



64555

**PHASE II REMEDIAL INVESTIGATION
TUTU WELLS SITE
ST. THOMAS, U.S. VIRGIN ISLANDS
VOLUME I OF III**

April 1995

Prepared for
Tutu Environmental Investigation Committee

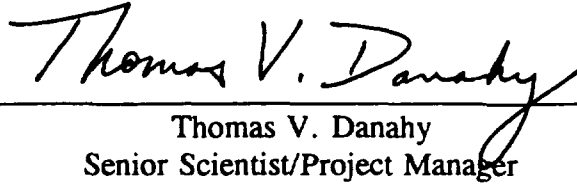
Prepared by
Geraghty & Miller, Inc.
201 West Passaic Street
Rochelle Park, New Jersey 07662
(201) 909-0700



**PHASE II REMEDIAL INVESTIGATION
TUTU WELLS SITE
ST. THOMAS, U.S. VIRGIN ISLANDS**

April 6, 1995

Prepared by GERAGHTY & MILLER, INC.



Thomas V. Danahy
Senior Scientist/Project Manager



Daniel Nachman
Vice President/Project Officer



VOLUME I

CONTENTS

	<u>Page</u>
1.0 INTRODUCTION	1-1
1.1 PURPOSE	1-2
1.2 SITE BACKGROUND	1-4
1.2.1 Site Location and Description	1-4
1.2.2 History of Known Public Concerns	1-4
1.2.3 History of Response Actions	1-5
1.3 PHASE II RI SCOPE OF WORK	1-7
1.3.1 Scope of Work Performed by Geraghty & Miller, Inc.	1-7
1.3.1.1 Source Identification and Characterization	1-8
1.3.1.2 Sitewide Hydrogeologic and Groundwater Quality Investigation	1-9
1.3.2 Scope of Work Performed by Other Consultants	1-11
1.4 REPORT ORGANIZATION	1-14
2.0 PREVIOUS INVESTIGATIONS	2-1
2.1 INDIVIDUAL SITE RECONNAISSANCE AND SAMPLING	2-1
2.1.1 Previous Investigations at the VIHA	2-3
2.1.2 Previous Investigations at the Curriculum Center (Former Laga Building)	2-3
2.1.3 Previous Investigations at Ramsay Motors	2-3
2.1.4 Previous Investigations at Antilles Auto Parts (formerly Gassett Auto Parts)	2-4
2.1.5 Previous Investigations at the Texaco Tutu Service Station	2-5
2.1.6 Previous Investigations at Four Winds Plaza	2-7
2.1.7 Previous Investigations at Western Auto	2-8
2.1.8 Previous Investigations at Tillett Gardens	2-8
2.1.9 Previous Investigations at the Esso Tutu Service Station	2-9
2.1.10 Previous Investigations at O'Henry Dry Cleaners	2-10
2.2 USEPA SUPPLY WELL SAMPLING	2-11



CONTENTS (continued)

	<u>Page</u>
2.3 TEIC SUPPLY WELL SAMPLING PROGRAM	2-11
2.4 PHASE I RI	2-12
3.0 INVESTIGATIVE METHODOLOGY	3-1
3.1 BASE MAP PREPARATION AND SURVEYING	3-1
3.2 CONTAMINANT SOURCE INVESTIGATIONS	3-2
3.3 METEOROLOGICAL INVESTIGATIONS	3-2
3.4 SURFACE-WATER AND SEDIMENT INVESTIGATION	3-3
3.5 GEOLOGIC INVESTIGATIONS	3-4
3.5.1 Review of Previous Geologic Studies	3-5
3.5.2 Fracture Trace Analysis	3-5
3.5.3 Geologic Mapping	3-6
3.5.3.1 Bedrock Outcrop Observations	3-6
3.5.3.2 USDA Soil Survey	3-6
3.5.4 Soil Borings	3-7
3.5.5 Bedrock Coring	3-8
3.5.6 Borehole Geophysical Logging	3-9
3.5.6.1 Borehole Preparation	3-10
3.5.6.2 Caliper Logging Procedure	3-10
3.5.6.3 Acoustic Logging Procedure	3-11
3.6 SOIL QUALITY INVESTIGATIONS	3-12
3.6.1 Soil Sampling	3-12
3.6.1.1 Subsurface Soil Sampling	3-12
3.6.1.2 Surface Soil Sampling	3-13
3.6.1.3 Disposal of Soils	3-14
3.6.2 HNU Screening	3-15
3.6.3 Field GC Screening	3-16
3.6.4 Soil-Gas Survey	3-16
3.7 GROUNDWATER INVESTIGATION	3-16



CONTENTS (continued)

	<u>Page</u>
3.7.1 Monitoring Well Installation	3-17
3.7.1.1 Shallow Monitoring Wells	3-17
3.7.1.2 Deep Monitoring Wells	3-18
3.7.2 Well Surveying	3-20
3.7.3 Well Development	3-20
3.7.4 Water-Level Measurements	3-21
3.7.5 Groundwater Analytical Parameters	3-22
3.7.6 Monitoring Well Sampling and Analysis	3-23
3.7.7 Supply Well Sampling	3-24
3.7.8 Treatment System	3-25
3.8 PUMPING TESTS	3-25
3.8.1 Phase I Aquifer Test - Four Winds Plaza	3-26
3.8.1.1 Water-Level Measurements	3-27
3.8.1.2 Aquifer Pumping Test Procedures	3-28
3.8.1.3 Discharge Water Treatment	3-28
3.8.1.4 Discharge Water Sample Collection and Analysis	3-29
3.8.2 Phase II Pumping Aquifer Test - Eglin III Pumpage Impact Test	3-29
3.8.2.1 Water-Level Measurements	3-29
3.8.2.2 Aquifer Pumping Test Procedures	3-30
3.9 DATA VALIDATION	3-31
3.10 HUMAN POPULATION SURVEY	3-31
4.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA	4-1
4.1 TOPOGRAPHY AND DRAINAGE	4-1
4.2 DEMOGRAPHY AND LAND USE	4-2
4.3 CLIMATE	4-3
4.3.1 Precipitation	4-3
4.3.2 Wind	4-4



CONTENTS (continued)

