008c).

3.2.5.2 Former, Current, and Future Land Use above MARBO Annex Groundwater

As previously discussed, land use at the MARBO Annex consisted of residential housing, military warehousing, and industrial support facilities. Currently, land use comprising the general area above the PCE- and TCE-impacted portion of the MARBO Annex OU groundwater aquifer is inactive. As part of the selected remedy in the MARBO Annex OU ROD, ICs restrict property deeds pertaining to the installation of water supply wells on properties affected by PCE- and TCE-impacted groundwater (Figure 3-10) (EA, 1998a). Re-development of this area is likely at some future date given the limited available land on Guam.

3.2.5.3 History of Contamination for MARBO Annex Groundwater

Based on historical groundwater monitoring results, TCE and PCE are identified as COCs in MARBO Annex groundwater. TCE has been detected in deep groundwater samples collected from GPA-1, GPA-2, and MW-2 (456, 458, and 368 feet bgs, respectively) at concentrations above the MCL of 5 micrograms per Liter ($\mu\text{g/L}$). PCE has been detected in deep groundwater samples collected from IRP-29 (475 feet bgs), at a concentration above the MCL of 5 $\mu\text{g/L}$. Both TCE and PCE have been detected in deep groundwater samples collected from IRP-31 (456 feet bgs), at concentrations above their respective MCLs of 5 $\mu\text{g/L}$ (Figure 3-11). With the exception of IRP-14 (382 feet bgs), TCE and PCE have either been non-detect or detected at concentrations below the MCL in all shallow monitoring wells. For IRP-14, PCE concentrations in groundwater samples have shown a historic decrease from concentrations that were initially above the MCL of 5 $\mu\text{g/L}$ to concentrations that are consistently below half the MCL. The exact source of TCE and PCE remains unknown based on the completed investigation of all potential TCE and PCE sources in MARBO Annex soil (EA, 2008a; EA, 2008c).

3.2.5.4 Initial Response for MARBO Annex Groundwater

Although the TCE and PCE plumes have been considered relatively immobile, the COCs detected in the MARBO Annex groundwater poses potential human health risks via groundwater production to the municipal water supply. The ROD for MARBO Annex OU, included long term groundwater monitoring of monitoring and production wells and wellhead treatment for three production wells in the MARBO Annex (MW-1, MW-2, and MW-3), until TCE and/or PCE concentrations were consistently below MCLs. Wellhead treatment on production well MW-2 was implemented as stated in the remedy; however, MW-2 was taken out of production in 1998 when the air stripping tower used to treat the water was fouling due to frequent carbonate build-up and the well was no longer required to meet demand. Wellhead treatment was therefore

discontinued at MW-2. Production wells MW-1 and MW-3 continue to produce potable water and have never required wellhead treatment.

3.2.5.5 Basis for Taking Action for MARBO Annex Groundwater

The basis for taking action for MARBO Annex groundwater was to protect human health, in accordance with the Remedial Action Objectives (RAOs) through implementation of ICs, against the presence of TCE and PCE in MARBO Annex groundwater at concentrations exceeding MCLs.

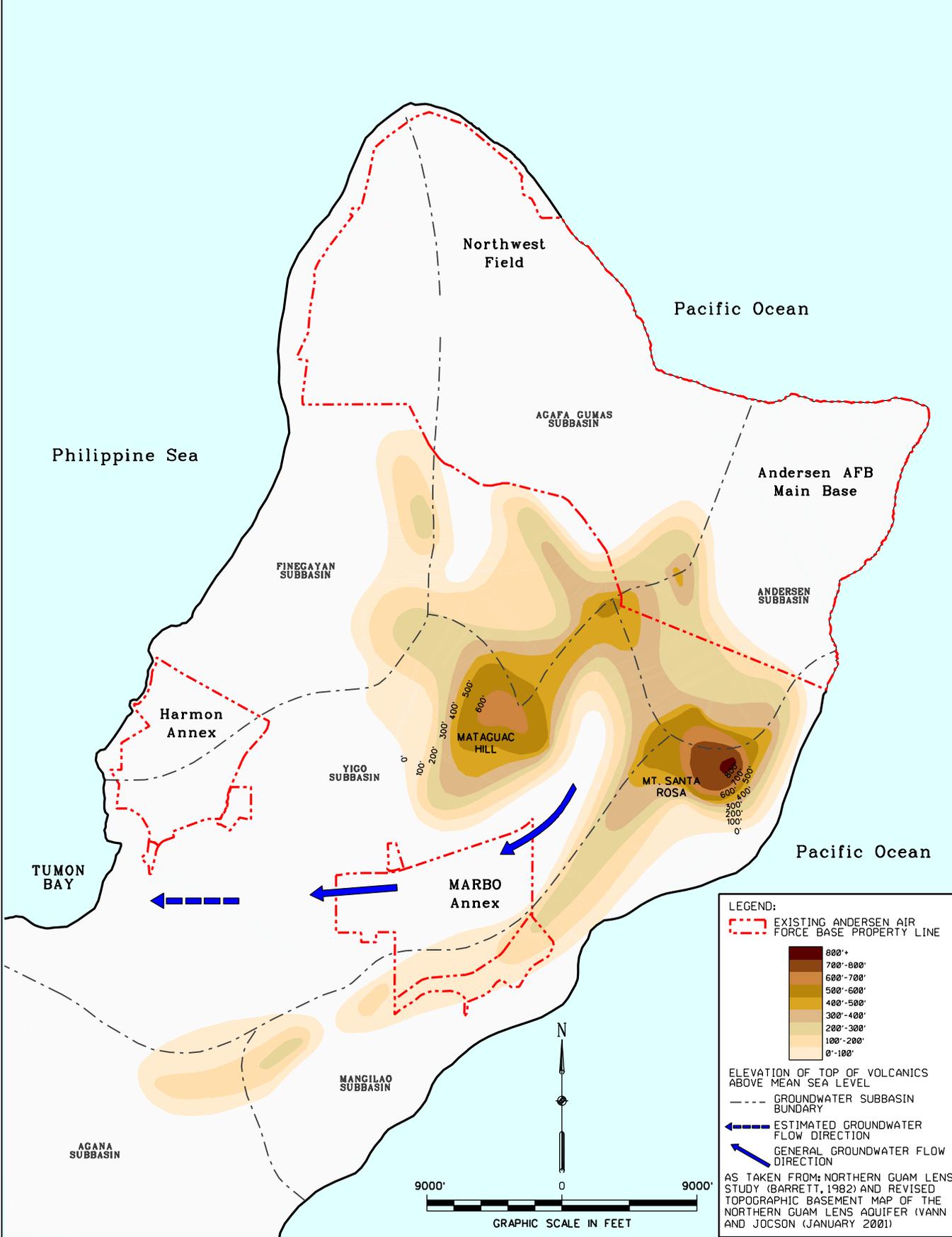
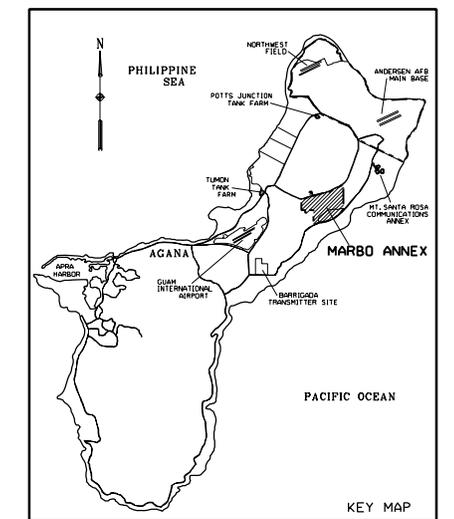
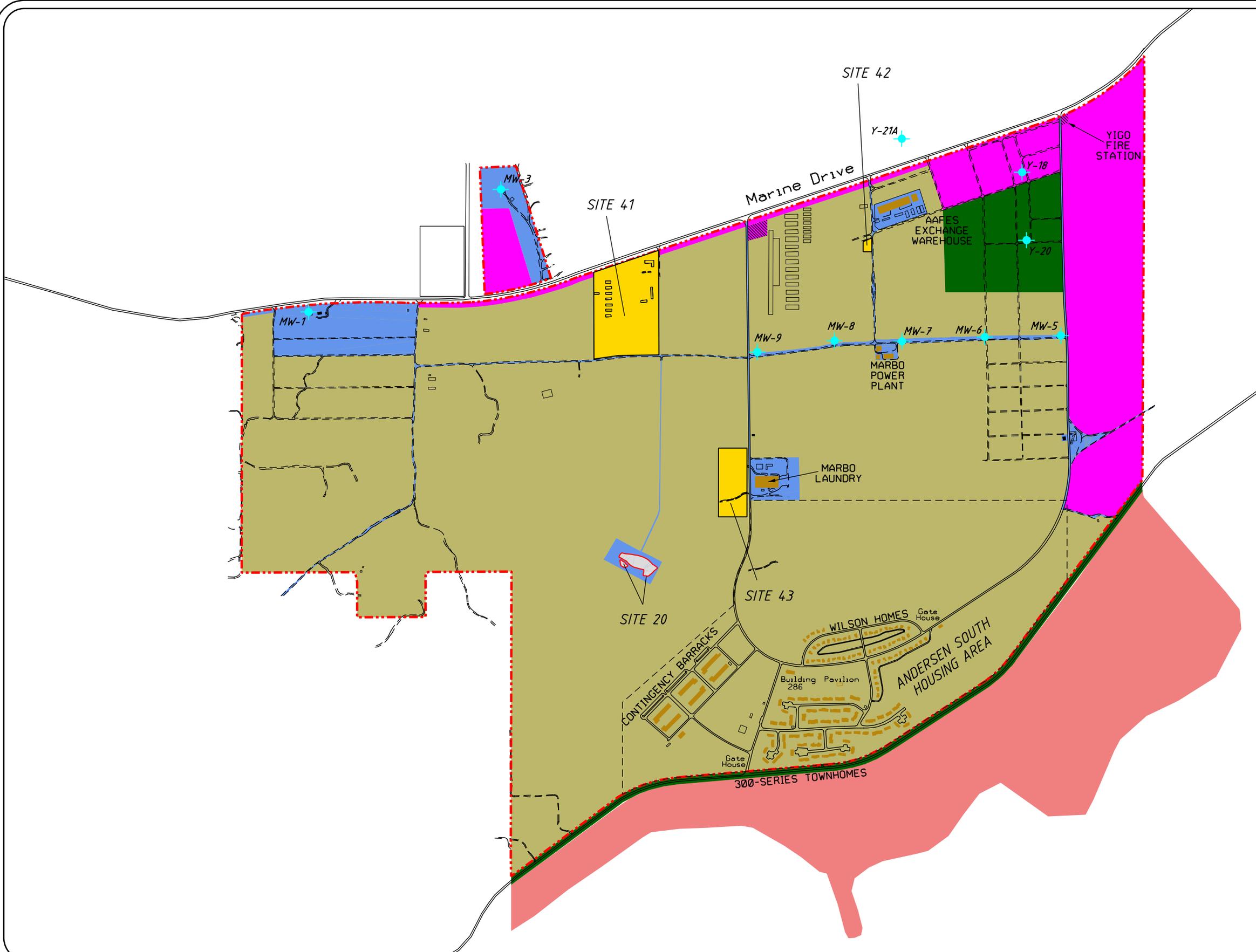


Figure 3-1. Volcanic Structure Contours.



- LEGEND:**
- EXISTING AIR FORCE PROPERTY LINE
 - EXISTING ROADS
 - EXISTING UNIMPROVED ROADS
 - FORMER BUILDING OR PAD
 - EXISTING BUILDING NOT INCLUDED IN THE FIRST FIVE-YEAR REVIEW OF THE MARBO ANNEX OPERABLE UNIT RECORD OF DECISION.
 - 224 ACRE AREA - AIR FORCE RETAINED PROPERTY
 - 1569 ACRE AREA - STILL PROPOSED FOR EXCESS
 - 81 ACRE AREA - GOVERNMENT OF GUAM
 - 395 ACRE AREA - CONVEYED TO GOVERNMENT OF GUAM IN 2000
 - 231 ACRE AREA - UNDERWOOD PROPOSAL
 - 6 ACRE AREA - GOVERNMENT OF GUAM FIRE AND POLICE STATION
 - ◆ MW-9 PRODUCTION WELL

SOURCE: ANDERSEN AFB REAL PROPERTY

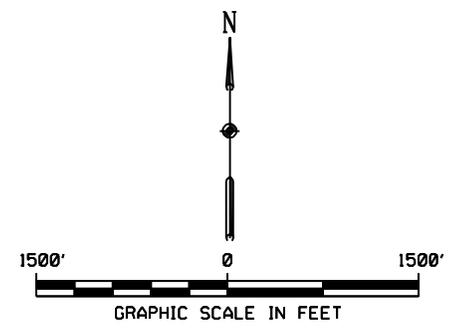
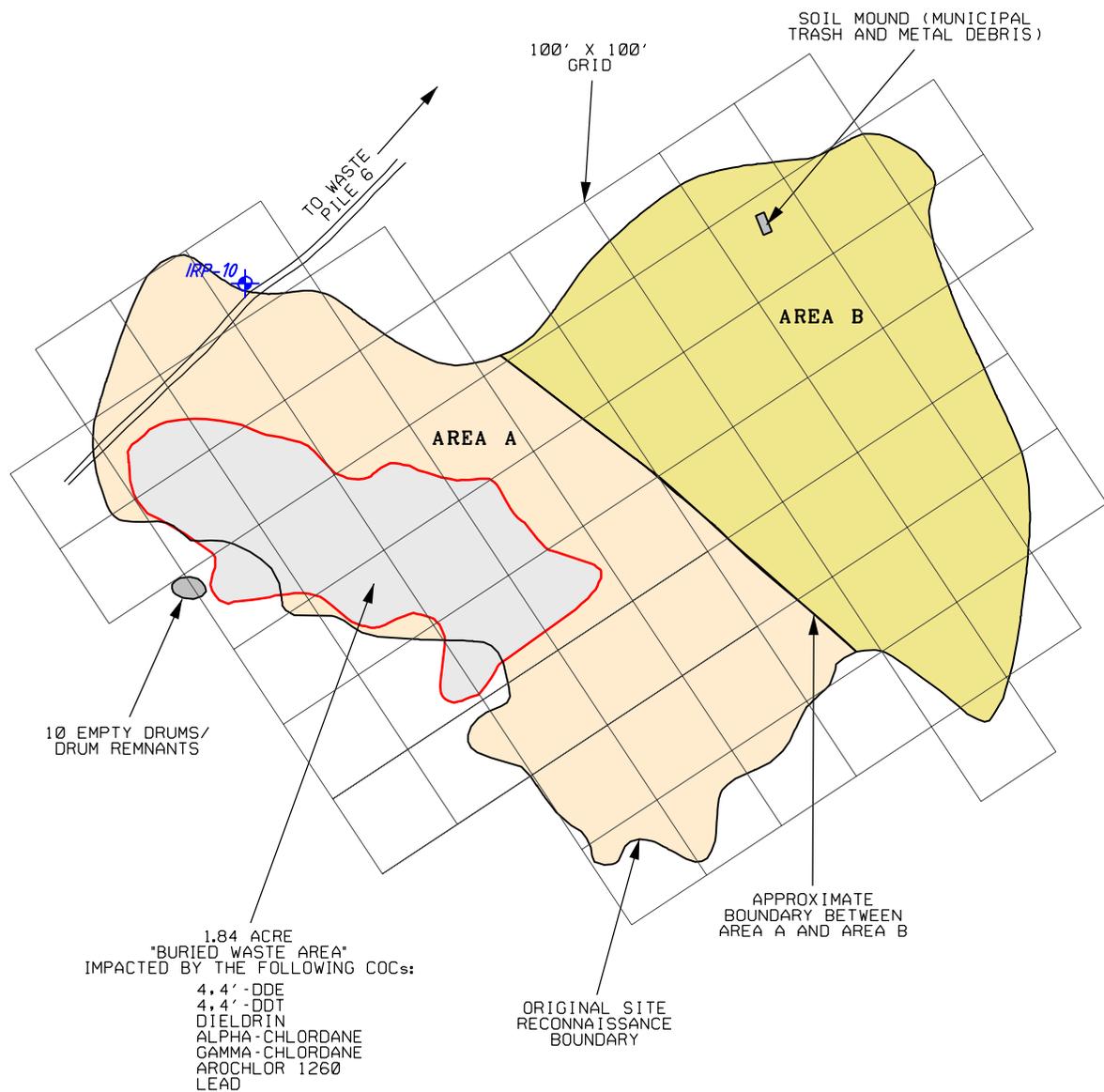
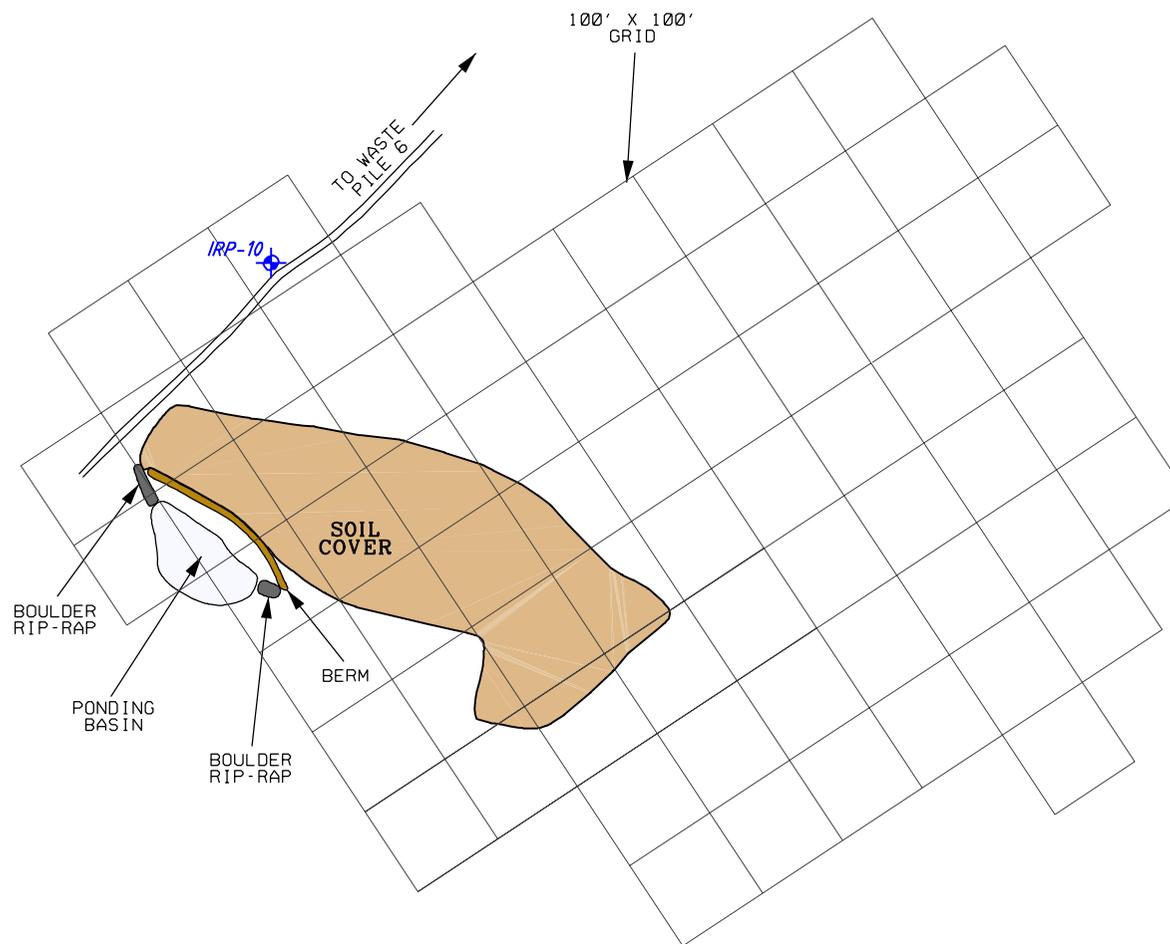


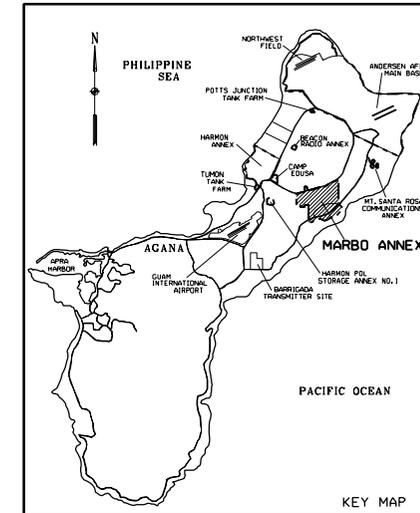
Figure 3-2.
MARBO Annex Operable Unit Land Use.