	<u>Page</u>
4.3.3 Temperature	4-5
4.3.4 Barometric Pressure	4-5
4.4 SOILS AND VEGETATION	4-6
4.5 GEOLOGY	4-6
4.5.1 Regional Geology	4-7
4.5.2 Site Geology	4-8
4.5.2.1 Inspection of Bedrock Exposures	4-10
4.5.2.2 Thin Section Analysis	4-11
4.5.2.3 Site Stratigraphy	4-12
4.5.3 Fracture Analysis	4-13
4.5.3.1 Aerial Photographic Interpretation Results	4-13
4.5.3.2 Bedrock Outcrop Fracture Analysis Results	4-15
4.5.3.3 Bedrock Core Fracture Analysis	4-16
4.5.3.4 Borehole Geophysical Results	4-16
4.6 HYDROGEOLOGY	4-17
4.6.1 Regional Hydrogeology	4-18
4.6.2 Site Hydrogeology	4-20
4.6.2.1 Shallow Bedrock Groundwater Flow	4-22
4.6.2.2 Deep Bedrock Groundwater Flow	4-24
4.6.2.3 Vertical Gradients	4-24
4.6.2.4 Seasonal Groundwater Elevation Fluctuation	4-25
4.6.2.5 Shallow Bedrock Hydraulic Characteristics	4-25
4.6.2.6 Deep Bedrock Hydraulic Characteristics	4-27
4.6.2.6.1 Monitoring Well MW-6D Aquifer Test Analysis	4-28
4.6.2.6.2 Eglin III Supply Well Aquifer Test Analysis	4-29
4.6.2.7 Hydraulic Conductivity Values	4-30
4.6.2.8 Pumpage Impact	4-31



CONTENTS (continued)

	<u>Page</u>
4.6.2.8.1 Shallow Bedrock Response	4-33
4.6.2.8.2 Deep Bedrock Response	4-34
4.6.2.8.3 Aquifer Response to the Simulated Eglin III Pumping Cycle	4-37
4.6.2.9 Current Status of Supply Wells	4-38
4.6.2.10 Summary of Aquifer Hydraulic Characteristics	4-38
4.6.3 Conceptual Hydrogeologic Model	4-39
5.0 NATURE AND EXTENT OF CONTAMINATION	5-1
5.1 SOIL QUALITY AND POTENTIAL SOURCES	5-1
5.1.1 VIHA Soil Sampling Results	5-5
5.1.2 Curriculum Center Soil Sampling Results	5-6
5.1.3 Ramsay Motors Soil Sampling Results	5-9
5.1.4 Antilles Auto Parts Soil Sampling Results	5-11
5.1.5 Texaco Tutu Service Station Soil Sampling Results	5-12
5.1.6 Tillett Gardens Soil Sampling Results	5-14
5.1.7 Four Winds Plaza Soil Sampling Results	5-16
5.1.8 Western Auto Soil Sampling Results	5-18
5.1.8.1 Pre-Excavation Soil Sampling Results	5-19
5.1.8.2 Excavation/Post-Excavation Soil Sampling Results	5-20
5.1.9 Esso Tutu Service Station Soil Sampling Results	5-23
5.1.10 O'Henry Dry Cleaners Soil Sampling Results	5-26
5.1.11 Soil Sampling Results at Other Properties	5-28
5.1.12 Summary of Soil Quality Results	5-29
5.1.12.1 Properties with Soil Impacted by BTEX, MTBE, and BNA Compounds	5-30
5.1.12.2 Properties with Soil Impacted by Chlorinated VOCs	5-31
5.1.12.3 Properties with Soil Impacted by Other Compounds	5-32
5.2 GROUNDWATER QUALITY	5-32
5.2.1 Organic Compounds	5-34



CONTENTS (continued)

	<u>Page</u>
5.2.1.1 BTEX and Petroleum-Related Compounds in Groundwater	5-34
5.2.1.2 Base Neutral and Acid Extractable Compounds	5-38
5.2.1.3 Chlorinated Volatile Organic Compounds	5-39
5.2.1.3.1 Northern Chlorinated VOC Plume	5-40
5.2.1.3.2 Southern Chlorinated VOC Plume	5-43
5.2.2 Evaluation of Potential Presence of Nonaqueous Phase Liquids . .	5-45
5.2.3 Vertical Distribution of Organic Compounds in Groundwater . . .	5-48
5.2.4 Inorganic Compounds	5-50
5.2.4.1 Total Metals	5-50
5.2.4.2 Dissolved Metals	5-50
5.2.4.3 Water Quality Indicators	5-51
5.2.5 QA/QC Samples	5-52
5.2.6 Summary and Conclusions	5-53
5.2.6.1 Sources of BTEX and Petroleum- Related Compounds in Groundwater	5-57
5.2.6.2. Sources of Chlorinated VOCs in Groundwater	5-58
5.3 SURFACE WATER, SANITARY SEWER, AND SEDIMENT RESULTS	5-59
5.3.1 Storm-Water Sewer Results	5-60
5.3.2 Sanitary Sewer Results	5-61
5.3.3 Sediment Results	5-61
5.4 AIR QUALITY	5-62
6.0 CONSTITUENT FATE AND TRANSPORT	6-1
6.1 CHEMICAL AND PHYSICAL PROPERTIES	6-1
6.2 MECHANISMS OF MIGRATION	6-6



CONTENTS (continued)

	<u>Page</u>
6.2.1 Migration in Air	6-7
6.2.2 Migration in Groundwater	6-8
6.2.3 Migration in Surface Water	6-10
6.2.4 Biodegradation/Biotransformation	6-11
 7.0 BASELINE RISK ASSESSMENT	 7-1
7.1 RISK ASSESSMENT PROCESS	7-1
7.2 RESULTS OF THE RISK ASSESSMENT	7-2
7.2.1 Groundwater	7-2
7.2.2 Soil	7-3
 8.0 SUMMARY AND CONCLUSIONS	 8-1
8.1 SITE GEOLOGY	8-1
8.2 SITE HYDROGEOLOGY	8-1
8.3 SOIL QUALITY	8-3
8.4 GROUNDWATER QUALITY	8-4
8.5 REMEDIAL OBJECTIVES	8-5
 9.0 REFERENCES	 9-1

TABLES

- 3-1. Soil Sampling Details, Phase II Remedial Investigation, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 3-2. Monitoring Well Construction Details, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 3-3. Groundwater Sampling Details for the Comprehensive Groundwater Sampling Event, May Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 3-4. Supply Well Construction Details and Estimated Pumping Rates, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 3-5. Schedule of Data Collection Intervals Used with the Data Logger During the May 1994 Eglin III Pumpage Impact Test, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.



TABLES (continued)

- 4-1. Precipitation Data from Estate Fort Mylner, 1961 Through 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-2. Temperature Data from Cyril E. King Airport, 1961 Through 1993, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-3. Soil Properties and Classification, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-4. Depths of Fracture Zones Identified by Downhole Geophysical Testings, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-5. Groundwater Elevations, September 10, 1992 through July 20, 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-6. Comparison of Groundwater Elevations for Monitoring Well Clusters, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-7. Vertical Gradients of Groundwater Flow, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-8. Calculated Transmissivity, Hydraulic Conductivity, and Storage Values for Bedrock Aquifer, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-9. Supply Wells Known to be in Use During the Remedial Investigation, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-1. Concentrations of Volatile Organic Compounds in Soil Samples Collected in March and April 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-2. Concentration of Base Neutral and Acid Extractable Organic Compounds in Soil Samples Collected in March and April 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-3. Concentrations of Metals in Soil Samples Collected in March and April 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-4. Concentrations of Total Cyanide, in Soil Samples Collected in March and April 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-5. Concentrations of Total Petroleum Hydrocarbons in Soil Samples Collected in March and April 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.



TABLES (continued)

- 5-6. Currently Available Soil Screening Levels, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-7. Volatile Organic Compounds Present in Soil Samples Exceeding New York State Technical and Administrative Guidance Memorandum Soil Cleanup Levels to Protect Groundwater Quality, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-8. Base/Neutral and Acid Extractable Compounds Present in Soil Samples Exceeding New York State Technical and Administrative Guidance Memorandum Soil Cleanup Levels to Protect Groundwater Quality, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-9. Comparison of Average Background Metal Concentrations with Maximum Background Concentrations, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-10. Concentrations of Volatile Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-11. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-12. Concentrations of Total Metals in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-13. Concentrations of Dissolved Metals in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-14. Concentrations of Indicator Parameters in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-15. Summary of Total Chlorinated Volatile Organic Compounds and Benzene, Toluene, Ethylbenzene, and Xylenes Detected in Supply Wells During Sampling Events Conducted by Geraghty & Miller, Inc., Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-16. Split Samples Collected During the Comprehensive Groundwater Sampling Event, May Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 6-1. Physical and Chemical Properties of Organic Constituents of Concern, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 7-1. Summary of Carcinogenic Risks Exceeding the U.S. Environmental Protection Agency Guidance Value, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.



7-2. Summary of Noncarcinogenic Risks Exceeding the U.S. Environmental Protection Agency Hazard Quotient of 1, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.



VOLUME II**FIGURES**

- 1-1. Site Location, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 1-2. Study Area, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 1-3. Study Area with Line of Cross Section A-A' Supply Well, Monitoring Well, and Soil Sampling Locations, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 1-4. Property Locations, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-1. Topographic Contours, Bedrock Outcrop Locations, Fracture Lineaments, and Distribution of Transmissivity and Hydraulic Conductivity Values, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-2. Storm Sewer Plan and Profile, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-3. Barometric Pressure Readings, November 1 Through 7, 1992, Cyril E. King Airport, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-4. Daily Precipitation, October 25 Through November 7, 1992, Estate Fort Mylner, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-5. Barometric Pressure Readings, May 8, 1994 Through May 14, 1994, Cyril E. King Airport, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-6. Daily Precipitation, May 1 Through May 31, 1994, Estate Fort Mylner, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-7. Soil Type Distribution, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-8. Overburden Thickness, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-9. Hydrogeologic Cross Section A-A', Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-10. Fracture Trace Rose Diagram, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-11. Generalized Potentiometric Surface September 11, 1987, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.



FIGURES (continued)

- 4-12. Groundwater Contour Map, Shallow Bedrock Wells, May 10, 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-13. Groundwater Contour Map, Shallow Bedrock Wells, May 23 to 24, 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-14. Groundwater Contour Map, Deep Bedrock Wells, May 10, 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-15. Groundwater Contour Map, Deep Bedrock Wells, May 23 to 24, 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-16. Monitoring Well MW-6R Drawdown Data, Pumping Test of MW-6R, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-17. Monitoring Well CHT-6D Drawdown Data, Pumping Test of MW-6D, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-18. Monitoring Well MW-6D Drawdown Data, Pumping Test of MW-6D, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-19. Eglin II Supply Well Drawdown Data, Eglin III Supply Well Pumpage Impact Test, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-20. Eglin II Supply Well Drawdown Data, Eglin III Supply Well Pumpage Impact Test, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-21. Eglin II Supply Well Recovery Data, Eglin III Supply Well Pumpage Impact Test, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-22. Maximum Drawdown in Deep Wells during Eglin III Pumpage Impact Test, May 12, 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 4-23. Groundwater Elevations during the Eglin III Pumpage Impact Test, May 12, 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-1. Soil and Oil Sampling Results, Virgin Islands Housing Authority, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-2. Soil Sampling Results, Curriculum Center (Former Laga Facility), Tutu Wells Site, St. Thomas, U.S. Virgin Islands.



FIGURES (continued)

- 5-3. Soil and Oil Sampling Results, Ramsay Motors, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-4. Soil Sampling Results, Antilles Auto Parts, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-5. Soil Sampling Results, Texaco Tutu Service Station, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-6. Soil Sampling Results, Tillett Gardens, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-7. Soil Sampling Results, Four Winds Plaza, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-8. Aqueous and Soil Sampling Results Prior to UST Removal, Western Auto Facility, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-9. Soil and Oil Sampling Results During and after UST Removal, Western Auto Facility, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-10. Soil Sampling Results, Esso Tutu Service Station, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-11. Soil Sampling Results, O'Henry Dry Cleaners, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-12. Soil Sampling Results, Fire Station, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-13. Soil Sampling Results, Vitelco Property, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-14. Soil Sampling Results, God of Holiness Church, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-15. Soil Sampling Results, Lutheran Church, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-16. Soil Sampling Results, Assembly of God Church, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.



FIGURES (continued)

- 5-17. Petroleum-Related Compounds in Shallow Groundwater, April Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-18. Petroleum-Related Compounds in Deep Groundwater, April Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-19. Chlorinated Volatile Organic Compounds and Benzene, Toluene, Ethylbenzene, and Xylenes in Supply Wells, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-20. Tert-Butyl Methyl Ether in Shallow Groundwater, April 1994 Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-21. Tert-Butyl Methyl Ether in Deep Groundwater, April 1994 Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-22. Chlorinated Volatile Organic Compounds in Shallow Groundwater, April 1994 Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-23. Chlorinated Volatile Organic Compounds in Deep Groundwater, April 1994 Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-24. Concentrations of Chlorinated Volatile Organic Compounds along Cross Section A-A', Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-25. Tetrachloroethene in Shallow Groundwater, April 1994 Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-26. Tetrachloroethene in Deep Groundwater, April 1994 Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-27. Trichloroethene in Shallow Groundwater, April 1994 Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-28. Trichloroethene in Deep Groundwater, April 1994 Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-29. 1,2-Dichloroethene in Shallow Groundwater, April 1994 Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-30. 1,2-Dichloroethene in Deep Groundwater, April 1994 Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.