IRP SITE 20
BEFORE REMEDIAL ACTION



IRP SITE 20
AFTER REMEDIAL ACTION COMPLETED IN MAY 1999



LEGEND:

-  PROPOSED AREA FOR EXCAVATION AND REMOVAL OF IMPACTED MATERIAL
 -  ACTUAL SOIL COVER AREA
 -  EXISTING ROADS
 -  IRP-10 SHALLOW MONITORING WELL
- COCs = CONTAMINANTS OF CONCERN

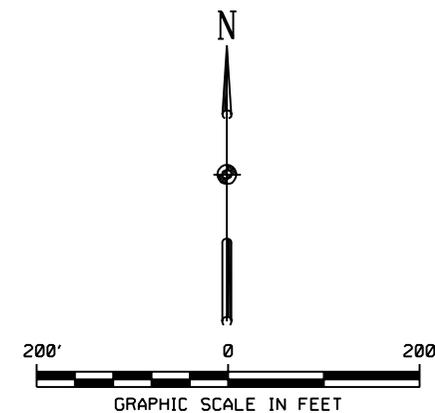
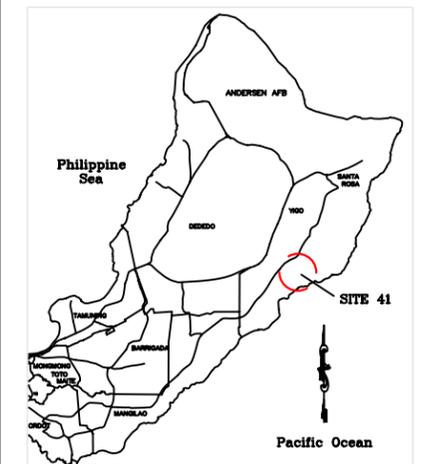
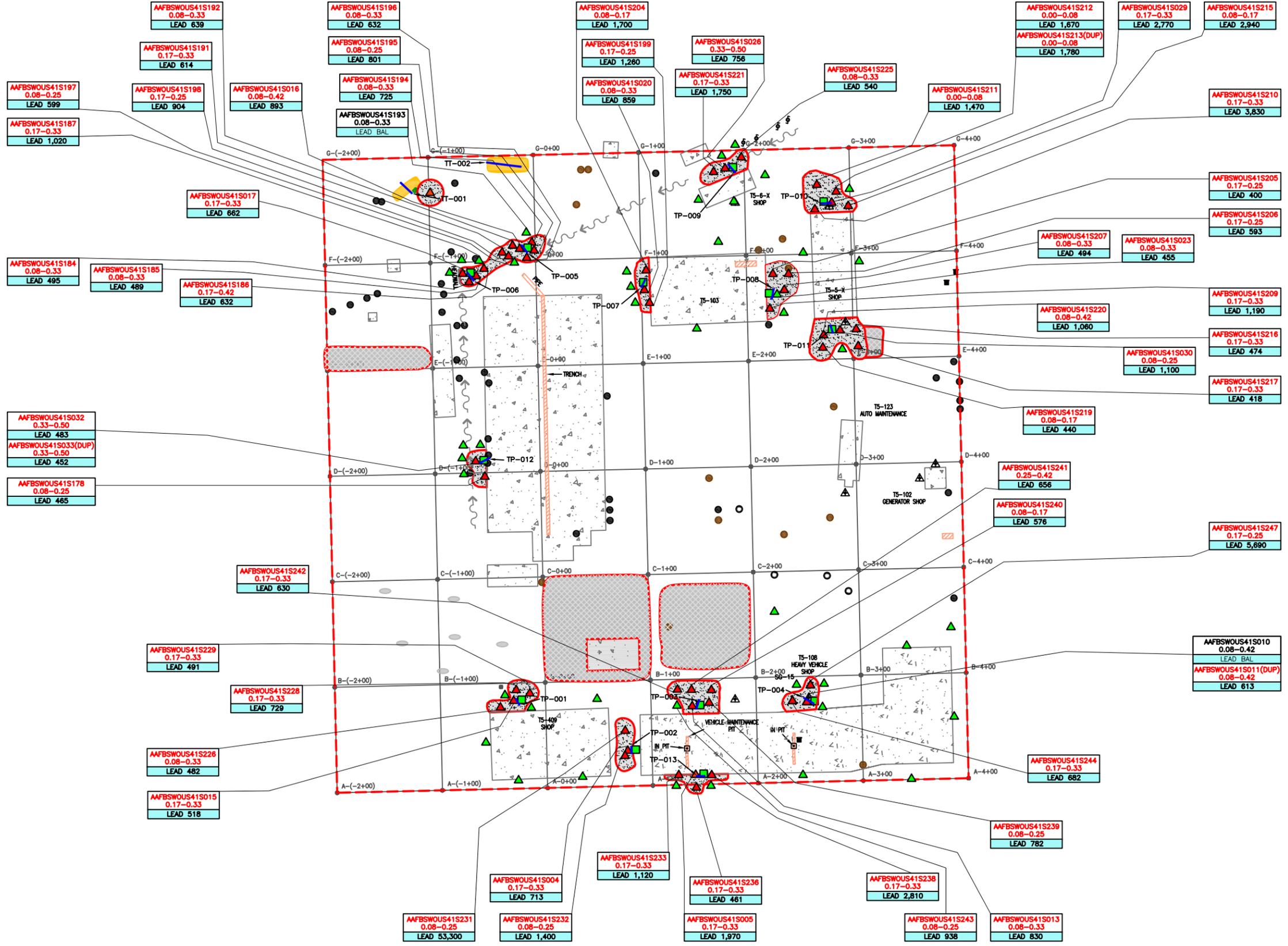


Figure 3-3.
Before and After
Remedial Action,
IRP Site 20,
MARBO Annex,
Andersen AFB, Guam.



- LEGEND:**
- ▲ SURFACE SOIL SAMPLE LOCATIONS ABOVE REGULATORY LIMIT
 - ▲ SURFACE SOIL SAMPLE LOCATIONS AND RESULTS BELOW RESIDENTIAL REMEDIAL GOAL
 - SUBSURFACE SOIL SAMPLE LOCATIONS AND RESULTS BELOW RESIDENTIAL REMEDIAL GOAL
 - ▲ SOIL GAS AND SURFACE SOIL COMPOSITE SAMPLE LOCATION
 - - - APPROXIMATE SITE BOUNDARY
 - - - SWALE
 - - - TEST PITS/TRENCHES
 - DETERIORATED 55 GALLON DRUM OR SUSPECTED DRUM REMNANTS
 - METAL WASTE/DEBRIS
 - WOODEN UTILITY POLES ON THE GROUND
 - TIRE DEBRIS
 - EXISTING WOODEN UTILITY POLE
 - MISCELLANEOUS DEBRIS INCLUDING HOUSEHOLD WASTE
 - MOUNDED AREA
 - ASPHALT DEBRIS AREA
 - CONCRETE PAD
 - - - EXISTING TRENCH
 - - - PROPOSED CLEANUP AREA
 - - - PROPOSED TAR/ASPHALT DEBRIS CLEANUP AREA
- SAMPLE LOCATIONS IN RED EXCEED RESIDENTIAL PRGs AND/OR BTVs**
- AAFBSWOU41S247 0.17-0.25 LEAD 5,690
- SAMPLE ID
 - SAMPLE DEPTH IN FEET
 - INORGANICS, MG/KG
- BOLDED** VALUES EXCEED BTVs AND/OR RESIDENTIAL PRGs

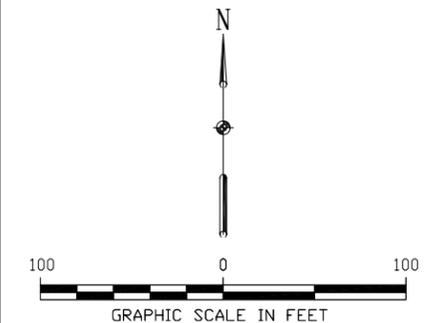
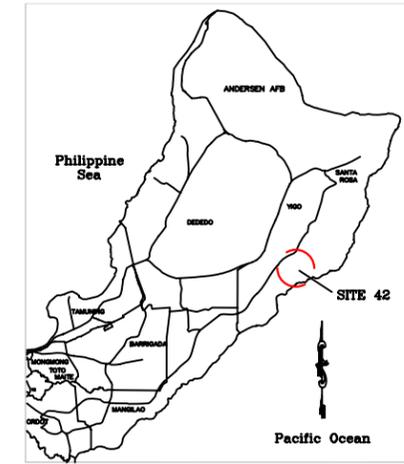
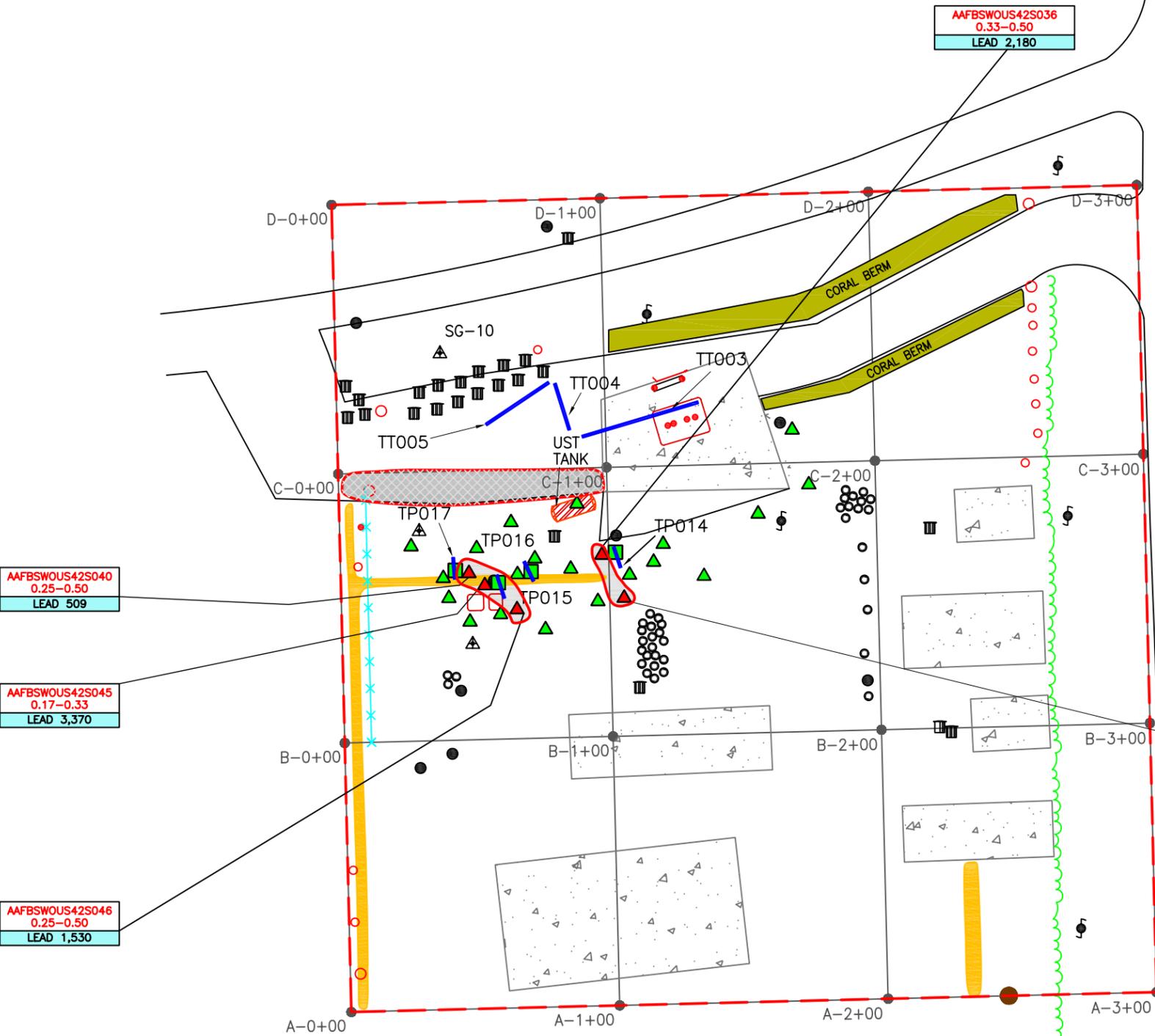


Figure 3-4. Proposed Soil Removal for Site 41 Unrestricted Land Use, MARBO Annex, Andersen AFB, Guam.



- LEGEND:**
- ▲ SURFACE SOIL SAMPLE LOCATIONS ABOVE REGULATORY LIMIT
 - ▲ SURFACE SOIL SAMPLE LOCATION AND RESULTS
 - SUBSURFACE SOIL SAMPLE LOCATIONS AND RESULTS
 - ▲ SOIL GAS AND SURFACE SOIL COMPOSITE SAMPLE LOCATION
 - APPROXIMATE SITE BOUNDARY
 - EDGE OF ASPHALT ROAD
 - EDGE OF CORAL BERM
 - CHAIN-LINK FENCE
 - EDGE OF VEGETATION
 - TIRE DEBRIS
 - METAL WASTE/DEBRIS ON THE GROUND
 - WOODEN UTILITY POLES ON THE GROUND
 - EXISTING WOODEN UTILITY POLE
 - UNKNOWN PIPE STUB-UPS
 - MISCELLANEOUS DEBRIS INCLUDING HOUSEHOLD WASTE
 - MOUNDED AREA
 - BERM
 - TAR/ASPHALT DEBRIS AREA
 - CONCRETE PAD
 - ABOVE GROUND STORAGE TANK
 - UNDERGROUND STORAGE TANK
 - PROPOSED CLEANUP AREA
 - PROPOSED TAR/ASPHALT DEBRIS CLEANUP AREA
 - FENCE POSTS
 - TEST PIT
- SAMPLE LOCATIONS IN RED EXCEED RESIDENTIAL PRGs AND/OR BTVs**
- | | |
|----------------------|----------------------|
| AAFBSW042S138 | SAMPLE ID |
| 1.50-2.00 | SAMPLE DEPTH IN FEET |
| LEAD BAL | VOCs, UG/KG |
- BOLDED** VALUES EXCEED BTVs AND/OR RESIDENTIAL PRGs

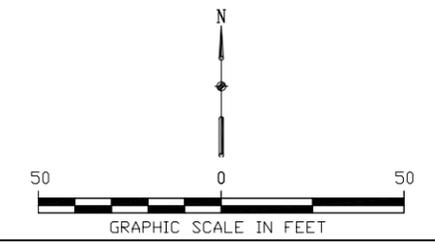


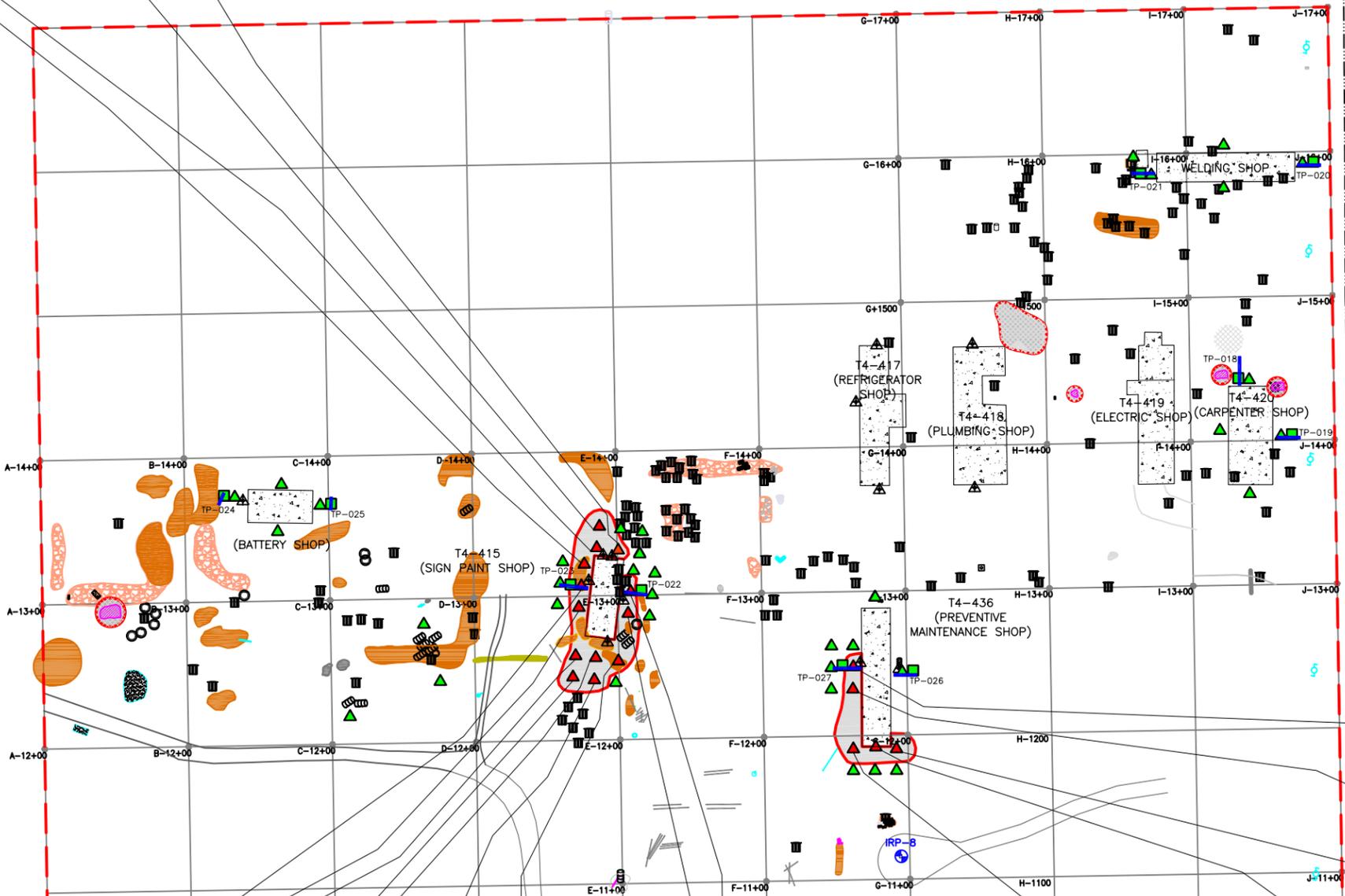
Figure 3-5.
Proposed Soil Removal for Site 42
Unrestricted Land Use,
MARBO Annex, Andersen AFB, Guam.

AAFBSWOU43S344
0.25-0.33
LEAD 889
AAFBSWOU43S345(DUP)
0.25-0.33
LEAD 560

AAFBSWOU43S112
0.33-0.50
LEAD 586

AAFBSWOU43S343
0.08-0.25
LEAD 5,400

AAFBSWOU43S346
0.17-0.25
LEAD 562



AAFBSWOU43S109
0.17-0.42
LEAD 1,190

AAFBSWOU43S328
0.17-0.33
LEAD 2,820

AAFBSWOU43S322
0.25-0.33
LEAD 583
AAFBSWOU43S323(DUP)
0.25-0.33
LEAD 918

AAFBSWOU43S113
0.08-0.33
LEAD 1,130

AAFBSWOU43S339
0.25-0.42
LEAD 501

AAFBSWOU43S338
0.17-0.25
LEAD 1,540

AAFBSWOU43S337
0.33-0.42
LEAD 2,060

AAFBSWOU43S110
0.17-0.33
LEAD 8,620

AAFBSWOU43S336
0.17-0.25
LEAD 5,270

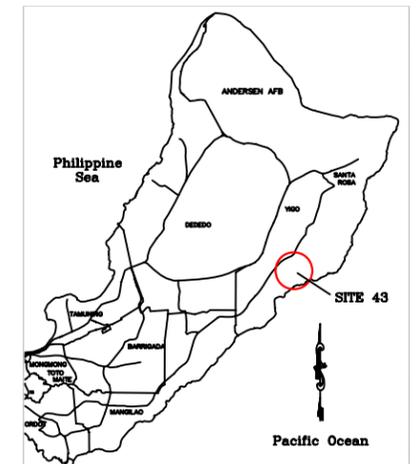
AAFBSWOU43S333
0.25-0.33
LEAD 714

AAFBSWOU43S354
0.17-0.25
LEAD 9,390

AAFBSWOU43S111
0.25-0.50
LEAD 1,000

AAFBSWOU43S327
0.25-0.33
LEAD 2,860

AAFBSWOU43S108
0.08-0.25
LEAD 828



- LEGEND:**
- ▲ SURFACE SOIL SAMPLE LOCATIONS ABOVE REGULATORY LIMIT
 - ▲ SURFACE SOIL SAMPLE LOCATIONS AND RESULTS
 - SUBSURFACE SOIL SAMPLE LOCATIONS AND RESULTS
 - TEST TRENCH
 - ▲ SOIL GAS AND SURFACE SOIL COMPOSITE SAMPLE LOCATION
 - - - APPROXIMATE SITE BOUNDARY
 - EDGE OF ASPHALT ROAD
 - ☑ DETERIORATED 55 GALLON DRUM OR SUSPECTED DRUM REMNANTS
 - WOODEN UTILITY POLES ON THE GROUND
 - STEEL PIPE ON THE GROUND
 - EXISTING WOODEN UTILITY POLE
 - MISCELLANEOUS DEBRIS INCLUDES LARGE AND SMALL METAL CONTAINERS, SHEET METALS, WIRES, CABLES, AUTO PARTS, ENGINE PARTS, GLASS, BOTTLES, CONCRETE SLABS, FOOD CANS, SODA CANS, AND HOUSEHOLD TRASH
 - ☑ DETERIORATED 5 GALLON DRUM
 - MOUNDED AREA
 - DEPRESSION
 - ASPHALT DEBRIS AREA
 - BERM
 - CONCRETE PAD
 - ASBESTOS AREA
 - DEBRIS AREA
 - FREON AREA
 - MONITORING WELL
 - TIRE DEBRIS
 - PROPOSED CLEANUP AREA
 - PROPOSED TAR/ASPHALT AND ASBESTOS DEBRIS CLEANUP AREA

SAMPLE LOCATIONS IN RED EXCEED RESIDENTIAL PRGs AND/OR BTvs

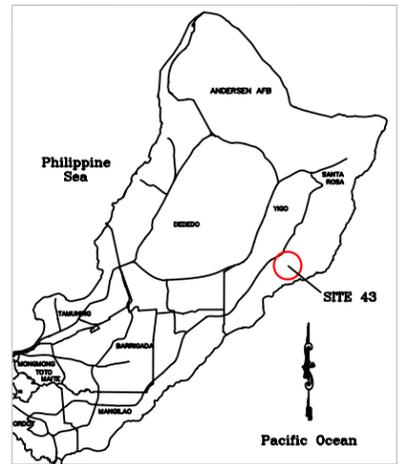
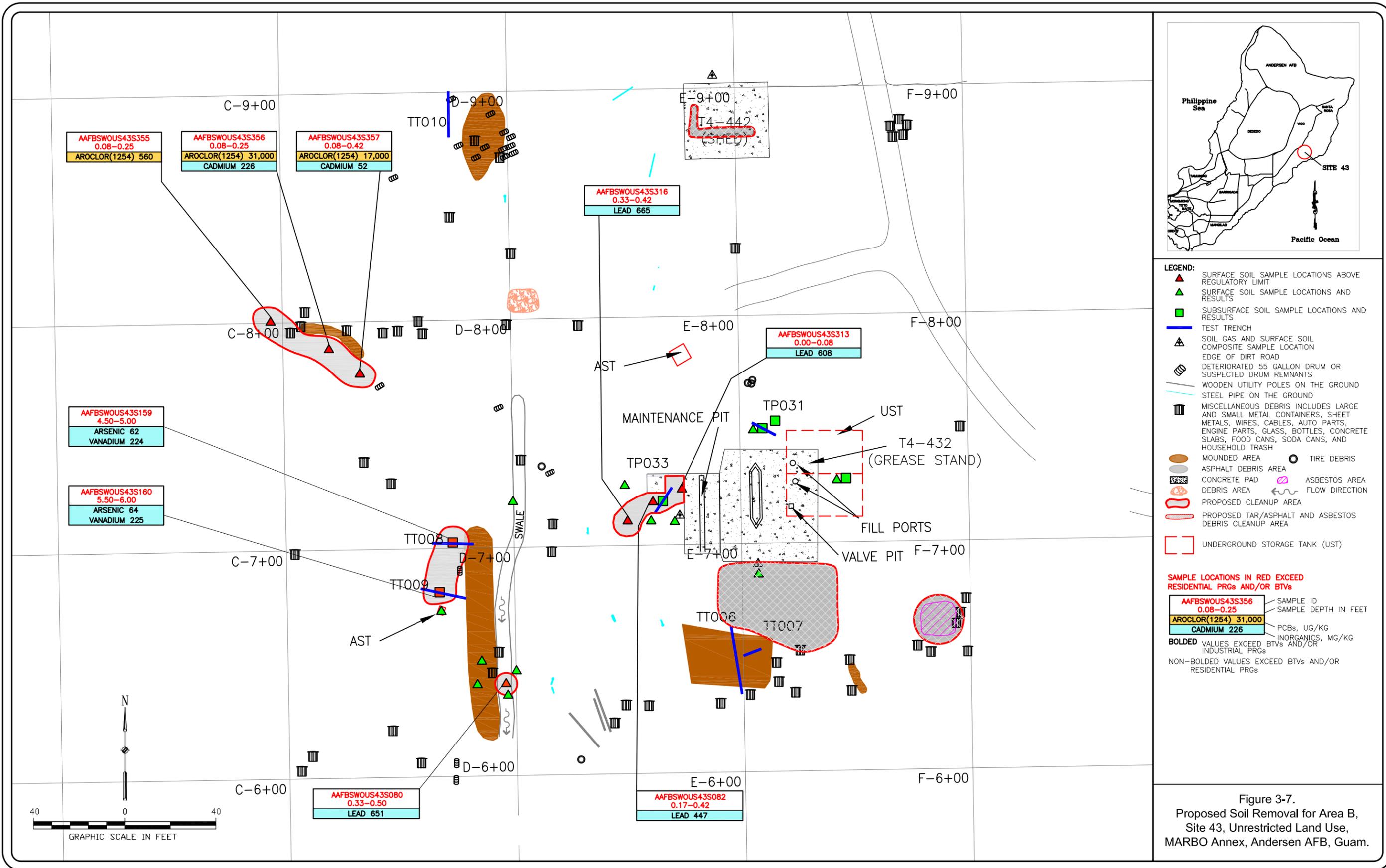
AAFBSWOU43S108
0.08-0.25
LEAD 828

SAMPLE ID
SAMPLE DEPTH IN FEET
INORGANICS, MG/KG

BOLDED VALUES EXCEED BTvs AND/OR INDUSTRIAL PRGs
NON-BOLDED VALUES EXCEED BTvs AND/OR RESIDENTIAL PRGs



Figure 3-6.
Proposed Soil Removal for Area A,
Site 43, Unrestricted Land Use,
MARBO Annex, Andersen AFB, Guam.



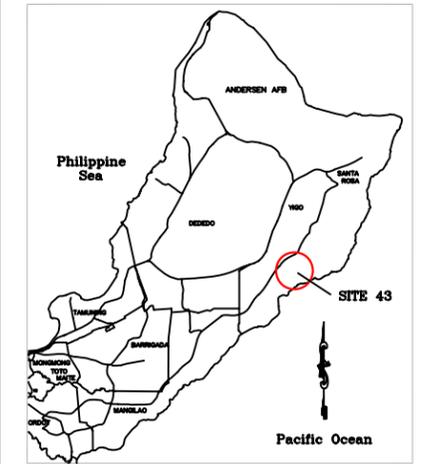
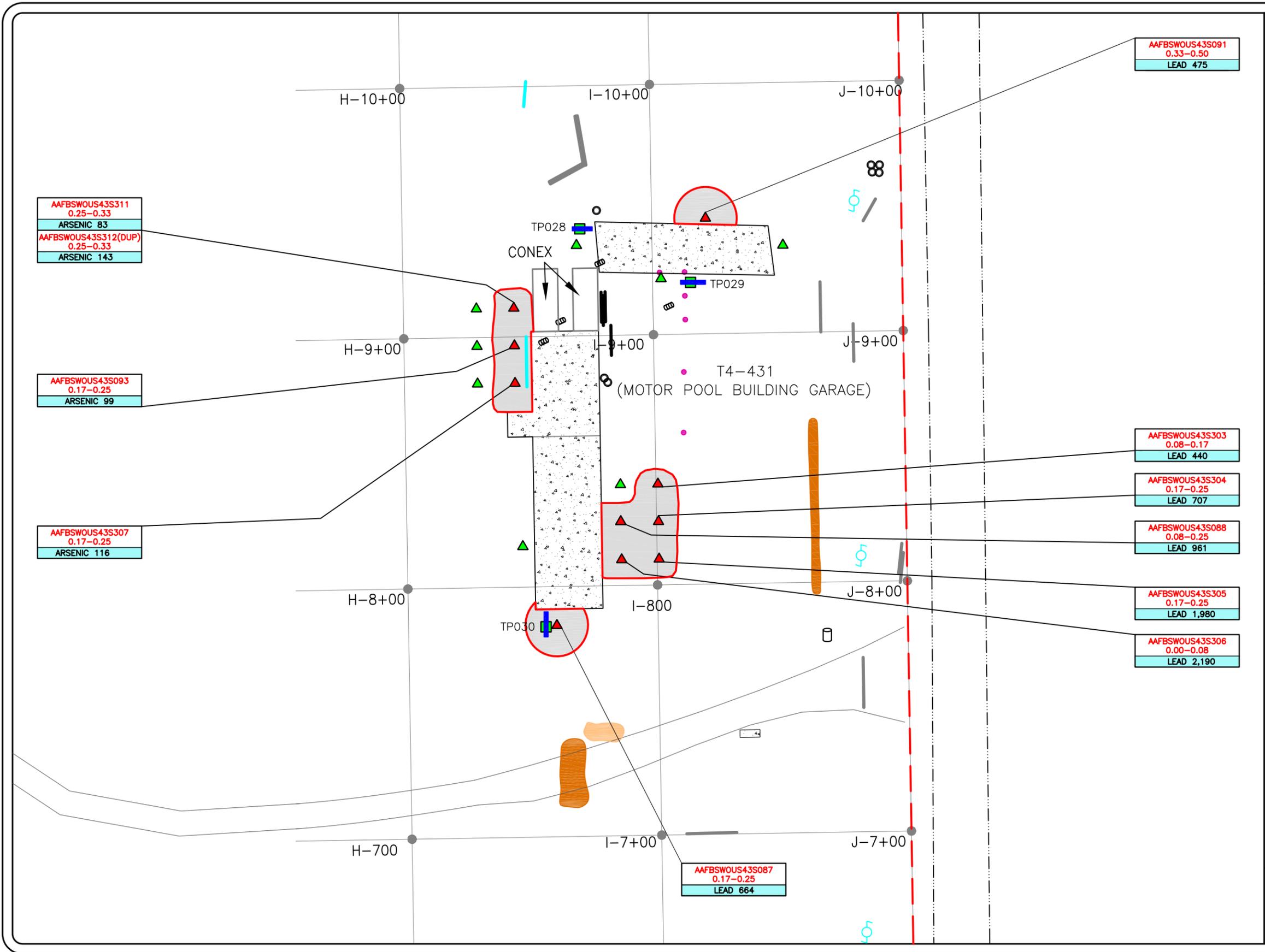
- LEGEND:**
- ▲ SURFACE SOIL SAMPLE LOCATIONS ABOVE REGULATORY LIMIT
 - ▲ SURFACE SOIL SAMPLE LOCATIONS AND RESULTS
 - SUBSURFACE SOIL SAMPLE LOCATIONS AND RESULTS
 - TEST TRENCH
 - ▲ SOIL GAS AND SURFACE SOIL COMPOSITE SAMPLE LOCATION
 - EDGE OF DIRT ROAD
 - ☐ DETERIORATED 55 GALLON DRUM OR SUSPECTED DRUM REMNANTS
 - WOODEN UTILITY POLES ON THE GROUND
 - STEEL PIPE ON THE GROUND
 - ☐ MISCELLANEOUS DEBRIS INCLUDES LARGE AND SMALL METAL CONTAINERS, SHEET METALS, WIRES, CABLES, AUTO PARTS, ENGINE PARTS, GLASS, BOTTLES, CONCRETE SLABS, FOOD CANS, SODA CANS, AND HOUSEHOLD TRASH
 - MOUNDED AREA
 - TIRE DEBRIS
 - ☐ ASPHALT DEBRIS AREA
 - ☐ CONCRETE PAD
 - ☐ ASBESTOS AREA
 - ☐ DEBRIS AREA
 - FLOW DIRECTION
 - ☐ PROPOSED CLEANUP AREA
 - ☐ PROPOSED TAR/ASPHALT AND ASBESTOS DEBRIS CLEANUP AREA
 - ☐ UNDERGROUND STORAGE TANK (UST)

SAMPLE LOCATIONS IN RED EXCEED RESIDENTIAL PRGs AND/OR BTVs

AAFBWOU43S356	SAMPLE ID
0.08-0.25	SAMPLE DEPTH IN FEET
AROCLOR(1254) 31,000	PCBs, UG/KG
CADMIUM 226	INORGANICS, MG/KG

BOLDED VALUES EXCEED BTVs AND/OR INDUSTRIAL PRGs
NON-BOLDED VALUES EXCEED BTVs AND/OR RESIDENTIAL PRGs

Figure 3-7.
 Proposed Soil Removal for Area B,
 Site 43, Unrestricted Land Use,
 MARBO Annex, Andersen AFB, Guam.