FIGURES (continued)

- 5-31. Vinyl Chloride in Shallow Groundwater, April 1994 Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-32. Vinyl Chloride in Deep Groundwater, April 1994 Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- 5-33. Storm Water, Sanitary Sewer, and Sediment Sampling Results, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

VOLUME III**APPENDICES**

- A. Site Inspection Report, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- B. Field Gas-Chromatograph Analytical Report, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- C. Previous Investigations Sampling Results, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- D. Sample/Coring Logs, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- E. Petrographic Study, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- F. Borehole Geophysical Logs, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- G. Geologic Logs, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- H. Monitoring Well Construction Details, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- I. Surveyor's Data, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- J. Water Sampling Logs, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- K. Data Validation Summary Report, Phase II Soil Sampling, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.
- L. Data Validation Summary Report, Phase II Groundwater Sampling, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.



APPENDICES (continued)

- M. Eglin III Supply Well Pumpage Impact Test Hydrographs, May 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.



**PHASE II REMEDIAL INVESTIGATION
TUTU WELLS SITE
ST. THOMAS, U.S. VIRGIN ISLANDS**

1.0 INTRODUCTION

In December 1989, Geraghty & Miller, Inc. was retained by Texaco Caribbean, Inc. (Texaco) and Esso Standard Oil, U.S.A., Inc. (Esso) to prepare a work plan for investigation of two automotive service stations and the surrounding area in Tutu, Anna's Retreat, St. Thomas, U.S. Virgin Islands (USVI). In March 1990, Texaco and Esso formed the Tutu Environmental Investigation Committee (TEIC). Following discussions with the United States Environmental Protection Agency (USEPA), Geraghty & Miller submitted the revised Tutu Service Station Investigation Work Plan (Work Plan) in March 1992 on behalf of TEIC (Geraghty & Miller, Inc. 1992a). This work plan was incorporated by reference into an Administrative Order by Consent (AOC) (No. II-RCRA-7003 and 9003-92-0401) dated February 19, 1992, with an effective date of March 4, 1992 (USEPA 1992a), that was issued to Texaco and Esso by the USEPA-Region II, pursuant to Subtitle I of the Resource Conservation and Recovery Act (RCRA).

In April 1992, Technical Memorandum I (Geraghty & Miller, Inc. 1992b) was submitted to the USEPA. This report provided the results of the preliminary reconnaissance activities described in the Work Plan (Geraghty & Miller, Inc. 1992a) and implemented from December 1989 through April 1992. The addendum to Technical Memorandum I was submitted on May 29, 1992 (Geraghty & Miller, Inc. 1992c). Technical Memorandum II (Geraghty & Miller, Inc. 1993a) was submitted to the USEPA in May 1993 after completion of the field activities for the Tutu Service Station Investigation. Technical Memorandum II provided a discussion of the field activities and the hydrogeological data collected, an interpretation of groundwater flow conditions, the soil and groundwater quality data, the data validation report, and an identification of remaining data gaps (Geraghty & Miller, Inc. 1993a). All work performed by Geraghty & Miller prior to May 1993, including Technical Memoranda I and II, is now referred to as the first phase (Phase I) of the Tutu Wells Site Remedial Investigation (RI). During the summer and



fall of 1993, communications between the USEPA and representatives for the other Potentially Responsible Parties (PRPs) resulted in an increase in the active involvement of the participating PRPs from two to eight, and an agreement to enlarge the study area to incorporate the area south of the Esso Tutu Service Station. The Tutu PRP Committee currently consists of technical and legal representatives for Four Winds Plaza, Ramsay Motors, L'Henri, Inc., Laga Industries (Laga), Esso, Western Auto, USVI Department of Education, and Texaco. Eight other interested parties (non-participating PRPs) are not currently members of the Tutu PRP Committee, but have attended meetings with the USEPA.

A Phase II RI Work Plan was submitted to the USEPA in December 1993 (Geraghty & Miller, Inc. 1993b). The Phase II RI Work Plan provided a summary of individual source investigations conducted by PRPs at numerous properties throughout the Tutu area, identified data gaps for the expanded RI study area (referred to as the Tutu Wells Site), and defined a scope of work that would gather the data needed to define the nature and extent of impact to environmental quality at the Tutu Wells Site. The Phase II RI Work Plan was approved by the USEPA in a March 17, 1994 letter to Ms. Ana Gloria Ramos, former Designated Coordinator for the TEIC, from Ms. Carole Petersen, USEPA Chief for Region II Superfund New York/Caribbean Branch (USEPA 1994a). The Phase II RI field activities were conducted from March to July 1994 in accordance with the Phase II RI Work Plan.

1.1 PURPOSE

The Phase II RI field investigation was designed to supplement and incorporate the data generated during the Phase I RI and investigations conducted by representatives of the individual PRPs. The overall objectives of the Phase II RI were to identify and characterize the potential sources, the horizontal and vertical extent, the rate and direction of transport, and the potential migration pathways for petroleum hydrocarbon constituents and chlorinated volatile organic compounds (VOCs) in soil and groundwater at the Tutu Wells Site. The specific chlorinated VOCs of concern at the site are tetrachloroethene (commonly known as perchloroethylene [PCE]) and the related compounds, trichloroethene (TCE), 1,2-dichloroethene (1,2-DCE), and



vinyl chloride. These related compounds may exist as breakdown (daughter) products of PCE, or may have been released as undegraded products or as initial impurities in other commercial products.

The Phase II RI field investigation activities were divided into two categories: source identification and characterization, and site-wide hydrogeologic and groundwater quality investigation. These two categories included the following activities:

Source Identification and Characterization

- Site Inspections
- Site Inspection Report
- Soil-Gas Survey
- Soil-Gas Survey Report

Sitewide Hydrogeologic and Groundwater Quality Inspection

- Monitoring Well and Supply Well Surveying
- Supply Well Inspection
- Pumpage Impact Monitoring
- Monitoring Well Installation and Storm Sewer Investigation
- Water-Level Measurements
- Comprehensive Groundwater Sampling Event

This Draft Final Phase II RI Report provides the data collected during the Phase II RI field investigation, incorporates previously collected data, and presents an evaluation of site conditions. The comments provided by the USEPA (USEPA 1994b) on the Draft Phase II RI Report (Geraghty & Miller, Inc. 1994) were incorporated into this Draft Final Phase II RI Report.