- LEGEND:**
- ▲ SURFACE SOIL SAMPLE LOCATIONS ABOVE REGULATORY LIMIT
 - ▲ SURFACE SOIL SAMPLE LOCATIONS AND RESULTS
 - SUBSURFACE SOIL SAMPLE LOCATIONS AND RESULTS
 - TEST TRENCH
 - ▲ SOIL GAS AND SURFACE SOIL COMPOSITE SAMPLE LOCATION
 - APPROXIMATE SITE BOUNDARY
 - EDGE OF ASPHALT ROAD
 - EDGE OF DIRT ROAD
 - ⊕ EXISTING WOODEN UTILITY POLE
 - ⊕ DETERIORATED 55 GALLON DRUM OR SUSPECTED DRUM REMNANTS
 - ⊕ WOODEN UTILITY POLES ON THE GROUND
 - ⊕ STEEL PIPE ON THE GROUND
 - ⊕ MISCELLANEOUS DEBRIS INCLUDES LARGE AND SMALL METAL CONTAINERS, SHEET METALS, WIRES, CABLES, AUTO PARTS, ENGINE PARTS, GLASS, BOTTLES, CONCRETE SLABS, FOOD CANS, SODA CANS, AND HOUSEHOLD TRASH
 - MOUNDED AREA
 - TIRE DEBRIS
 - CONCRETE PAD
 - DEPRESSION
 - 5-GALLON CONTAINER
 - FENCE POSTS
 - PROPOSED CLEANUP AREA
 - PROPOSED TAR/ASPHALT DEBRIS CLEANUP AREA
- SAMPLE LOCATIONS IN RED EXCEED RESIDENTIAL PRGs AND/OR BTVs**
- | | | |
|----------------|-----------|----------------------|
| AAFBSWOU43S088 | 0.08-0.25 | SAMPLE ID |
| LEAD 961 | | SAMPLE DEPTH IN FEET |
| | | INORGANICS, MG/KG |
- BOLDED** VALUES EXCEED BTVs AND/OR INDUSTRIAL PRGs
NON-BOLDED VALUES EXCEED BTVs AND/OR RESIDENTIAL PRGs

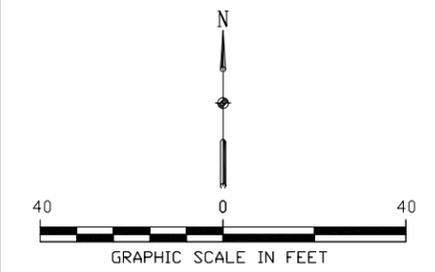
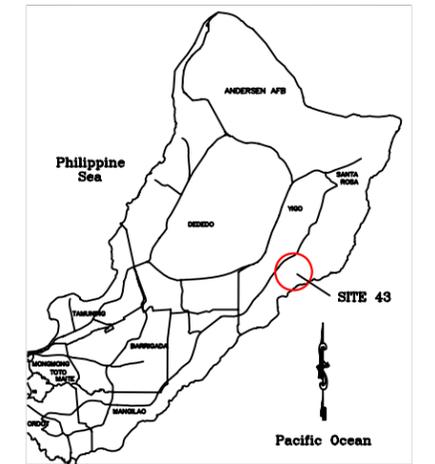
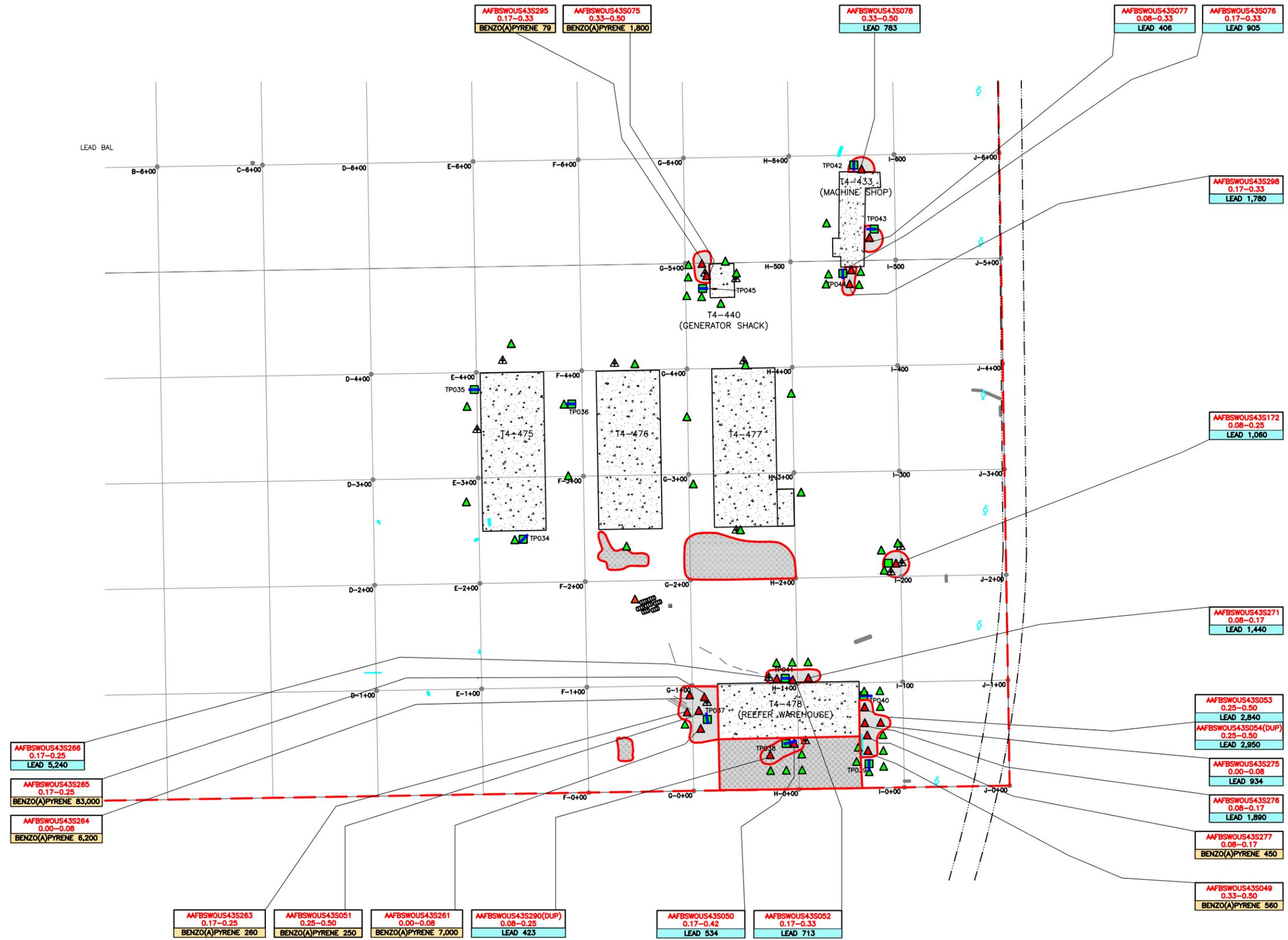


Figure 3-8.
 Proposed Soil Removal for Area C,
 Site 43, Unrestricted Land Use,
 MARBO Annex, Andersen AFB, Guam.



- LEGEND:**
- ▲ SURFACE SOIL SAMPLE LOCATIONS ABOVE REGULATORY LIMIT
 - ▲ SURFACE SOIL SAMPLE LOCATIONS AND RESULTS
 - SUBSURFACE SOIL SAMPLE LOCATIONS AND RESULTS
 - ▲ SOIL GAS AND SURFACE SOIL COMPOSITE SAMPLE LOCATION
 - APPROXIMATE SITE BOUNDARY
 - EDGE OF ASPHALT ROAD
 - ♂ EXISTING WOODEN UTILITY POLE
 - DETERIORATED 55 GALLON DRUM OR SUSPECTED DRUM REMNANTS
 - WOODEN UTILITY POLES ON THE GROUND
 - STEEL PIPE ON THE GROUND
 - TIRE DEBRIS
 - TEST PIT
 - MISCELLANEOUS DEBRIS INCLUDES LARGE AND SMALL METAL CONTAINERS, SHEET METALS, WIRES, CABLES, AUTO PARTS, ENGINE PARTS, GLASS, BOTTLES, CONCRETE SLABS, FOOD CANS, SODA CANS, AND HOUSEHOLD TRASH
 - ASPHALT DEBRIS AREA
 - CONCRETE PAD
 - PROPOSED CLEANUP AREA
 - PROPOSED TAR/ASPHALT DEBRIS CLEANUP AREA

SAMPLE LOCATIONS IN RED EXCEED INDUSTRIAL PRGs AND/OR BTvs

AAFBW043S075	0.17-0.33	BENZO(A)PYRENE 1,800	LEAD 1,440
--------------	-----------	----------------------	------------

BOLDED VALUES EXCEED BTvs AND/OR INDUSTRIAL PRGs

NON-BOLDED VALUES EXCEED BTvs AND/OR RESIDENTIAL PRGs

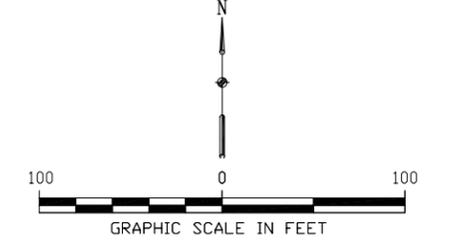
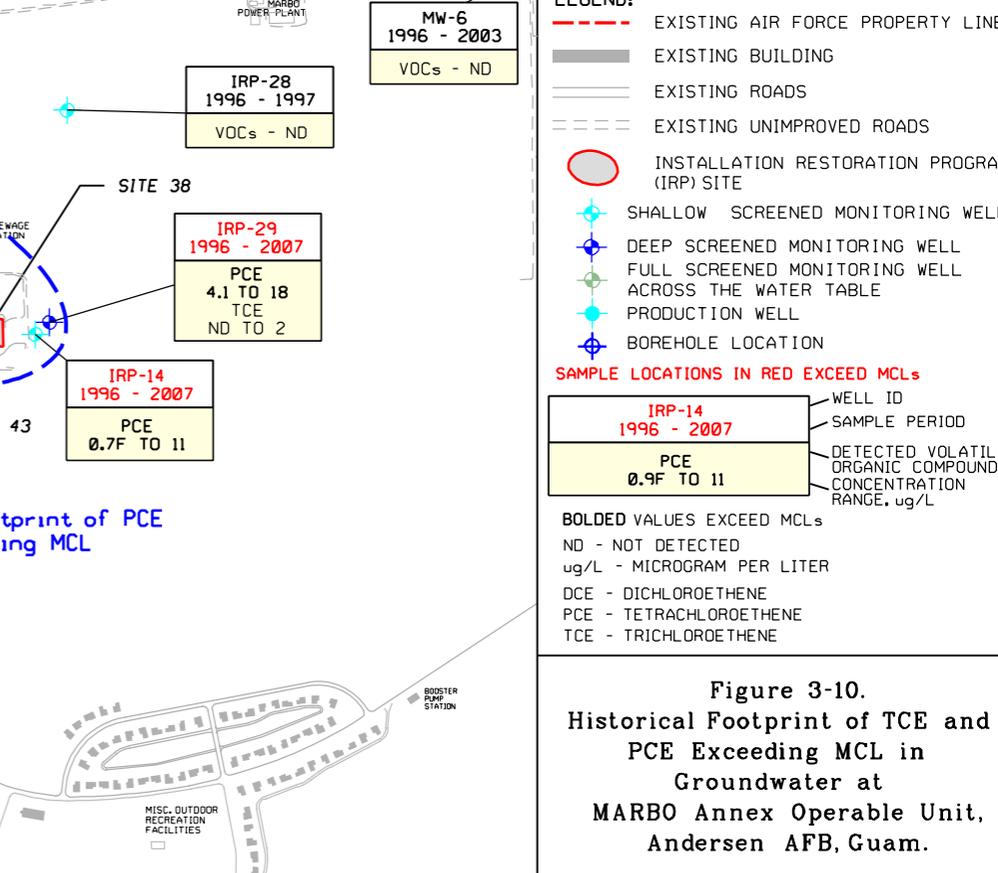
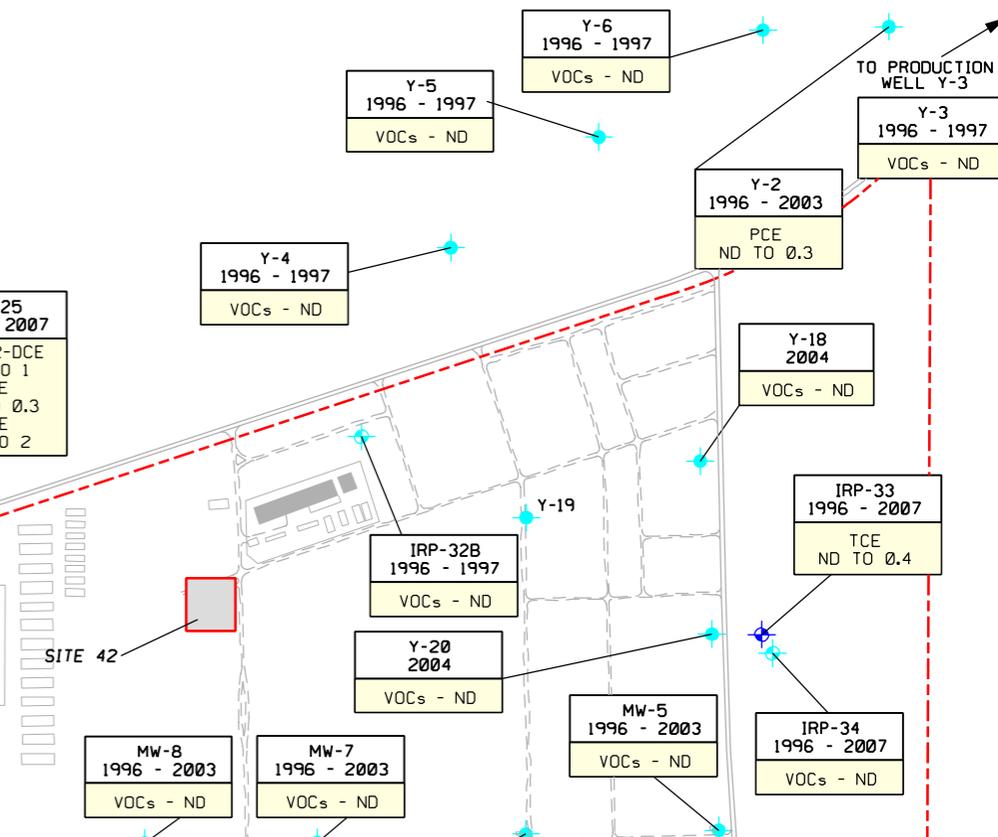
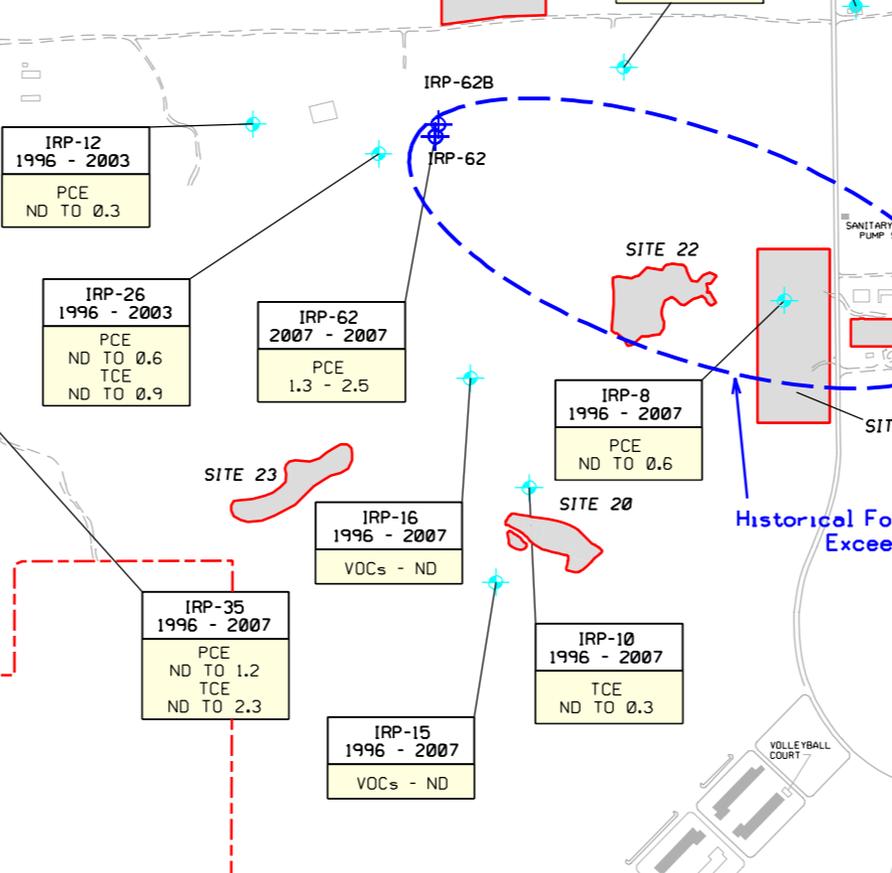
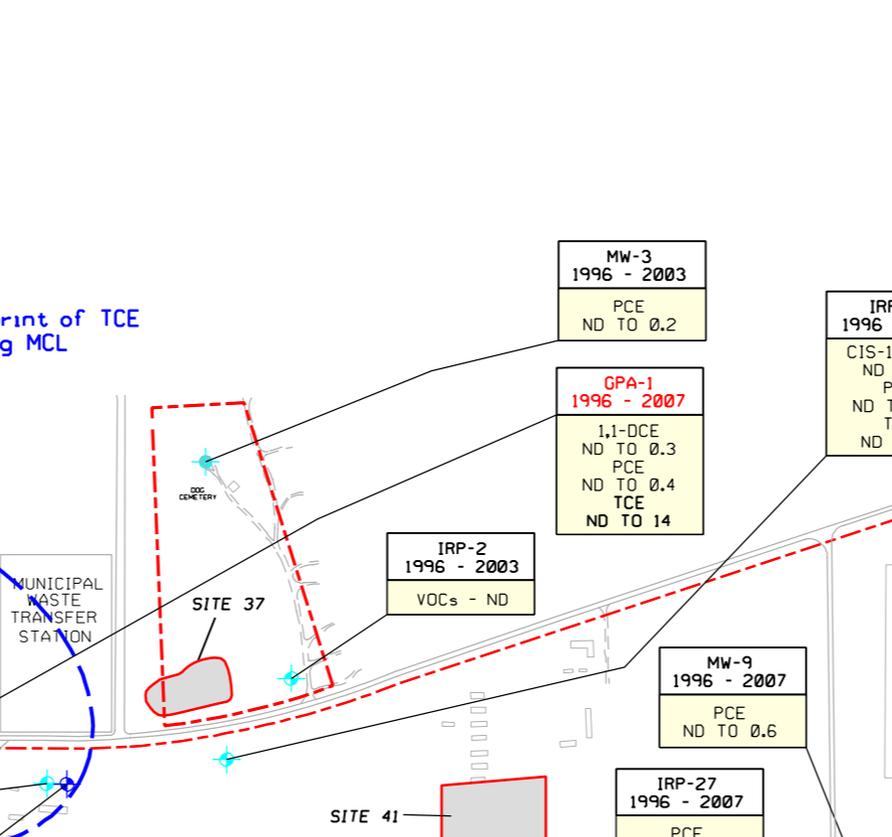
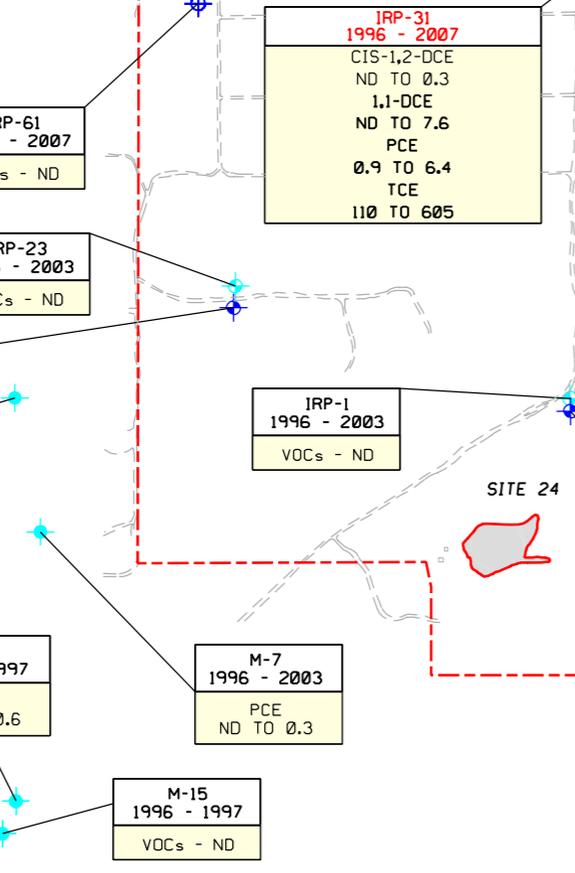
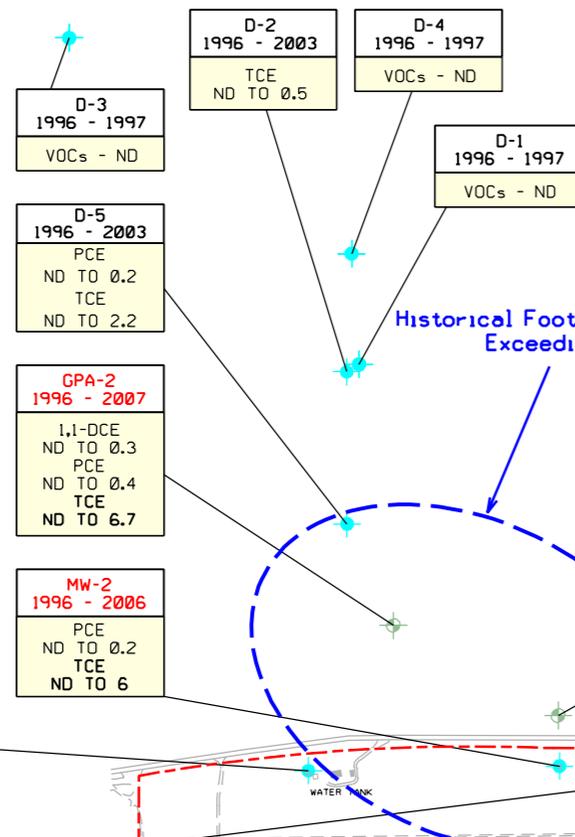
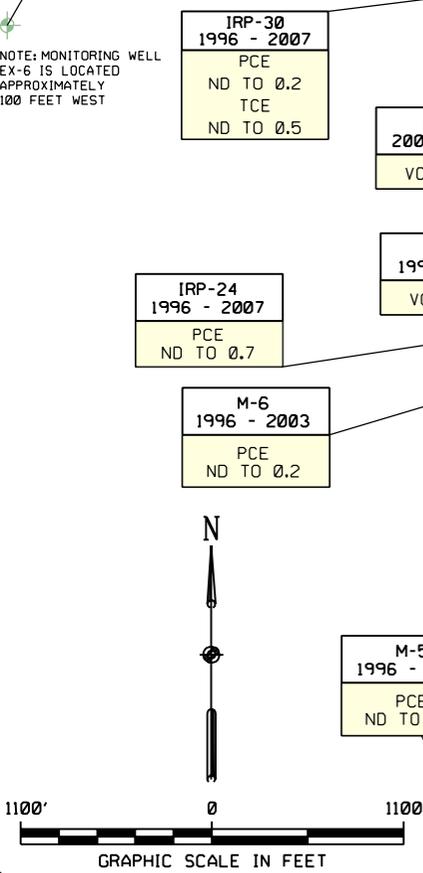
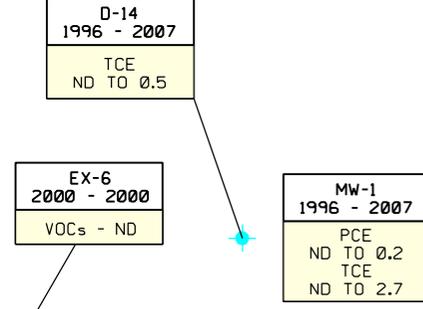
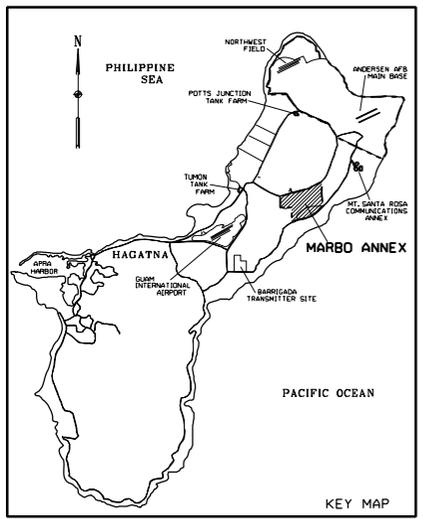


Figure 3-9.
Proposed Soil Removal for Area D,
Site 43, Unrestricted Land Use,
MARBO Annex, Andersen AFB, Guam.



Historical Footprint of TCE Exceeding MCL

Historical Footprint of PCE Exceeding MCL

LEGEND:

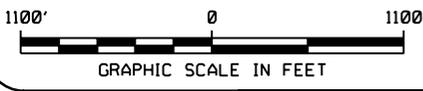
- EXISTING AIR FORCE PROPERTY LINE
- EXISTING BUILDING
- EXISTING ROADS
- EXISTING UNIMPROVED ROADS
- INSTALLATION RESTORATION PROGRAM (IRP) SITE
- ◆ SHALLOW SCREENED MONITORING WELL
- ◆ DEEP SCREENED MONITORING WELL
- ◆ FULL SCREENED MONITORING WELL ACROSS THE WATER TABLE
- ◆ PRODUCTION WELL
- ◆ BOREHOLE LOCATION

SAMPLE LOCATIONS IN RED EXCEED MCLs

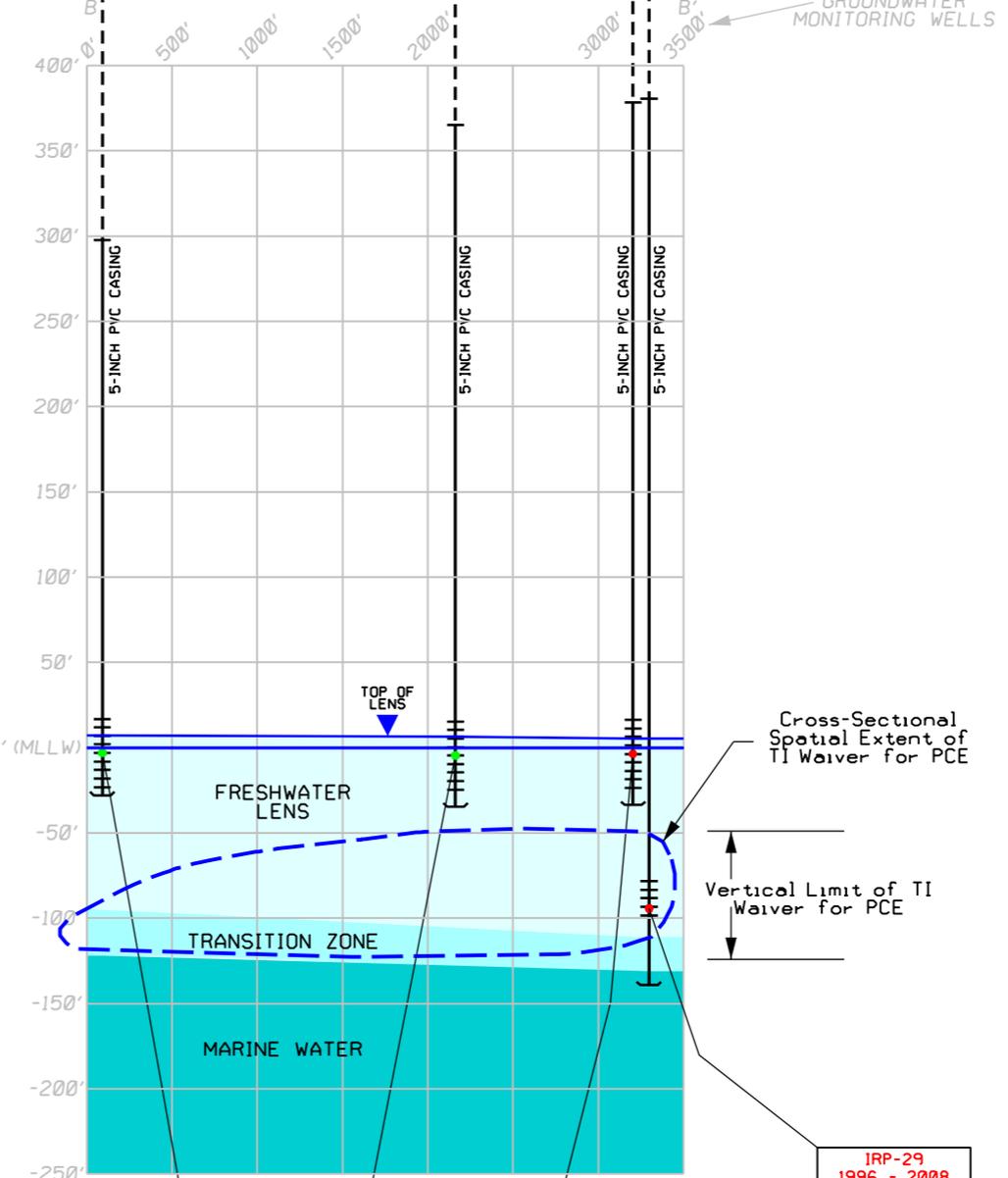
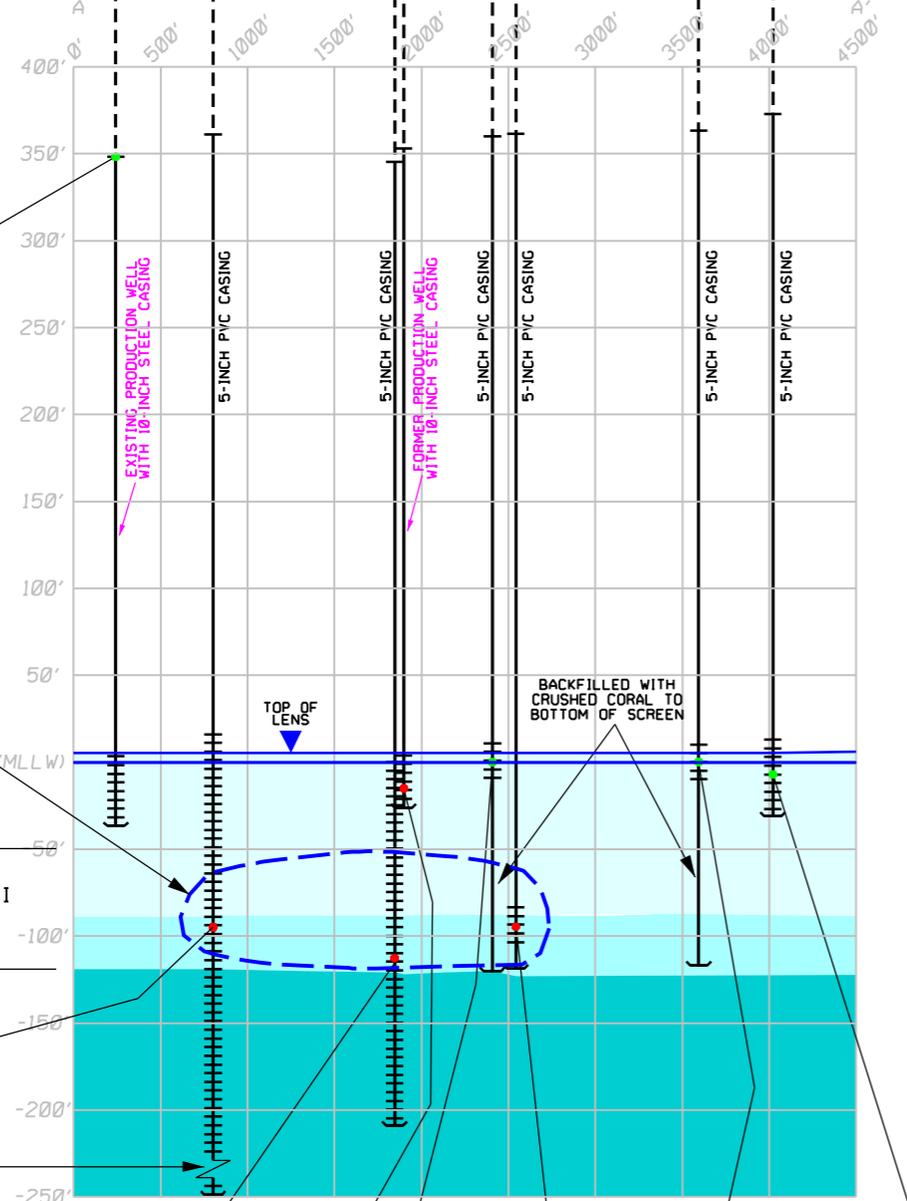
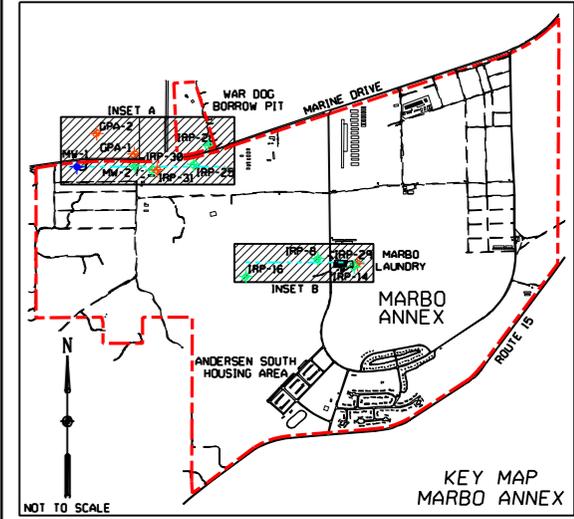
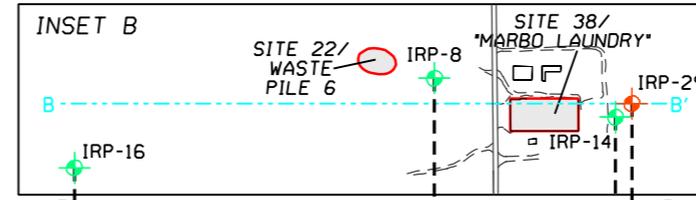
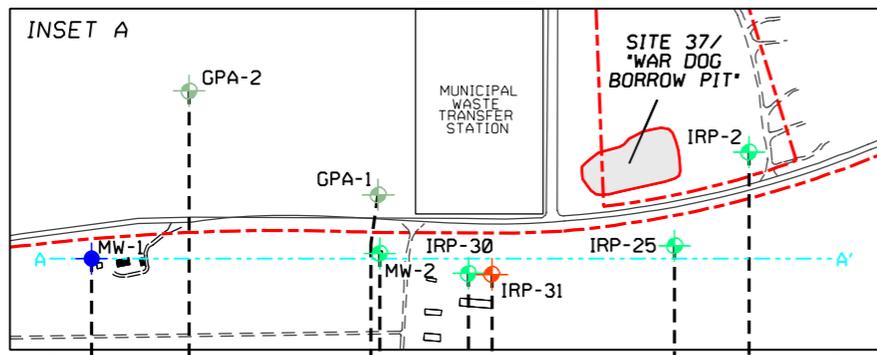
IRP-14 1996 - 2007	WELL ID
PCE 0.9F TO 11	SAMPLE PERIOD
DETECTED VOLATILE ORGANIC COMPOUNDS CONCENTRATION RANGE, ug/L	

BOLDED VALUES EXCEED MCLs
 ND - NOT DETECTED
 ug/L - MICROGRAM PER LITER
 DCE - DICHLOROETHENE
 PCE - TETRACHLOROETHENE
 TCE - TRICHLOROETHENE

Figure 3-10.
Historical Footprint of TCE and PCE Exceeding MCL in Groundwater at MARBO Annex Operable Unit, Andersen AFB, Guam.



NOTE: MONITORING WELL EX-6 IS LOCATED APPROXIMATELY 100 FEET WEST



MW-1
1996 - 2008
SPIGOT
TCE RANGE
ND TO 2.7
PCE RANGE
ND TO 0.2

GPA-2
1996 - 2008
458 FEET BGS
TCE RANGE
ND TO 6.7
PCE RANGE
ND TO 0.4

GPA-1
1996 - 2008
456 FEET BGS
TCE RANGE
ND TO 14
PCE RANGE
ND TO 0.4

MW-2
1996 - 2006
368 FEET BGS
TCE RANGE
ND TO 6
PCE RANGE
ND TO 0.2

IRP-30
1996 - 2008
360 FEET BGS
TCE RANGE
ND TO 0.5
PCE RANGE
ND TO 0.2

IRP-31
1996 - 2008
456 FEET BGS
TCE RANGE
110 TO 605
PCE RANGE
0.9 TO 6.4

IRP-25
1996 - 2007
363 FEET BGS
TCE RANGE
ND TO 2
PCE RANGE
ND TO 0.3

IRP-2
1996 - 2003
380 FEET BGS
TCE RANGE
ND
PCE RANGE
ND

IRP-16
1996 - 2007
301 FEET BGS
TCE RANGE
ND
PCE RANGE
ND

IRP-8
1996 - 2007
370 FEET BGS
TCE RANGE
ND
PCE RANGE
ND TO 0.6

IRP-14
1996 - 2008
382 FEET BGS
TCE RANGE
ND
PCE RANGE
0.72 TO 11

IRP-29
1996 - 2008
475 FEET BGS
TCE RANGE
ND TO 2
PCE RANGE
4.5 TO 18

- LEGEND:**
- EXISTING AIR FORCE PROPERTY LINE
 - ▬ EXISTING BUILDING
 - ▬ EXISTING ROADS
 - INSTALLATION RESTORATION PROGRAM (IRP) SITE
 - SHALLOW SCREENED MONITORING WELL
 - DEEP SCREENED MONITORING WELL
 - FULL SCREENED MONITORING WELL ACROSS THE WATER TABLE
 - PRODUCTION WELL
 - SAMPLE LOCATION
 - SAMPLE LOCATION IN RED EXCEEDS MAXIMUM CONTAMINANT LEVELS
 - THREADED END CAP
 - SCREENED INTERVAL

SAMPLE LOCATIONS IN RED EXCEED MAXIMUM CONTAMINANT LEVELS

IRP-29	WELL ID
1996 - 2008	SAMPLING PERIOD
475 FEET BGS	SAMPLE DEPTH BGS
TCE RANGE ND TO 2	TCE AND PCE IN ug/L
PCE RANGE 4.5 TO 18	

ND - NOT DETECTED
ug/L - MICROGRAM PER LITER

PCE - TETRACHLOROETHENE
TCE - TRICHLOROETHENE
BGS - BELOW GROUND SURFACE
MLLW - MEAN LOWER LOW WATER

TRANSITION ZONE - BASED ON CHLORIDE AND CONDUCTIVITY READINGS COLLECTED FROM GROUNDWATER SAMPLES AND GEOPHYSICAL LOGS DURING THE 1995 MONITORING WELL BOREHOLE INSTALLATION (ICF TECHNOLOGY INC. OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT, MARBO ANNEX, APPENDIX B AND APPENDIX D, 1997.)

Figure 3-11.
Cross-Sectional View of Spatial Extent of Technical Impracticability Waiver Based on Historic Long Term Groundwater Monitoring Data, MARBO Annex Operable Unit, Andersen AFB, Guam.

4.0 REMEDIAL ACTIONS

The MARBO Annex OU ROD was completed in May 1998. RAs selected under the ROD were implemented before the first five-year review, which took place in March 2004. A ROD Amendment with TI Waiver for MARBO Annex groundwater will be completed by December 2009 and will result in a change to the selected remedy. The RAs for the MARBO Annex OU are discussed in the following sections.

4.1 Remedial Actions at Site 20

4.1.1 Remedial Action Description at Site 20

The RA for Site 20, *Soil Cover and ICs*, was implemented by May 1999. Site 20 is classified as an *Operating RA*, as the RA has been implemented but residual COCs have been left in place at concentrations that do not allow for unrestricted use of or unlimited access to the land.