1.2 SITE BACKGROUND

A description of the location and history of the Tutu Wells Site is presented in the following sections.

1.2.1 Site Location and Description

The Tutu Wells Site is located in the east-central portion of St. Thomas in the Turpentine Run drainage basin (Figure 1-1). The study area is surrounded by high hills to the west, north, and east (Figure 1-2). Various commercial establishments are located along the major roads in the area (Figure 1-3). The locations of the properties of interest and of other commercial establishments within the Tutu Wells Site are shown on Figure 1-4.

1.2.2 History of Known Public Concerns

In 1982, Geraghty & Miller was retained by the USVI Department of Conservation and Cultural Affairs (DCCA) to inventory the groundwater resources of St. Croix, St. Thomas, and St. John and prepare a groundwater management plan for the USVI. As part of this program, sampling activities were carried out in the Turpentine Run Basin. These activities included an aquifer pumping test of the Virgin Islands Housing Authority (VIHA) Well No. 1 (VIHA I). Geraghty & Miller collected a groundwater sample on May 20, 1982 from the VIHA I supply well, after 5 hours of pumping, for analysis of USEPA priority pollutant organic compounds. The sample was sent to the USEPA in Edison, New Jersey, where it was forwarded to Mead Compuchem Laboratories in Research Triangle Park, North Carolina (Geraghty & Miller, Inc. 1983).

Chlorinated VOCs were detected in the VIHA I groundwater sample. Those constituents included 1,2-DCE at a concentration of 12 micrograms per liter (ug/L) (equivalent to parts per billion [ppb]), PCE at 55 ug/L, and TCE at 10 ug/L (Geraghty & Miller, Inc. 1983). At that time, drinking water standards for these VOCs had not been established by the USEPA. In the



April 1983 report submitted to the DCCA, Geraghty & Miller recommended further investigation to identify the source of these chlorinated VOCs (Geraghty & Miller, Inc. 1983).

In July 1987, Mr. Eric Tillett, owner of Tillett Gardens, contacted the USVI Department of Planning and Natural Resources (DPNR) regarding an odor emanating from his well water. In July 1987, representatives of the USEPA and its Technical Assistance Team (TAT) collected groundwater samples from the Tillett well and five other commercial wells located in Turpentine Run. The analytical results from this July 1987 sampling event indicated that the Tillett well and the five other commercial wells sampled contained petroleum hydrocarbons and chlorinated VOCs. Based on these results, the DPNR declared that an imminent health threat existed that could affect 20,000 people living in St. Thomas, and an indefinite number of tourists who vacation there (USEPA 1991).

1.2.3 History of Response Actions

Based on groundwater sampling results, the DPNR closed 13 commercial and five private wells in the Tutu area between July and September 1987 (USEPA 1991). Many of these wells are currently in use for non-potable purposes. After the initial sampling of the six supply wells in July 1987, the USEPA's TAT sampling and screening analysis was expanded to include 24 supply wells beginning in August 1987. Analyses for benzene, toluene, PCE, TCE, and 1,2-DCE were performed using a Photovac portable field gas chromatograph (GC) for samples collected monthly during August through December 1987. Photovac analyses were also performed for samples collected in January, February, May, August, and November 1988 and February, May, and August 1989 (Weston/SPER 1989a).

The October 1987 groundwater samples were also analyzed for Hazardous Substance List (HSL) VOCs, base neutral and acid extractable compounds (BNAs), and metals by USEPA-contracted laboratories. Fourteen of the 24 supply wells sampled during this sampling event had elevated values of VOCs including trans-1,2-DCE, TCE, PCE, toluene, benzene, and tertiary-butyl methyl ether (MTBE). The October 1987 sampling event confirmed the August 1987



groundwater sampling results and also detected arsenic (15 ug/L), selenium (15 ug/L), and zinc (460 ug/L) in some of the wells sampled (Weston/SPER 1988a). The highest reported contaminant concentration for the October 1987 sampling event (excluding methylene chloride, which is a common laboratory contaminant) was 2,000 ug/L of PCE in the Harvey Supply Well sample (Weston/SPER 1988a).

Laboratory analysis for HSL VOCs, BNAs, metals, and cyanide were performed on 18 supply well samples collected in November 1988 (Weston/SPER 1989b). The USEPA also sampled and analyzed 123 cisterns that were filled with groundwater pumped from supply wells located in this area. Three of the cisterns contained total VOCs in excess of 1,000 ug/L (USEPA 1991).

In January 1988, the USEPA initiated a limited Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) removal action that included the decontamination and cleaning of five residential cisterns contaminated by hazardous substances, modification of plumbing, delivery of water by tank trucks as a temporary alternative water supply, and implementation of a well-water monitoring program (USEPA 1991).

On November 6, 1988, the USEPA sent Esso, O'Henry Dry Cleaners (O'Henry), and Texaco an information request letter under Section 104(e) of CERCLA and 3007 of RCRA regarding operations and waste containment and disposal at the Esso and Texaco Service Stations and the O'Henry facility. Based on the findings of this request, the USEPA issued a unilateral Administrative Order (AO) under CERCLA and RCRA on March 22, 1990 to Texaco, Esso, and O'Henry (USEPA 1990a). This AO required these parties to assume the USEPA's well-water monitoring program, to provide potable water to residents with contaminated well water, and to coordinate and design plans to connect those residents to the public water supply.

In June 1989, the USEPA-Region II sent Texaco and Esso a draft AOC requiring the implementation of an RI in the Tutu area. Texaco and Esso formed the TEIC in March 1990 and retained Geraghty & Miller to prepare a work plan for, and to implement, the Tutu Service



Station Investigation, which is now referred to as Phase I of the RI. A final AOC was entered into by the USEPA, Texaco, and Esso in February 1992 (USEPA 1992a).

In August 1991, the USEPA presented its Hazard Ranking System (HRS) document for the Tutu Wells Site (USEPA 1991). In this document, at least nine PRPs were identified as known or potential sources of groundwater contamination. These PRPs include, from north to south, the VIHA, the Curriculum Center (former Laga facility), Ramsay Motors, Antilles Auto Parts, Texaco Tutu Service Station, Tillett Gardens, Esso Tutu Service Station, O'Henry, and Rodriguez Auto Parts. Preliminary site assessments were conducted at these properties by USEPA subcontractors. The Western Auto facility, which was investigated during Phase II activities by Geraghty & Miller and others, was not included in the HRS or preliminary site assessments.

1.3 PHASE II RI SCOPE OF WORK

The Phase II RI was conducted by Geraghty & Miller from February through July 1994 in accordance with the Phase II RI Work Plan. In addition, from October 1993 to July 1994, other investigations were carried out by other consultants for Laga, Ramsay Motors, Texaco, Four Winds Plaza, Western Auto, Esso, and L'Henri. This work was performed to supplement previous work conducted, as described in Section 2.1 (Individual Site Reconnaissance and Sampling).

1.3.1 Scope of Work Performed by Geraghty & Miller, Inc.

The following tasks were performed during the Phase II RI field effort for source identification and characterization:

- Task 1: Site Inspections
- Task 2: Site Inspection Report
- Task 3: Soil-Gas Survey



- Task 4: Soil-Gas Survey Report

The following tasks were performed during the sitewide hydrogeologic and groundwater quality investigation:

- Task 5: Monitoring Well and Supply Well Surveying
- Task 6: Supply Well Inspection
- Task 7: Pumpage Impact Monitoring
- Task 8: Monitoring Well Installation and Storm Sewer Investigation
- Task 9: Water-Level Measurements
- Task 10: Comprehensive Groundwater Sampling Event

1.3.1.1 Source Identification and Characterization

Geraghty & Miller conducted source investigations that included site inspections, a site inspection report, a soil-gas survey, and a soil-gas survey report. The site inspections were initially proposed at nine properties:

- Faith Christian Fellowship Church (former Storage Facilities, Inc. and former West Indies Enterprises, Inc.)
- The VIHA (former Tropical Motors)
- The Curriculum Center (former Laga Building)
- Tracy Dodd Property
- Antilles Auto Parts (former Gassett Auto Parts and former Consolidated Auto Parts)
- USVI Department of Human Services (former Classic Printers)
- Archie's Welding & Auto Body Repair
- Overseas Steel Fabrication
- Gorrachetaguaj & Vigoreaux (previously referred to as the Unknown Property southeast of the USVI Department of Human Services)



Formal site inspections were conducted at the first four properties listed above. Based on discussions with Mr. Tracy Dodd, Geraghty & Miller determined that the Overseas Steel Fabrication property was located on Mr. Dodd's property. At the four remaining properties, site inspections were not conducted either because difficulties were encountered in obtaining site access, or because Geraghty & Miller determined that sufficient information was already known regarding the properties' potential to act as a source for impact to the environment. The purpose of the site inspections was to observe each property for evidence of potential sources of petroleum hydrocarbons and chlorinated VOCs. Potential sources such as aboveground storage tanks (ASTs), underground storage tanks (USTs), manholes, vents, septic systems, dry wells, oil/water separators, drum storage areas, and oil pits/sumps were identified. Areas indicative of waste disposal or releases at each property, such as stained soils and stressed vegetation, were also noted, if present. The site inspection report is included as Appendix A.

The soil-gas survey was conducted at the VIHA and the Curriculum Center (former Laga facility) to identify possible sources of VOCs at these sites. Locations for the soil-gas survey were selected based on potential or suspected sources observed during site inspections or reported by other investigators. The soil-gas survey report was submitted to the USEPA on March 22, 1994 and is included in this report as Appendix B.

1.3.1.2 Sitewide Hydrogeologic and Groundwater Quality Investigation

During the Phase II RI, Geraghty & Miller conducted a comprehensive hydrogeologic and groundwater quality investigation of the Tutu area. This investigation included monitoring well and supply well surveying, a supply well inspection, pumpage impact monitoring, monitoring well installation, a storm sewer investigation, water-level measurements, and comprehensive groundwater sampling. During the field effort, modifications were made to the scope of the field investigation due to site conditions and to difficulties in obtaining access to privately owned properties and permits from governmental agencies. The deviations to the Phase II RI Work Plan (Geraghty & Miller, Inc. 1993b) are described below. The USEPA was notified of all



deviations and agreed to the changes. These modifications did not result in any significant data gaps.

Difficulties were encountered during the drilling of Monitoring Well MW-24, which is located at the former UST area located behind Western Auto. The originally proposed location was too close to the northern wall of Western Auto to allow adequate clearance for the drilling rig; therefore, Monitoring Well MW-24 was relocated 1.5 feet to the north. At a depth of 2 feet below land surface (bls), a 4-inch diameter, non-pressurized, polyvinyl chloride (PVC) pipe was struck and subsequently ruptured. The purpose of this pipe is unknown. Representatives of Four Winds Plaza indicated that the pipe apparently led from an underground spring north of Western Auto to a cistern in the southern part of the Four Winds property (ENSR 1994a). On approval from representatives of Western Auto and Four Winds Plaza, a local excavator (De Vira, Inc.) was contracted by Geraghty & Miller to excavate and repair the PVC pipe. De Vira was provided with specifications to excavate a pit to repair the PVC pipe, backfill the excavation pit, and place a concrete pad over the excavated location. Monitoring Well MW-24 was relocated a second time and was successfully installed 10.5 feet north of the originally proposed location.

Geraghty & Miller encountered difficulty in contacting property owners and obtaining site access at several properties for supply well inspection, sampling, and/or conducting the pumpage impact monitoring. The schedule for Tasks 1 through 10 (specified in Section 7.0 of the Phase II RI Work Plan [Geraghty & Miller, Inc. 1993b]) was modified in consultation with the USEPA to compensate for these delays. Geraghty & Miller was ultimately granted access from the necessary property owners to conduct the field investigation.

Eight supply wells and two monitoring wells were not sampled during the Phase II RI. Sampling of the Four Winds I and Four Winds II Supply Wells was postponed because the maintenance manager was hospitalized and could not arrange access. The VIHA I, Eglin II, Rodriguez, and Harthman-Wilfred Supply Wells were inaccessible because the well pumps were inoperable. The Ottley Supply Well is inactive and the current property owner does not know



the location of this former well. The Harthman-Crusher Supply Well was destroyed during construction of the Tutu Park Shopping Mall. Monitoring Well MW-14 was apparently paved over and was not found. Monitoring Well CHT-5 could not be located during the sampling event. A representative from Caribbean Hydro-Tech, Inc. (CHT) subsequently located CHT-5 in August 1994.