The COC-impacted soils at the *Buried Waste Area* covered approximately 1.8-acres to depths ranging from 3 to 17 feet (Figure 3-3). According to the MARBO Annex OU ROD, *No Action*, *Institutional Controls*, *Soil Removal*, and *Soil Cover* remedial alternatives were evaluated for Site 20 (EA, 1998a). However, due to the high volume of COC-impacted soils that would require removal or treatment, the *Soil Cover* alternative was selected as the preferred alternative. The *Soil Cover* alternative was deemed to be protective of human health and the environment and includes the following RAOs:

- eliminate the direct exposure path to COCs, and
- minimize the potential migration of COCs to groundwater beneath the site.

Though the *Soil Cover* alternative eliminates direct exposure to COCs, it does not allow for unrestricted future land use at Site 20. A Land Use Control Management Plan (LUCMP) was created to document the responsibilities and procedures for maintaining, managing/tracking, enforcing and, when appropriate, modifying or terminating the LUCs. To ensure that no present or planned Andersen AFB activity will disturb the *Soil Cover* at Site 20 the LUCMP will be integrated into the base planning process, the base contracting process, and the base engineering and construction program (Andersen AFB, 2009). A database will be developed on a common drive and maintained by the base civil engineer. The Andersen AFB GeoBase map will integrate with the database so that one map can be referred to and audited to ensure compliance with CERCLA requirements. As such, a written concurrence of the three FFA signatories (USAF, USEPA, and Guam EPA) is required before USAF can take any action at Site 20 that could compromise the structural integrity of the soil cover. Similarly, the USAF shall notify the other two FFA signatories of any plan to release or transfer the Site 20 property to a Federal or non-Federal entity, in accordance with CERCLA 120(h)(3) (EA, 1998a). In addition, the MARBO Annex OU ROD stipulates that the USAF shall also post and maintain warning signs around the periphery of Site 20 to notify the public and to restrict activities that may jeopardize the structural integrity of the soil cover, such as trenching or excavation.

4.1.2 Remedy Implementation at Site 20

According to the final RVR, mobilization for the remedial actions began in March 1999 and completed in May 1999. All municipal trash and metallic debris were relocated to the low-lying section of the *Buried Waste Area* and then the soil cover was constructed over the *Buried Waste Area* (Shaw, 2000).

The soil cover consisted of a 6-inch crushed coral sub grade of 6-inch minus, covered by a 12-inch containment layer of 2-inch minus limestone gravel, which in turn was covered by a 6-inch layer of topsoil. The sub grade and containment layers were compacted to 95 percent of the maximum dry density. As presented in Figure 3-3, water control structures were constructed using 12-inch deep earthen swales, 6- to 10-inch diameter boulder riprap, and a large ponding basin to control the drainage pattern and minimize the erosion against a potential 50-year storm. The site was then re-vegetated and an orange plastic fence was temporarily installed to protect the area from wildlife during the re-vegetation period (Shaw, 2000).

4.1.3 Systems Operations/Operation and Maintenance at Site 20

In the ROD, the O&M at Site 20 consisted of three components: site controls (posting signs), public education, and periodic site reviews (supporting five-year reviews). Based on the findings of the first five-year review, quarterly and event driven inspections of the soil cover were recommended as additional O&M activities at Site 20. The posting of warning signs around the periphery of the site was also recommended as these signs were not present during the first five-year review site inspection. Generally, these maintenance requirements have been conducted as planned. However, inspections of the soil cover have been conducted on an annual basis, instead of on a quarterly basis as recommended by the first five-year review.

In the ROD, O&M costs for Site 20 were estimated at \$260,800, based on net present value assuming a discount rate of 5% over a 30-year period. No costs were estimated for the additional O&M components in the first five-year review, but they were expected to increase costs significantly over what was originally estimated in the ROD.

Table 4-1. Annual System Operations/O&M Cost for Site 20¹.

Dates		Approximate cost rounded to the nearest \$1,000
From	To	
2004	2005	\$1,000
2005	2006	\$1,000
2006	2007	\$1,000
2007	2008	\$1,000
2008	2009	\$1,000

The measures required to maintain the soil cover were more fully defined in the LUCMP (Andersen AFB, 2009). The LUCMP emphasizes that a vegetative layer on the soil cover is

¹ The costs reflect the approximate costs associated with the annual site inspections conducted at Site 20 over the past five years. Assumptions: 16 hours to complete the site visit and prepare report at \$75/hour and one field truck for one day. Site visits conducted by 36th Civil Engineering Services/Civil Engineering IRP staff.

critical to its performance, but deeply rooted vegetation such as trees and shrubs should be removed to avoid damaging the soil cover. Also, visual inspections should include checking for subsidence, erosion, or vehicular traffic that might change the drainage of, or cause damage to, the soil cover.

Five O&M inspections have been performed since the last five-year review, the results of which are presented in Appendix C. Each site inspection included a review of the condition of the posted signs, soil cover and associated vegetation, site drainage channels, and protective riprap. Generally, the inspections found that the sword grass cover was preventing erosion of the soil cover, and the drainage channels and protective riprap were in good condition. The following observations of minor concern were noted in the inspection reports:

- The posted sign stating that access to the site is restricted was damaged by bullet holes,
- A few non-damaging vehicle tracks were observed on the soil cover,
- Shallow pig wallows were observed on the edges of the soil cover,
- Pooling water was visible on the soil cover,
- Small trees were observed growing on the soil cover.

These minor deficiencies do not pose any immediate threat to the integrity of the soil cover; however, they should continue to be monitored during the next five-year review period.

4.2 Remedial Actions at Site 41

4.2.1 Remedial Action Description at Site 41

No interim removal actions have been implemented and the selection of the final remedy is pending a ROD. The total volume of lead-impacted soil at Site 41 is approximately 540 loose cubic yards (lcy) or 415 bank cubic yard (bcy). The estimated volume of surface soil for removal was calculated by considering a 1-foot thick depth by 25-foot radius centered on any single lead contaminated surface soil sample, or a 1-foot thick depth extended over an area with multiple lead-contaminated surface soil samples (Figure 3-4). According to the FS, *No Action, Industrial Institutional Controls, Resident Institutional Controls, and Soil Removal (Unrestricted Land Use)* remedial alternatives were evaluated for Site 41 (EA, 2008a). The USAF has identified *Soil Removal (Unrestricted Land Use)* as the preferred remedial alternative to address human health and ecological risks. Under this alternative, lead-impacted soil and designated surface debris (including the asphalt debris) would be removed from the site. Upon completion of the RA no restrictions on future land use would be required. It is anticipated that the *Soil Removal* alternative would provide clean closure with minimal administrative effort and no associated long-term monitoring costs.

4.2.2 Remedy Implementation at Site 41

The RA has not been implemented at the site.

4.3 Remedial Actions at Site 42

4.3.1 Remedial Action Description at Site 42

No interim removal actions have been implemented and the selection of the final remedy is pending a ROD. The total volume of lead-impacted soil at Site 42 is approximately 30 lcy or 17 bcy. The estimated volume of surface soil for removal was calculated by considering a 1-foot thick depth extended over an area with multiple lead-contaminated surface soil samples (Figure 3-5). According to the FS, *No Action, Resident Institutional Controls, and Soil Removal (Unrestricted Land Use)* remedial alternatives were evaluated for Site 42 (EA, 2008a). The USAF has identified *Soil Removal (Unrestricted Land Use)* as the preferred remedial alternative to address human health and ecological risks. Under this alternative, lead-impacted soil and designated surface debris (including the asphalt debris) would be removed from the site. Upon completion of the RA no restrictions on future land use would be required. The *Soil Removal* alternative would provide clean closure with minimal administrative effort and no associated long-term monitoring costs.

4.3.2 Remedy Implementation at Site 42

The RA has not been implemented at the site.

4.4 Remedial Actions at Site 43

4.4.1 Remedial Action Description at Site 43

No interim removal actions have been implemented and the selection of the final remedy is pending a ROD. The total volume of COC-impacted soil at Site 43 (Areas A, B, C, and D) is approximately 890 lcy or 681 bcy. The estimated volume of surface soil for removal was calculated by considering a 1-foot thick depth by 25-foot radius centered on any single lead contaminated surface soil sample, or a 1-foot thick depth extended over an area with multiple lead-contaminated surface soil samples (Figures 3-6 through 3-9). According to the FS, *No Action, Resident Institutional Controls, and Soil Removal (Unrestricted Land Use)* remedial alternatives were evaluated for Site 43 (EA, 2008a). The USAF has identified *Soil Removal (Unrestricted Land Use)* as the preferred remedial alternative to address human health and ecological risks. Under this alternative, the COC-impacted soil and designated surface debris (including the asphalt debris) would be removed from the site. Upon completion of the remedial action, no restrictions on site exposure or future land use would be required. The *Soil Removal* alternative would provide clean closure with minimal administrative effort and no associated long-term monitoring costs.

4.4.2 Remedy Implementation at Site 43

The RA has not been implemented at the site.

4.5 MARBO Annex Groundwater Remedial Actions

4.5.1 Original Remedial Action Description for MARBO Annex Groundwater

The RA for the MARBO Annex groundwater selected in the 1998 ROD, *Natural Attenuation with Wellhead Treatment*, was designed to eliminate the risk of direct exposure to COCs. The ICs included in the remedy consisted of the following three components:

- 1) **Land Use Restrictions** that placed restrictions on the property deeds pertaining to the installation of water supply wells on properties affected by PCE- and TCE-impacted groundwater. The intent of land use restrictions was to reduce potential exposure to COCs by legally restricting future groundwater development from those areas that are impacted. The implementation mechanism for this component would be through Guam EPA's Wellhead Protection Program and Well Installation permitting process. Guam EPA was involved with the development of the ROD for MARBO Annex groundwater, which would facilitate the implementation of ICs during their routine well permit application review. They would not grant a new well installation permit for the area subject to ICs unless the operator stipulated that they were prepared to perform wellhead treatment on any groundwater production well.
- 2) **Long-Term Groundwater Monitoring** at the MARBO Annex was proposed for the existing monitoring wells and production wells. Groundwater would be analyzed for TCE, PCE, and other constituents that would be deemed pertinent for monitoring the immobility of the TCE/PCE in groundwater. Long-term monitoring was to proceed according to a formalized LGTM program.
- 3) **Existing Wellhead Treatment** was proposed for three of the production wells in MARBO Annex (MW-1, MW-2, and MW-3), until TCE and/or PCE concentrations were consistently below MCLs. Groundwater samples from two of these wells (MW-1 and MW-2) had slightly exceeded the MCL for TCE in the past. The endorsement and recommendation of continued wellhead treatment in these production wells was to provide additional health risk benefit to those wells that exceed MCLs for TCE and/or PCE.

4.5.2 Remedy Implementation for MARBO Annex Groundwater

The original RA for MARBO Annex groundwater, *Natural Attenuation with Wellhead Treatment*, has always had natural attenuation occurring, and the ICs that were stipulated in the RA were fully implemented by 1998. The only exception was wellhead treatment for MW-2. MW-2 was taken off production in early 1998 as it was no longer required to meet USAF water demand and the stripping tower used to treat the water was fouling due to severe carbonate encrustation of the spherical packing media. MARBO Annex production wells MW-1 and MW-3 continue to produce potable water and have never required wellhead treatment. While wellhead treatment would have been implemented on any new production wells located in areas within the PCE- and TCE-impacted groundwater, no new production wells have been proposed in these areas. The LTGM program implemented prior to the ROD continued for existing groundwater and production wells at the MARBO Annex.

Based on the extensive data-set collected over the course of the MARBO Annex groundwater LTGM program, it is apparent the original selected remedy for addressing the PCE- and TCE-impacted groundwater, *Natural Attenuation with Wellhead Treatment*, is not going to achieve the milestone for clean-up within the timeframe specified in the original ROD (10 to 40 years). This failure of the selected remedy led the USAF to seek a TI Waiver for achieving the PCE and TCE MCLs in the aquifer and resulted in a ROD Amendment for the MARBO Annex groundwater. Further discussion of the amended remedy and TI Waiver is presented in Section 5 of this document.

4.5.3 Systems Operations/Operation and Maintenance for MARBO Annex Groundwater

Annual O&M components for the MARBO Annex groundwater original selected remedy included point of use groundwater treatment (\$88,000 per year), LTGM program semi-annual sampling (\$105,000 per year), and five-year review (\$23,000; one every five years pro-rated annually). Costs were calculated in the OU2 FFS and totaled an estimated \$217,000 annually, which includes a 20% contingency (\$39,000 per year) (EA and Montgomery Watson [EA/MW], 1997).

Although groundwater treatment was factored into the original cost estimate, this component of the remedy was discontinued in early 1998, as described in Section 4.5.2. Without the wellhead treatment component, the estimated annual cost of the remedy, escalated at 5% per year over the past eleven years, would be approximately \$200,000.

During the past five years, the combined annual cost to conduct the LTGM program for both the MARBO Annex OU and Main Base OU has averaged approximately \$400,000 in present dollar value. The cost and level of effort associated with the MARBO Annex portion of the LTGM program comprises slightly more than half of the entire LTGM program.

Table 4-2. Annual System Operations/O&M Cost for MARBO Annex Groundwater.

Dates		Total cost rounded to the nearest \$1,000
From	To	
2004	2005	\$217,000
2005	2006	\$217,000
2006	2007	\$217,000
2007	2008	\$217,000
2008	2009	\$217,000

Overall, the costs estimated for the amended selected remedy, even in consideration of the modifications associated with the discontinuation of the wellhead treatment, are similar to those originally estimated under the MARBO Annex OU ROD.

4.5.3.1 Performance of the LTGM Program

Stipulated as part of the original RA in the ROD, the USAF has continued the semi-annual groundwater sampling at the MARBO Annex under the LTGM program. A total of 27 monitoring events have been conducted since the program was initiated in 1995. Data from

these monitoring events is presented in Appendix B. Overall, there have been no major issues associated with maintaining an effective LTGM, and the program has been successfully implemented each year. As part of each semi-annual monitoring event, the monitoring wells are inspected and maintenance is performed, as required, to ensure the performance and security of the well network. When a monitoring well or sampling pump becomes damaged, or is deemed unserviceable, the USAF has addressed the issue by either repairing or replacing the damaged item.

The LTGM program has effectively provided a regular snapshot of the conditions in the freshwater aquifer beneath the MARBO Annex. This extensive data set provides a valuable tool for understanding the characteristics and trends of the PCE and TCE plumes. The data has been useful in understanding the rate of dechlorination processes and the mobility of the PCE and TCE plumes that have allowed a re-evaluation of the originally selected RA. As discussed previously in Section 4.5.2, the LTGM data has allowed the USAF to recognize that variations in the measured concentrations of PCE and TCE in the basal part of the freshwater aquifer from fixed monitoring points vary cyclically in response to fluctuations in the elevation and thickness of the freshwater lens. In turn, the elevation and thickness of the freshwater lens vary in response to the rapid flush of short-term rainfall events, moderate-term seasonal rainfall and monsoonal wind effects on sea level, and long-term fluctuations due to El Nino/Southern Oscillation events and eustatic sea level rise.

4.5.3.2 Modifications to the LTGM Program

The USAF also periodically evaluates the LTGM in an effort to optimize the effort and expenditures associated with maintaining this program. Since it was originally implemented in 1995, there have been three separate points in the history of the LTGM where the USAF has determined that modifications to the LTGM were appropriate. A summary of the modifications that occurred prior the first five-year review is documented in the *Final First Five-Year Review of Record of Decision for MARBO Annex Operable Unit, Andersen AFB, Guam* (EA, 2004).

As part of the ROD Amendment that will be completed this year, the USAF evaluated whether there could be additional reductions in the number of monitoring wells sampled and/or whether the frequency of the monitoring events could be reduced. This Remedial Process Optimization (RPO) effort is described in the Post ROD Amendment Remedial Design (EA/M&E, 2009b), that follows the MARBO Annex OU ROD Amendment. The results of the RPO are expected to include the following recommendation for establishing selection criteria for wells to be retained in the LTGM:

- wells with detected TCE or PCE concentrations greater than or equal to half of their respective MCL,
- wells that provide a strategic monitoring location (such as wells located down gradient of the plume but up gradient of active production wells).

Recommendations for specific wells to be included in the LTGM made in the Post ROD Amendment Remedial Design are presented in Appendix D.

Once the recommendations made in the Post ROD Amendment Remedial Design are implemented into the LTGM program, the costs associated with collecting groundwater samples are expected to decrease significantly. However, increased costs associated with abandoning monitoring wells that are no longer needed or are unserviceable will likely offset most or all of the cost reductions to the overall program costs in the near term.

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

5.1 Progress at Site 20

5.1.1 Protectiveness Statement from Last Five-Year Review at Site 20

At the time that the first five-year review was conducted in 2004, the selected remedy at Site 20, *Soil Cover*, was found to be protective of human health and the environment based on document review and site inspections. This protectiveness was deemed valid as long as erosion, tree roots, typhoons, or earthquakes do not damage the structural integrity of the soil cover. The first five-year review recommended that, for the soil cover to be protective in the long-term, a regular maintenance program should be implemented along with a site inspection after any natural disaster to ensure the structural integrity of the soil cover. Additionally, the posting of signs around the periphery of the site was recommended to prevent any subsurface exploration that may damage the soil cover.

5.1.2 Status of Recommendations and Follow-up Actions from Last Five-Year Review at Site 20

Recommendations and issues identified during the first five-year review, along with the follow-up action completions, are presented in Table 5-1. As discussed in Section 4.1.3, the quarterly O&M site visits to inspect the integrity of the soil cover were conducted on an annual basis.

Table 5-1. First Five-Year Review Issues, Recommendations, and Follow-up Actions for Site 20.

Issues	Recommendations / Follow-Up Actions	Party Responsible	Oversight Agency	Date Milestone Achieved	Affect Protectiveness? Yes/No	
					Current	Future
1) No signs are posted around the soil cover to prevent activities that may cause damage, such as driving trucks, trenching, or excavation.	Post warning signs around the periphery of the site to restrict activities that may jeopardize the structural integrity of the soil cover.	USAF	USEPA & Guam EPA	10/01/04	N	Y
2) Pig wallow and small trees have damaged small area of the soil cover. If continues, soil erosion may expose COCs to surface.	Implement a quarterly O&M program to check the integrity of the soil cover).	USAF	USEPA & Guam EPA	12/04/04	N	Y
3) The soil cover is subject to frequent island natural disasters such as typhoons and earthquakes that can damage the structural integrity of the soil cover.	Implement an event driven inspection program to check the integrity of the soil cover after each natural disaster.	USAF	USEPA & Guam EPA	None (a)	N	Y
Note: (a) No triggering event occurred during the second five-year review period. COC = contaminant of concern USAF = United States Air Force Guam EPA = Guam Environmental Protection Agency USEPA = United States Environmental Protection Agency						

5.1.3 Results of Implemented Actions at Site 20

- 1) **Posting of Warning Signs:** Following the first five-year review, appropriate warning signs were posted at the periphery of Site 20 as recommended.
- 2) **Quarterly O&M Inspections:** O&M inspections were initiated and have been performed five times since their implementation: 02 December 2004, 01 April 2006, 02 February 2007, 19 July 2007, and 28 February 2008. Each site inspection included checking for the presence and condition of posted warning signs, and checking the condition of the soil cover, drainage channels, and the protective riprap.
- 3) **Event-Driven Inspections:** Since no significant natural events (such as typhoon or earthquake) have occurred since the first five-year review, no event driven inspections were conducted at Site 20.