Pumpage impact testing was planned during Phase II for the Four Winds and Eglin Supply Wells. The Four Winds Plaza representatives did not want to pump groundwater to the large cistern beneath the shopping plaza because the Four Winds treatment system has not received a permit for operation. Although other options for treatment of groundwater were considered, there was no viable alternative to allow for continuous pumpage at a constant flow rate that would give adequate test results. The USEPA consented to eliminate the test at the Four Winds supply wells. Because the Eglin II Supply Well pump was inoperable, the Eglin III Supply Well was used for the pumpage impact monitoring.

1.3.2 Scope of Work Performed by Other Consultants

From October 1993 to July 1994, representatives of Laga, Ramsay Motors, Texaco, Four Winds Plaza, Western Auto, Esso, and L'Henri retained consultants to conduct investigations at their properties to identify potential sources, characterize the nature and extent of soil and groundwater contamination, and evaluate potential remedial requirements. In addition, on December 7, 1994, Weston Major Programs Division (Weston) conducted sampling on behalf of USEPA at the Curriculum Center and O'Henry Dry Cleaners (Weston 1994). These source investigations are summarized briefly in this section; the results are incorporated into Section 5.0 (Nature and Extent of Contamination) of this report.

Laga representatives retained Arthur D. Little, Inc. (ADL) to conduct a field reconnaissance to evaluate potential impact from drums, soil, sewer water, storm water, and groundwater. The investigation was conducted in 1993 and 1994 at the Curriculum Center and other locations at the Tutu Wells Site (Arthur D. Little, Inc. 1994).



Cooper Environmental, Inc. (CEI) was retained by representatives of Ramsay Motors to conduct several investigations. From April 14 to 19, 1993, CEI sampled the soil at ten shallow soil borings near the Ramsay UST area. From July 1 to 5, 1993, CEI sampled 12 shallow soil borings near the drum pad and south fence areas (near Antilles Auto Parts) and collected four composite samples from storage drums. Samples were analyzed by Enseco Corporation of Somerset, New Jersey for VOCs, total petroleum hydrocarbons (TPH), and BNAs (Cooper Environmental, Inc. 1993). From March 28 to 29, 1994, CEI collected split samples at the soil boring locations for Monitoring Wells MW-15 and MW-17, which were installed at the Ramsay Motors property by Geraghty & Miller during the Phase II RI field investigation.

Texaco retained Geoscience Consultants, Ltd. (GCL) to conduct a soil and groundwater investigation at the Texaco Tutu Service Station. The investigation, conducted in December 1993, involved drilling soil borings adjacent to waste management units; submitting soil samples for laboratory analysis; evacuating, sampling, and disposing of fluid from the oil/water separator and septic tank; visually inspecting all waste units for structural integrity; and installing and sampling five shallow and two deep groundwater monitoring wells (Geoscience Consultants, Ltd. 1994a). These seven monitoring wells were surveyed as part of the Phase II RI. GCL also split aqueous and non-aqueous samples at the Four Winds Plaza property during CHT's storm sewer investigation (Geoscience Consultants, Ltd. 1994b).

Four Winds retained CHT and Hydrologic Associates U.S.A. (Hydrologic Associates) to conduct soil and groundwater investigations at Four Winds Plaza. These investigations included removal and closure of a UST located in the rear of Four Winds Plaza in October 1993 (Caribbean Hydro-Tech, Inc. 1994a). In addition, in December 1993, CHT performed an investigation of the storm sewer at Four Winds Plaza property that included excavating beneath the storm drain and sampling both aqueous and non-aqueous media (Caribbean Hydro-Tech, Inc. 1994b). During this time, CHT collected an aqueous sample from a concrete vault located at the southeast corner of the Cost-U-Less food store and performed a dye test at this vault to determine where it discharged. Also in December 1993, CHT coordinated the investigation of



two anomalies identified during Blasland, Bouck & Lee, Inc.'s (BB&L) ground-penetrating radar (GPR) and magnetometer surveys.

Western Auto retained ENSR Consulting and Engineering, Inc. (ENSR) to coordinate the removal and closure of two USTs located near the rear service bays of Western Auto. In October 1993, ENSR sampled the contents of the USTs, screened excavated soils, segregated contaminated soils, and conducted confirmatory sampling of the excavation (ENSR 1994a). Samples from the tank excavations and USTs were split with BB&L. In addition, a preliminary investigation was performed on the leaking pipes unearthed during excavation and soil-gas surveys were performed by W.L. Gore, Associates (referred to as a Gore-Sorber study) in December 1993 and July 1994 (ENSR 1994b and 1994c). ENSR also split soil samples with Geraghty & Miller from the boreholes and split groundwater samples from Geraghty & Miller's Phase II RI Monitoring Wells MW-24 and MW-25. Also in December 1993, ENSR split aqueous samples at the Four Winds Plaza property during CHT's storm sewer investigation (ENSR 1994b).

BB&L (and subsequently Forensic Environmental Services, Inc. [FES]) was retained by Esso to conduct a site investigation at the Esso Tutu Service Station. In January 1993, BB&L performed a GPR survey, a magnetometer survey, and non-intrusive subsurface pipe tracing, and also drilled shallow soil borings. From November 1993 through April 1994, BB&L conducted a second phase of investigative work at, and proximal to, the Esso Tutu Service Station. Activities completed during this phase included the sampling of four soil borings, installation of nine monitoring wells, excavation of subsurface piping systems, trenching and test pit excavation, soil sampling, and collection of groundwater quality and aquifer hydraulic data. In December 1993, BB&L also performed an inspection of the storm sewer system proximal to the Esso Tutu Service Station and Four Winds Plaza.

Representatives of L'Henri retained IT Corporation (IT) to conduct investigations at the O'Henry Dry Cleaners. Investigations included slug testing, groundwater sampling, and water-level measurements in existing O'Henry monitoring wells (designated OHMW). Additionally,



IT surveyed the top of the inner casing of O'Henry Monitoring Wells OHMW-1 through OHMW-4 relative to an arbitrary datum, and plotted previously installed O'Henry monitoring wells on a base map (IT Corporation 1993).

1.4 REPORT ORGANIZATION

This Phase II RI Report is organized as follows:

- Section 2.0: Previous Investigations. This section summarizes the work performed by Geraghty & Miller and other investigators prior to Phase II of the RI (prior to May 1993).
- Section 3.0: Investigative Methodology. This section discusses the methodologies employed during the implementation of the Phase I and II RI field tasks and related activities.
- Section 4.0: Physical Characteristics of the Study Area. This section provides a general overview of topography, drainage, demography, land use, meteorology, soils, vegetation, geology, and hydrogeology in the Tutu area.
- Section 5.0: Nature and Extent of Contamination. This section provides an evaluation of confirmed sources of contamination in the Tutu Wells Site; the data compiled relative to groundwater, soil, surface water, sediment, and air quality; and a detailed discussion of the nature and extent of contamination.
- Chapter 6.0: Contaminant Fate and Transport. This section examines contaminant characteristics and behavior, evaluates contaminant migration, and presents a conceptual site model describing potential routes of contaminant transport and potential routes of exposure.