5.1.4 Status of Prior Issues at Site 20

The issues have been appropriately addressed. Signs were posted and the O&M program will address any potential future damage to the cover.

5.2 Progress at Sites 41, 42, and 43

No recommendations or protectiveness statements have been made for these three sites as they are still pending the selection of final remedies.

5.3 Progress on MARBO Annex Groundwater

5.3.1 Protectiveness Statement from Last Five-Year Review for MARBO Annex Groundwater

The first five-year review found the remedy to be functioning as intended in the ROD, in that it was still protective of human health and the environment as long as ICs continued to be implemented. The protectiveness statement made in the first five-year review reads:

Tap water samples were collected from Y-18 and Y-20 on May 2004 and analyzed for VOCs as part of the Spring 2004 LTGM program. Based on the results (ND for PCE and TCE) the ICs are functioning as intended and the remedy is protective of the human health and the environment.

Additionally, even though wellhead treatment of MW-2 was part of the initial remedy, it is no longer in effect. However its usefulness was more effective as a protective measure than as a means to remediate the groundwater. MARBO Annex production wells MW-1 and MW-3 continue to produce potable water, and are monitored to assure that PCE and TCE concentrations remain consistently below the MCL. (EA, 2004)

The first five-year review found no changes in exposure assumptions, toxicity data, cleanup values, or RAOs that were significant or that altered the validity of the selected remedy. However, the review recommended that a TI Waiver be invoked if the PCE and TCE

concentrations in MARBO Annex groundwater remained unchanged or increased during the next five-year review period because ARARs would not be met in the timeframe stated in the ROD (10 to 40 years). Additional discussion on the TI Waiver is provided in Section 5.3.4.

5.3.2 Status of Recommendations and Follow-up Actions from Last Five-Year Review of MARBO Annex Groundwater

Recommendations and issues identified during the first five-year review are presented in Table 5-2.

Table 5-2. First Five-Year Review Issues, Recommendations, and Follow-up Actions for MARBO Annex Groundwater.

Issues	Recommendations / Follow-Up Actions	Party Responsible	Oversight Agency	Date Milestone Achieved	Affect Protectiveness? Yes/No	
					Current	Future
1) PCE and TCE sources in MARBO Annex have not been identified.	Deep borings should be drilled at IRP Sites 41 and 43 to look for potential source areas. If chlorinated VOC sources are found at either site, one or more borings may be drilled at strategic locations through the extent of the fresh water lens.	USAF	USEPA & Guam EPA	Target date of 12/31/05	N	Y
2) Fate and transport of TCE and PCE within MARBO Annex are poorly understood, particularly at depth.	To better understand hydrogeology and fate and transport at depth, drill 1-2 borings (open bore wells) through the entire freshwater lens. In addition a dye trace study, relevant to IRP-31 and IRP-29, should be considered.	USAF	USEPA & Guam EPA	Target date of 12/31/05	N	Y
3) Tumon-Maui Well is currently not being used, and as such no benefits are derived from either use of the water or the remedial effects.	USAF should assess long-term need for the Tumon Maui well. Determine what to do with the Tumon-Maui well if the well is not essential to USAF mission	USAF	USEPA & Guam EPA	Target date of 10/01/05	N	Y
Guam EPA = Guam Environmental Protection Agency IRP = Installation Restoration Program MARBO = Marianas Bonins Command PCE = tetrachloroethene TCE = trichloroethene USAF = United States Air Force USEPA = United States Environmental Protection Agency VOC = volatile organic compound						

5.3.3 Results of Implemented Actions for MARBO Annex Groundwater

- 1) **Potential Source Areas:** A RI/FS was completed at Sites 41, 42, and 43 in 2008 to characterize potential PCE and TCE source areas. Sites 42 and 43 both formerly used underground storage tanks (USTs); however, PCE and TCE were not detected in media samples collected from either site. Because volatile organic compounds (VOCs) were not encountered, deep soil borings were not performed. The deepest excavation at the sites was approximately 12 feet bgs, the maximum reach of excavator (EA, 2008a).
- 2) **Hydrogeology and Fate and Transport:** Two open boreholes that fully penetrate the freshwater lens were installed at MARBO Annex (IRP-61 and IRP 62B). IRP-62B was located between the MARBO Laundry and IRP-31, and defines the downgradient edge of the PCE plume. IRP-61 was located at the western boundary of MARBO Annex, downgradient of IRP-31 and MW-2. IRP-61 groundwater data indicate that the TCE plume does not extend downgradient to the property boundary. The groundwater data from IRP-61 and IRP-62B precluded the need to perform the dye tracer study (EA/M&E, 2009c).
- 3) **Tumon-Maui Well:** The Tumon Maui well has not been in operation since 1995; however, the USAF has included the well in the LTGM program and continues to monitor and sample the well in the event that it is required to meet future drinking water demands.

5.3.4 Status of Prior Issues for MARBO Annex Groundwater

5.3.4.1 Follow-up Action on TI Waiver Recommendation

The technical assessment in the previous five-year review found that the natural attenuation process was not operating as intended at IRP-31, based on the lack of a clear decreasing trend of TCE concentrations at depth within the fresh water lens. The review questioned whether the assumptions made in the ROD, relevant to recharge rates and residence times used to estimate the timeframe for TCE and PCE to attenuate, were accurate. The review recommended that if the PCE and TCE concentrations in the aquifer remained unchanged or increased during the next five-year review period, indicating the ineffectiveness of natural attenuation in remediating the site in timely manner, a ROD Amendment may be required to either specify an active remediation or a TI Waiver.

Data collected under the LTGM program during the subsequent five-year period continued to confirm the conclusions of the first five-year review. In recognition of this, and in response to the recommendation made in the first five-year review, the USAF completed a *Focused Feasibility Study to Support a Record of Decision Amendment with a Technical Impracticability Waiver for the MARBO Annex OU* (EA, 2008c). The Focused Feasibility Study (FFS) supported a modification to the groundwater remedy selected in the MARBO Annex OU ROD.

The basis for performing the FFS was that residual TCE and PCE concentrations in the deep aquifer have persisted and will not allow for unrestricted use of the property within an acceptable timeframe. Because natural attenuation of TCE and PCE in the deep groundwater is not proceeding within a reasonable timeframe, MNA has been deemed a failed remedy. As such, the

FFS evaluated a limited number of remedial alternatives and/or presumptive remedies that could address groundwater contamination and serve to replace MNA in support of a ROD Amendment.

Presumptive remedial alternatives that were identified in the FFS that would address dissolved-phase TCE and PCE in groundwater at MARBO Annex include: Enhanced Anaerobic Bioremediation, Chemical Oxidation, Micro-Scale Zero Valent Iron, In-Well Air Stripping, and Pump and Treat. Evaluation criteria included implementability, restoration potential, and cost. A screening matrix presenting a summary of the alternatives and evaluation criteria is presented in Appendix E. The technology screening found that all of the remedial alternatives were not implementable, had low restoration potential, and were too costly.

The FFS concluded that, due to the complexities of the underlying vadose zone and limestone aquifer, technologies that might have been retained for further consideration under more conventional subsurface conditions were eliminated. Based on the technical impracticability of utilizing existing remedial technologies, the FFS recommended invoking a TI Waiver for the CERCLA requirement of achieving MCLs in the aquifer. The justification for invoking a TI Waiver was included as an appendix to the FFS. The site conditions that support the TI Waiver include: deep location of groundwater beneath the surface, limitations on remediating the source of contaminants, complex geologic conditions, large volumes of water that would need to be treated, and the inordinately high cost to treat groundwater given the physical constraints posed by the hydrogeology at the MARBO Annex.

The FFS proposed a modified remedy for MARBO Annex groundwater which removed the requirement to achieve cleanup of PCE and TCE in groundwater to levels below MCLs, but retained the ICs and the contingency for wellhead treatment at any on-MARBO Annex production wells or existing or future off-MARBO Annex production wells within the extent of the PCE and TCE plumes. Under the new remedy, the USAF would still be required to conduct the LTGM program.

5.3.4.2 MARBO Annex OU ROD Amendment

By December 2009, the USAF will have prepared a ROD Amendment for MARBO Annex Groundwater, which presents the amended remedy of *Long-Term Groundwater Monitoring with Contingency for Wellhead Treatment*. The remedy is summarized as follows:

- **TI Waiver** for groundwater to achieve MCLs in the aquifer. The TI Waiver is necessary because the aquifer will not be actively remediated to MCLs with MNA and because the restoration goals and cleanup timeframe are considered unachievable.
- **Long-Term Groundwater Monitoring** will be performed at selected monitoring wells and production wells. Groundwater samples will be analyzed for TCE, PCE, and other parameters that are useful in monitoring the immobility of TCE and PCE in groundwater.
- **Contingency for Wellhead Treatment** at on-MARBO Annex water production wells or existing or future off-MARBO Annex production wells within the extent of the TCE and PCE plumes. Upon TCE or PCE concentrations exceeding half of the MCL, the USAF will

perform additional sampling and analysis to determine if the concentration is likely to approach the MCL (5 µg/L). If statistical significance is found, the well will continue to be monitored for potential exceedance of the MCL. If PCE or TCE concentrations exceed the MCL, wellhead treatment will be applied to the affected well. Treatment units would be installed by the USAF if no treatment system exists on that well or the USAF would pay the incremental cost caused by the presence of TCE and/or PCE if a well already had a treatment system.

- **Five-Year Reviews** would continue to be performed to determine if the remedy is still effective and if the remedy has achieved its goals, and thus can be discontinued.

5.3.4.3 Post ROD Amendment Remedial Design

By December 2009, the USAF will have prepared a Post ROD Amendment Remedial Design that provides a rationale for the inclusion or exclusion of monitoring wells in the LTGM in light of the amended remedy for MARBO Annex groundwater (EA/M&E, 2009b). This document recommends which monitoring wells are retained in the LGTM program and the frequency that they are to be sampled. A summary of the wells proposed for retention is presented in Appendix D.

6.0 FIVE-YEAR REVIEW PROCESS

6.1 Administrative Components

The five-year review team was led by Mr. Gregg Ikehara, Remedial Project Manager (RPM) and Restoration Chief of Andersen AFB (Civil Engineer Squadron/ Civil Engineering Installation Restoration Program [CES/CEVR]) and included members from the CES/CEVR staff and their contractor, EA.

Document reviews began in September 2008 and were extended through June 2009 to incorporate the ROD Amendment for the MARBO Annex OU groundwater and the Post ROD Amendment Remedial Design documents (EA/M&E, 2009a; EA/M&E, 2009b). The components of the review included:

- Community Involvement,
- Document Review,
- Data Review,
- Site Inspection,
- Local Interviews, and
- Five-Year Review Report Development and Review

The ROD Amendment for MARBO Annex OU groundwater is being prepared by Andersen AFB and will be completed by December 2009. The USAF reaffirmed that the key elements of the original remedy for MARBO Annex groundwater (long-term monitoring and a provision for wellhead treatment) would continue to provide protection to human health and the environment.

6.1.1 Community Involvement

The USAF has promoted community relations and encouraged public involvement in cleanup decisions through the RAB, established in 1995. The RAB is comprised of community members, USAF officials, and representatives from regulatory agencies and meets on a quarterly basis to discuss program progress and to advise the community on the status and plans for the various IRP sites. A complete summary of the history and status of community involvement for the IRP at Andersen AFB is presented in the December 2000 *Final Management Action Plan* (USAF, 2000).

Five-year reviews of RODs are important milestones for public involvement. The public was informed of the Andersen AFB five-year review for the MARBO Annex OU ROD by distributing a notice to RAB members, who were encouraged to disseminate this information to other community members. Also, a notice of the RAB meeting, which included a discussion of the five-year review, was published in the *Guam Pacific Daily News*.

6.1.2 Other Community Involvement Activities

The USAF has been actively involved in soliciting public involvement and input regarding the decisions on environmental investigations and remedial activities for Andersen AFB IRP sites. This has been done through Community Relations Plans (CRPs), Public Notices and Public Meetings, and the RAB.

In accordance with CERCLA Sections 113 and 117, a community relations program was initiated by Andersen AFB to involve the community in the decision-making process. In August 1992, to inform and involve the local community, Andersen AFB conducted 67 interviews with local government officials, residents, and concerned citizens to determine the level of community concern and interest in the environmental investigations. These community interviews provided the basis for the 1993 CRP (ICF, 1993). The 1993 CRP described activities to keep the nearby communities informed of the progress of the environmental investigations at Andersen AFB sites and provide opportunities for input from residents regarding cleanup plans. In response to the USEPA request, Andersen AFB conducted 27 additional interviews in 1998, and updated the CRP (EA, 1998b). During the first five-year review, interested community representatives and government officials were interviewed and opportunities for residents of the nearby communities to provide input were made available.

As part of this review, Andersen AFB notified the public of the five-year review period milestones via the RAB and interviewed community representatives that are active in the RAB as well as officials from the Guam EPA.

Andersen AFB also made copies of all relevant IRP documents available to the public in the Information Repository at the following locations:

Installation Restoration Program

36 CES/CEVR

Unit 14007

APO AP 96543-4077

Phone: (671) 366-5080

Contact: Mr. Gregg Ikehara, Installation Project Manager

University of Guam Government Documents Department

Robert F. Kennedy Library, University of Guam Station

Mangilao, Guam 96923

Phone: (671) 735-2316, -2315

Contact: Walfrid C. Benavente

Nieves M. Flores Memorial Library

254 Martyr Street

Hagåtña, Guam 96910

Phone: (671) 475-4751, -4752, -4753, or -4754

Contact: Teresita L.G. Kennimer

6.2 Document Review

Since the first five-year review, semi-annual groundwater monitoring reports for the fall and spring groundwater monitoring events, an Agency Draft RI/FS Report for Sites 41, 42, and 43, a FFS and TI Waiver have been completed for the MARBO Annex OU. A ROD Amendment and a Post ROD Amendment Remedial Design are currently in progress and are expected to be completed by December 2009.

Other than the site inspection reports summarized in Section 4.5.3 of this review, there have been no new documents that address Site 20 in the last five years.

The first five-year review recommendations with respect to groundwater were largely satisfied by the installation of rock borings IRP-61 and IRP-62B. Groundwater data from IRP-61 and IRP-62B are provided in the groundwater monitoring reports listed in Section 2 of this document. Based on review of these documents, no significant new information was obtained regarding the source or the fate and transport of the TCE/PCE in the MARBO Annex groundwater. The TCE/PCE trends observed in groundwater over this review period continue to support the conclusion that the deep groundwater lens is relatively immobile and that natural attenuation processes are ineffective in remediating the PCE/TCE in the deep groundwater lens.

Subsequently, in September 2008 the final *Focused Feasibility Study to Support a Record of Decision Amendment with a Technical Impracticability Waiver for the MARBO Annex Operable Unit* was completed (EA, 2008c). This document provided the justification for a TI waiver with regards to the TCE/PCE in the MARBO Annex groundwater and served as the basis for the ROD Amendment for MARBO Annex Groundwater as described in Section 5.3.4 of this document.

As described in Section 5.3.4, the significant outcome of the documentation prepared for the MARBO Annex OU during the five-year review period was the modification of the remedy for MARBO Annex OU groundwater.

6.3 Data Review

There are no new data to discuss relevant to the remedy in effect at Site 20. The complete set of MARBO Annex LTGM data for all monitoring events up through fall 2008 are presented in Appendix B.

6.3.1 Discussion of the PCE/TCE Trends in the MARBO Annex OU LTGM Data Since 1998

Even though the remedy is functioning as intended in the ROD, and is still protective of human health and the environment as long as ICs are implemented, MNA appears to be ineffective as a means of achieving the MCLs within the period of time stated in the original ROD (10 to 40 years). Data indicate that time frame for the attenuation of TCE and PCE in MARBO Annex in deep groundwater may take significantly longer than 40 years.

6.3.1.1 Estimated Attenuation used in Developing Original Remedy

The ROD recognized that the success of the *Natural Attenuation* component of the remedy hinged on whether physical processes of dispersion and dilution were occurring at a rate in-line with the estimated degradation rate for TCE and PCE to attenuate below MCLs. At the time of the ROD, there were two locations (three monitoring wells) that exceeded the MCLs: IRP-31 exceeded the MCL for TCE, and IRP-14 and IRP-29 (located adjacent to each other) exceeded the MCL for PCE. The estimated time to achieve the MCL for TCE in IRP-31 was estimated to range between 10 and 40 years. The estimated time to achieve the MCL for PCE in IRP-14 and IRP-29 ranged from 1 to 10 years and 2 to 10 years respectively. The ROD noted that the primary limitation of these estimates include the uncertainty of the total TCE/PCE mass that may exist in the subsurface.

6.3.1.2 LTGM Data Trends in Shallow and Deep Aquifer

Two geographically distinct areas within the deep portion of the freshwater lens have dissolved-phase TCE and PCE concentrations exceeding MCLs. All suspected TCE and PCE contaminant source areas identified within the MARBO Annex property, including the recent RI/FS at Sites 41, 42, and 43, have been investigated and no residual TCE or PCE source has been identified. Also, the fact that the shallow freshwater lens has shown a consistent decline in TCE and PCE concentrations over time is indicative that there is no continued contaminant TCE/PCE sourcing from the vadose zone. The following findings regarding the nature and extent of TCE and PCE occurrence provide the basis for the conceptual site model of groundwater contamination at the MARBO Annex.

Based on historical results of the LTGM program, two COCs have been identified: PCE and TCE. These COCs have historically been detected in deep groundwater samples collected from IRP-29 and IRP-31 at concentrations above their respective MCLs (5 µg/L). The historic distribution of PCE and TCE concentrations in groundwater exceeding the MCL in both shallow and deep monitoring wells are depicted on Figure 3-11.

TCE and PCE have either been non-detect or detected at concentrations below the MCL in all shallow monitoring wells, with the exception of IRP-14. PCE concentrations in groundwater samples collected from IRP-14 have shown a linear decline over the past 11 years, suggesting that PCE in the shallow aquifer is being attenuated through the physical process of hydrodynamic dispersion as a result of strong lateral flow of groundwater in the shallow portion of the freshwater lens (EA, 2008c).

The data from the shallow freshwater lens indicate the following:

- There is no continued shallow contaminant source of PCE or TCE in the MARBO Annex area.
- The PCE concentrations observed in the shallow freshwater lens in the vicinity of the former MARBO Laundry have decreased linearly over time.

- The physical processes (strong horizontal flow) operating in the shallow freshwater lens have attenuated the dissolved-phase PCE to levels below the MCL.

TCE and PCE concentrations observed in groundwater samples collected from deep wells IRP-31 and IRP-29 are one to two orders of magnitude higher than groundwater samples from their paired shallow wells. This indicates that conditions within the deep freshwater lens are significantly more static and less mobile than in the shallow freshwater lens. TCE and PCE concentrations observed in the deep freshwater lens over time show cyclical increases and decreases that appear to coincide with temporal variations in the elevation of the water table and thickness of the freshwater lens. These variations in the configuration of the freshwater lens appear to be influenced by short term and long term variations in precipitation and sea level. The historical data indicate that the overall freshwater lens has gotten thicker and thinner in response to long term variations in precipitation while the vertical horizon of the groundwater sampling points of MARBO Annex monitoring wells have remained static. More specifically, with an increase in precipitation there is a corresponding rise in the top of the freshwater lens that is coupled with a lowering in the base of the freshwater lens.

Historical data also suggest that the processes operating in the deep freshwater lens are not as dynamic as in shallow portion of the lens. The cyclical PCE and TCE trends in the deep freshwater lens indicate the following:

- The highest concentrations of PCE and TCE (detected at IRP-29 and IRP-31, respectively) have been observed in groundwater samples collected near the base of the freshwater lens.
- There is a much weaker lateral flushing (and thus hydrodynamic dispersion) in the deep portion of the freshwater lens than shallower in the lens.
- The observed TCE and PCE contamination may be from relatively “old” sources.
- The TCE and PCE observed in IRP-31 and IRP-29, respectively, appear to have resulted from separate sources (Figure 3-10).
- PCE and TCE concentrations have fluctuated over time in relation to variations in the freshwater lens thickness, but have stayed within an established concentration range and show no appreciable increase or decrease, on average, over the past 11 years.
- Neither physical (e.g., dilution) nor biological processes (e.g., reductive dehalogenation) are operating to significantly attenuate TCE or PCE in the deep freshwater lens. Groundwater geochemical conditions are not favorable to allow for biological reductive dehalogenation.

6.3.1.3 LTGM Data Trends in Groundwater Production Wells at MARBO Annex OU

Over the past five years, VOC analysis on samples collected from dedicated sampling points on three production wells located in the MARBO Annex OU (D-14, MW-1, and MW-9) indicate that the remedy is still protective. TCE and PCE concentrations were below the laboratory reporting limit in groundwater samples collected from production wells D-14 and MW-9, respectively. In production well MW-1, although TCE concentrations showed a slight increase over the review period, TCE concentrations are still below the MCL (5 µg/L). Additionally, the highest measured TCE concentration in production well MW-1 was 1.2 µg/L (sample collected

in May 2008), which is at the lower end of the range of historically measured concentrations at this sampling point (maximum TCE concentration was 6 µg/L in October 2002).

Although groundwater production well MW-2 was taken out of operation in 1998, groundwater samples have been collected from this well three times since the last five-year review (November 2004, November 2005, and May 2006). TCE and PCE concentrations were below the laboratory reporting limit in samples collected in November 2004 and 2005. TCE and PCE were detected at concentrations below the MCLs in the samples collected in May 2006 (0.10 and 0.53 µg/L, respectively). The continued presence of TCE and PCE in MW-2 at trace concentrations, since it was taken out of operation, suggest that the higher concentrations observed when it was operational would likely return under pumping conditions.

6.4 Site Inspections

EA conducted site inspections on 09 September 2008. The site inspection form is presented in Appendix F. The purpose of the inspections was to assess the protectiveness of the remedy, including the presence and condition of warning signs limiting access (Site 20), the integrity of the soil cover (Site 20), and the condition of the monitoring well network. Monitoring wells are also inspected on a semi-annual basis as part of the LTGM program. Institutional controls were evaluated by visiting the Andersen AFB Environmental Office, and reviewing the Base General Plan and the LUCMP.

The site visit to Site 20 found no significant issues that immediately compromised the protectiveness of the soil cover, but did identify conditions that if left unchecked, might potentially affect the remedies protectiveness. Examination of the soil cover revealed that there had been some slight burrowing into the soil cover by feral pigs. Several trees up to 1 inch diameter at breast height and up to five feet tall were observed growing within the soil cover and their effects on the soil cover should be monitored. Another minor issue observed was trespassing and its effect on soil cover, particularly the tire tracks associated with vehicular activity. The signs citing restricted access to Site 20 were damaged by bullet holes, but were still readable and served their intended purpose. These observations corroborated with other periodic site inspections at Site 20 since the first five-year review. Photos taken during the site inspection are presented in Appendix G.

The ICs that are in place for MARBO Annex groundwater include prohibitions on the use or disturbance of groundwater until cleanup levels are achieved, excavation activities, disturbance of the soil cover, and any other activities or actions that might interfere with the implemented remedy. No activities were observed that would compromise the institutional controls. No significant damage to the monitoring well network has occurred, and no new groundwater development has occurred.

6.5 Interviews

As part of the five-year review, interviews were conducted with various parties. Ms. Joanne M. Salas Brown, Assistant Director of Soil and Water at the University of Guam College of Natural and Applied Sciences, was interviewed on 19 November 2008. Mr. John Jocson, a Staff

Hydrogeologist at the Water and Environmental Research Institute of the Pacific (WERI), was interviewed via e-mail on 25 November 2008. Two representatives from the Guam EPA, Mr. Michael Cruz and Mr. Victor Wuerch, were interviewed on 02 December 2008. Overall, the interviewees were pleased with the status of the MARBO Annex OU and responsiveness of the Base. No significant problems regarding the MARBO Annex OU were identified during the interviews; however, Mr. Cruz stated that illegal dumping frequently occurs at the MARBO Annex, but that the issue is out of the Base's control.

Several constructive recommendations were made during the interviews. Ms. Brown commented that it would be a good idea to incorporate media outreach during field visits to the site and to keep the public informed at every available opportunity. Ms. Brown also expressed her belief that, following the Base's merger with the Navy, an important quality of the new project staff should be that they are able to relate to the community, as Andersen AFB has successfully done by basing their staff on Guam.

With regard to groundwater, Mr. Wuerch suggested that the Base establish a routine reporting system with GWA to ensure that the Base is made aware of the presence of TCE/PCE in GWA wells that are down gradient of MARBO Annex, including Tumon Bay. He requested that the Air Force consider funding or co-funding the continuation of a study that he and Mr. Benny Cruz reported on in 2007, relating low pressure systems to solidity in the wells, in order to complete the conceptual site model for groundwater. Mr. Wuerch further recommended that the Base conduct a water table elevation salinity profile measurement and a TCE/PCE concentration sampling event prior to, during, and after a major storm event, in order to fill in the data gap of the conceptual site model as to what is controlling the vertical distribution of TCE and PCE.

The content of the interview was recorded, transcribed, and presented in Appendix H, using forms from the USEPA Guidance Document (USEPA, 2001).

This page is intentionally left blank

7.0 TECHNICAL ASSESSMENT OF SELECTED REMEDIES

7.1 Technical Assessment of Remedial Action at Site 20

Question A: Is the remedy functioning as intended by the ROD?

The review of the document, ARARs, risk assumptions, and the results of the site inspection indicates that the remedy is currently functioning as intended. Since the completion of the first five-year review, the quarterly inspection reports were the only data generated with regard to Site 20. Even though the quarterly inspection of Site 20 did not occur quarterly as intended by the recommendations of the first five-year review, the inspection reports have been thorough with consistent observations being made. For now, the remedy at Site 20 is still fully functioning as intended by the ROD.

Question B: Are the exposure assumptions, toxicity data, cleanup values, and remedial action objectives (RAOs) used at the time of the remedy selection still valid?

The land and resource use at Site 20 has not changed. With COC-impacted soil beneath the soil cover, the future land use at Site 20 is still restricted. The LUCs are functioning as intended; therefore, exposure assumptions for the HHRA and ERA are still valid for the site and RAOs are being met. No new human health or ecological exposure pathways or receptors have been identified for the site.

The toxicity data and residential PRGs for 4,4'-DDE, 4,4-DDT, dieldrin, alpha chlordane, gamma chlordane, and Aroclor 1260 have changed slightly since the ROD was signed on 17 July 1998. When the HHRA was completed for Site 20, the 1995 PRGs were the most current. As screening criteria are periodically updated, the EPCs are compared with the most recent version (currently the 2009 RSLs) to examine if the HHRA also needs to be updated due to significant and more stringent established PRGs with respect to each COC (USEPA, 2008).

As presented in Table 7-1, the 2009 RSLs for each of the COCs are either the same or less stringent than the 1995 PRGs; therefore, the 1995 HHRA and ERA results and the effectiveness of the selected remedy still remain valid.

Table 7-1. Comparison of Site 20 EPCs to 2009 Residential RSLs and BTVs.

COCs	EPCs (mg/kg)	1995 Residential PRGs (mg/kg)	2009 Residential RSLs (mg/kg)	BTVs (mg/kg)
4,4'-DDE	6.7	1.3	1.4	NA
4,4'-DDT	6.2	1.3	1.7	NA
Dieldrin	0.12	0.028	0.030	NA
Alpha chlordane	0.44	0.34	1.6	NA
Gamma chlordane	0.38	0.34	1.6	NA
Aroclor 1260	4.4	0.066*	0.22	NA
Lead	3,604	400	400	166

* = PRG is based on total PCB concentration; prior to 2000 there was no PRG for Aroclor 1260.
 BTV = Background Threshold Value
 COC = contaminant of concern
 EPC = Exposure Point Concentration
 mg/kg = milligrams per kilogram
 NA = not applicable; BTV is applicable only for inorganic compounds (metals).
 PRG = Preliminary Remediation Goal
 RSL = Regional Screening Level

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

Based on the site inspection, the integrity of the soil cover is still intact. However, as long as the site is accessible, the structural integrity of the soil cover may be compromised due to vehicle traffic, small trees, and pig wallows. Therefore, the soil cover may not be protective of the human health or the environment in the future without inspections and periodic maintenance.

7.1.1 Technical Assessment Summary of Site 20

Annual site inspections and at least semi-annual maintenance of the soil cover, in the form of brush clearing, is recommended to protect against damage to the cover.

7.2 Technical Assessment of Remedial Action for MARBO Annex Groundwater

Question A: Is the remedy functioning as intended by the ROD?

The remedy selected in the 1998 ROD consisted of three components: natural attenuation, wellhead treatment, and ICs. The overall intent of the selected remedy was to ensure that the RAOs were met in order to be protective of human health. As noted in Section 5.1.5, the first five-year review concluded that the remedy was still functioning as long as ICs were in-place, but questioned whether the assumptions made in support of the natural attenuation component were still valid. The first five-year review also acknowledged that the wellhead treatment component of the remedy was no longer applicable because MW-2 had been taken out of production, but that wellhead treatment would resume if MW-2 were brought back into service.

During the second five-year review time period, protectiveness goals were being achieved because there was no direct human exposure to groundwater containing TCE and PCE at concentrations exceeding MCLs. However, groundwater monitoring data indicated that the

natural attenuation component was not functioning as intended, because the time frame for TCE and PCE in the deep freshwater lens to achieve MCLs will take longer than the original high end estimate of 40 years.

A ROD Amendment is being developed that will change the remedy from *Natural Attenuation with Institutional Controls* to *Long-Term Groundwater Monitoring with Contingency for Wellhead Treatment*. The change in remedy has no effect on the protectiveness. The remedy is protective because the ICs established in the first ROD preclude a completed pathway.

Question B: Are the exposure assumptions, toxicity data, cleanup values, and Remedial Action Objectives (RAOs) used at the time of the remedy selection still valid?

There are no changes in exposure assumptions, toxicity data, cleanup values, or RAOs that are significant or that alter the validity of the amended remedy.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

There is no new information that has come to light that questions the protectiveness of the remedy. Modifications to the groundwater remedy made in the MARBO Annex OU ROD Amendment will not result in any change that affects the protectiveness of the remedy. The continued monitoring of TCE and PCE concentrations in production wells and timely action when, if ever, TCE or PCE concentrations are found to increase to the MCL will ensure that the remedy continues to be protective.

7.2.1 Technical Assessment Summary of the MARBO Annex Groundwater

Based on the data review, the RAOs were addressed as intended in the ROD Amendment.

This page is intentionally left blank

8.0 ISSUES IDENTIFIED IN THE SECOND FIVE-YEAR REVIEW

8.1 Issues Identified at Site 20

Table 8-1 presents the issues that were identified at Site 20 during the second five-year review.

Table 8-1. Issues Identified at Site 20.

Issue	Currently Affects Protectiveness (Y/N)	Affects Future Protectiveness (Y/N)
Evidence of pig wallowing at a few locations on the periphery of the soil cover.	N	Y
Trees with roots that could potentially damage the soil cover are not being removed on a periodic basis. Little or no maintenance of the soil cover is being performed.	N	Y
O&M site inspection frequency is not performed in accordance with recommendations made under the previous review.	N	N
O&M = Operations and Maintenance		

8.1.1 Determination of Whether Issues Affect Protectiveness at Site 20

The damage caused by the growth of small trees, pig wallowing activity, and vehicular traffic has been minor and has not breached the soil cover at Site 20, but ongoing inspections and maintenance are important to ensure that the integrity of the soil cover does not deteriorate and reduce the protectiveness of the remedy in the future.

8.1.2 Unresolved Issues Raised by Regulatory Support or Community Groups at Site 20

None were identified during this review or during the public presentation of this review. Various community members have historically expressed concern with the implementation of the ICs as a remedy at the IRP sites. The root issue is that if and when the USAF returns lands currently under their control to public domain that includes property with ICs, that lay persons will not appreciate the significance of the risk-based land management decisions that were made by the USAF IRP. In essence, the lay viewpoint is that the land is either useable or not.

8.2 Issues Identified for the MARBO Annex Groundwater Remedy

Table 8-2 presents the issues that were identified for MARBO Annex groundwater during the second five-year review.

Table 8-2. Issues Identified for the MARBO Annex Groundwater Remedy.

Issue	Currently Affects Protectiveness (Y/N)	Affects Future Protectiveness (Y/N)
MNA not achieving clean-up of PCE/TCE in accordance with expected timeframe.	N	N
LTGM data indicates TCE concentration are increasing in production well MW-1. However, the observed TCE concentrations are still well below the MCL.	N	N
LTGM = Long-Term Groundwater Monitoring MNA = monitored natural attenuation PCE = tetrachloroethene TCE = trichloroethene MCL = Maximum Contaminant Level		

8.2.1 Issues Identified During Technical Assessment of MARBO Annex Groundwater

As shown in Table 5-2, during the first five-year review, the remedy was determined to be functioning as intended in the ROD, in that the remedy was protective of human health and the environment as long as ICs were implemented. However, the review suggested that the natural attenuation process was not operating as intended at IRP-31, based on the lack of a clear decreasing trend of TCE concentrations.

In recognition that this trend was continuing, the USAF has drafted a ROD Amendment with TI Waiver document in conjunction with this review. As a result, this second five-year review has not identified any significant issues in the technical assessment of the remedy.

The LTGM data observed in production well MW-1 indicates that TCE concentrations have been rising slightly over the past five years. However, the observed TCE concentrations are still well below the performance standard established for wellhead treatment (MCL of 5 µg/L). Should TCE concentrations continue to rise; the remedy includes a contingency for wellhead treatment so that protectiveness will be maintained.

8.2.2 Determination of Whether Issues Affect Protectiveness of MARBO Annex Groundwater Remedy

No issues were identified that affected protectiveness under the amended remedy currently in place.

8.2.3 Unresolved Issues Raised by Regulatory Support or Community Groups for MARBO Annex Groundwater Remedy

No issues were identified during this review or during the public presentation of this review. There has historically been concern that PCE/TCE concentrations observed in the Tumon-Maui well and seeps along Tumon Bay may be associated with the same source that resulted in the PCE and TCE contamination in the MARBO Annex groundwater. Based on this review, groundwater data continue to reaffirm that the plumes are stable and there is little to no evidence that the two separate occurrences of VOCs are related.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

9.1 Recommendations and Follow-up Actions at Site 20

With the exception of the posted sign, the issues that were noted during the first five-review continue to be an issue during the second five-year review, as presented in Table 9-1.

Table 9-1. Second Five-Year Review Issues, Recommendations, and Follow-up Actions for Site 20.

Issues	Recommendations / Follow-Up Actions	Party Responsible	Oversight Agency	Milestone Date	Affect Protectiveness? Yes/No	
					Current	Future
1) Vehicle access, pig wallows, and small trees continue to threaten the structural integrity of the <i>Soil Cover</i> . Although, these deficiencies do not pose an immediate threat to the integrity of the soil cover, if these activities continue RAOs will not be met if COCs are exposed at the surface.	Recommend annual site inspections of the soil cover and create a program for periodic (semi-annual) mowing and maintenance of <i>Soil Cover</i> , drainage channel and riprap. In addition, should uprooted trees damage the integrity of the <i>Soil Cover</i> , the soil cover will need to be repaired.	USAF	USEPA & Guam EPA	04/01/10 and Brush Clearing on Semi-Annual Basis	N	Y
2) The <i>Soil Cover</i> is subject to frequent island natural disasters such as typhoons and earthquakes that can damage the structural integrity of the <i>Soil Cover</i> .	Continue event driven inspection program to check the integrity of the <i>Soil Cover</i> after each natural disaster.	USAF	USEPA & Guam EPA	TBD	N	Y
COC = Contaminant of Concern Guam EPA = Guam Environmental Protection Agency O&M = Operation and Maintenance RAO = Remedial Action Objective TBD = to be determined USAF = United States Air Force USEPA = United States Environmental Protection Agency						

An annual record of O&M inspections, similar to what is presented in Appendix C, should be created for Site 20. These reports should be compiled in an annual report and distributed to the RPM for the subsequent five-year reviews.

9.2 MARBO Annex Groundwater Remedy Recommendations and Follow-up Actions

There were no issues that were identified with the operating remedy under the 2009 ROD Amendment. A recommendation came out of the data review that concentrations of TCE in

MW-1 were showing a very gradual increasing trend and some forward planning on the future use of this well in the context of Andersen AFB water supply may be appropriate (Table 9-2).

Table 9-2. Second Five-Year Review Issues, Recommendations, and Follow-up Actions for MARBO Annex Groundwater.

Issues	Recommendations / Follow-Up Actions	Party Responsible	Oversight Agency	Milestone Date	Affect Protectiveness? Yes/No	
					Current	Future
1) TCE concentrations are increasing in MW-1	Continue to monitor sampling data from this well and share with Andersen AFB potable water supply facility managers.	USAF	USEPA & Guam EPA	08/30/09	N	Y
AFB = Air Force Base Guam EPA = Guam Environmental Protection Agency RAO = Remedial Action Objective TCE = trichloroethene USAF = United States Air Force USEPA = United States Environmental Protection Agency						

10.0 PROTECTIVENESS STATEMENTS

10.1 Protectiveness Statement for Site 20

Based on the review of existing data and site inspections, the remedy at Site 20 is protective of human health and the environment since exposure pathways that could result in unacceptable risks are being controlled.

10.2 Protectiveness Statement for MARBO Annex Groundwater

The remedy for MARBO Annex groundwater is protective of human health and the environment since exposure pathways that could result in unacceptable risks are being controlled.

This page is intentionally left blank

11.0 NEXT REVIEW

The next and third five-year review of the MARBO Annex OU ROD is due five years from USEPA approval of this review and should include review of the remedies for Sites 20, 41, 42, and 43, and for MARBO Annex groundwater. The related review period will be from 02 March 2009 to 02 March 2014.