- **Chapter 7.0: Baseline Risk Assessment.** This section provides a brief summary of the Baseline Risk Assessment prepared by Camp, Dresser & McKee Federal Programs Corporation on behalf of USEPA (CDM Federal Programs Corporation 1995).
- **Chapter 8.0: Summary and Conclusions.** This section summarizes the current understanding of site hydrogeology; the sources, nature, and extent of contamination; contaminant fate and transport; and the potential risks to human health and the environment.



2.0 PREVIOUS INVESTIGATIONS

This section provides a summary of previous site reconnaissance and sampling activities conducted prior to May 1993. This date was selected because it includes all work conducted prior to the Phase II RI efforts. The previous work performed includes reconnaissance and sampling activities by the USEPA and its consultants, site-specific investigations by the PRPs, site-wide supply well sampling conducted by the USEPA and TEIC, and the Phase I RI conducted by Geraghty & Miller. Summary tables providing analytical results from these previous investigations are presented in Appendix C. The analytical results are discussed in Section 5.0 (Nature and Extent of Contamination).

2.1 INDIVIDUAL SITE RECONNAISSANCE AND SAMPLING

The USEPA and its consultants conducted several reconnaissance and sampling activities from August 1987 to June 1989. During this period, Texaco and Esso removed USTs and completed subsurface sampling programs at their respective service stations. Owners of other facilities that had been identified in the HRS Report as potential sources also carried out site-specific investigations prior to and during the Tutu Service Station Investigation (Phase I RI).

Activities carried out by the USEPA, its consultants, and the PRPs included sampling of surface soils, surface water, groundwater, waste oil, and drums. The properties investigated included the following:

- The VIHA (former Tropical Motors)
- The Curriculum Center (former Laga Building)
- Ramsay Motors
- Antilles Auto Parts (formerly Gassett Auto Parts)
- Texaco Tutu Service Station
- Tillett Gardens
- Four Winds Shopping Plaza
- Western Auto



- Esso Tutu Service Station
- O'Henry Dry Cleaners

Waste oil sampling was conducted at Ramsay Motors, the Texaco Tutu Service Station, the Esso Tutu Service Station, and the VIHA in August 1987 by USEPA-Region II TAT Weston/SPER Division. A surface-water sample was also collected from the gutter/storm drain at Antilles Auto Parts (formerly Gassett Auto Parts) during the August 1987 sampling. In October 1987, Weston/SPER Division collected groundwater samples from 24 supply wells in the Tutu area for laboratory analyses (USEPA 1991).

In September 1988, a sampling event was performed by CDM, consultants to USEPA-Region II. Soil samples were collected from Ramsay Motors, the Texaco Tutu Service Station, Tillett Gardens, O'Henry, and Antilles Auto Parts. Aqueous samples were collected from drum storage areas, tanks, and/or excavation pits at Ramsay Motors, the Texaco Tutu Service Station, and Antilles Auto Parts. Waste oil samples were collected at the Texaco Tutu Service Station and the Esso Tutu Service Station (USEPA 1991).

In June and July 1989, CDM collected oil samples from various locations at Ramsay Motors, Antilles Auto Parts (formerly Gassett Auto Parts), the Texaco Tutu Service Station, and the Esso Tutu Service Station. Soil samples were collected at the Curriculum Center, Ramsay Motors, the Texaco Tutu Service Station, the Esso Tutu Service Station, and O'Henry. One sample was collected from an open drum in an area behind the Curriculum Center (USEPA 1991).

In 1989, preliminary site assessments were performed by NUS Corporation (NUS), consultants to USEPA-Region II, at the Curriculum Center, Antilles Auto Parts (formerly Gassett Auto Parts), Ramsay Motors, the Texaco Tutu Service Station, and the Esso Tutu Service Station (USEPA 1991).



At some of the sites investigated by the USEPA and its consultants, the property owners implemented their own investigative activities. Details of the investigations conducted at each facility by the USEPA, its contractors, and consultants for the property owners are provided below. The results are incorporated into the discussion of soil and groundwater quality in Section 5.0 (Nature and Extent of Contamination).

2.1.1 Previous Investigations at the VIHA

On August 17, 1987, a waste oil sample was collected by Weston/SPER Division personnel from a UST at the VIHA. The waste oil sample was analyzed for VOCs by S-Cubed Laboratories, but, according to the summary of laboratory results, the holding time was exceeded (Weston/SPER 1988b).

2.1.2 Previous Investigations at the Curriculum Center (Former Laga Building)

Previous investigations conducted at the Curriculum Center (former Laga Building) consisted of a preliminary site assessment, the sampling of surface soils, and sampling of an open drum located in an area behind the Curriculum Center. The site assessment was performed by NUS Corporation on February 15, 1989, and included site reconnaissance, a compilation of information related to site operations and waste sources, and a hazard assessment (NUS Corporation 1989a). In June 1989, CDM collected two surface soil samples from a drum storage area behind the Curriculum Center and one aqueous sample from a drum at this location (CDM 1988a).

2.1.3 Previous Investigations at Ramsay Motors

Previous investigations at Ramsay Motors by various consultants in 1987, 1988, and 1989 included sampling of waste oil and surface soil, and conducting a preliminary site assessment. On August 17, 1987, one waste oil sample was collected by Weston/SPER Division from a waste oil UST located under the workshop area at Ramsay Motors. This waste oil sample was



analyzed for VOCs by S-Cubed Laboratories. According to a summary of laboratory results, the holding time was exceeded (Weston/SPER 1988b).

On September 12, 1988, CDM collected two surface soil samples from the south end of the Ramsay Motors property and one water sample from a 500-gallon aboveground holding tank that reportedly stored water pumped from an on-site well located behind the mechanical garage (CDM 1988a). The samples were analyzed for VOCs and BNAs (CDM 1989a).

On February 15, 1989, a preliminary site assessment of the Ramsay Motors property was performed by NUS. This preliminary site assessment consisted of site reconnaissance; a compilation of information related to site operations, waste sources, and waste handling; and a hazard assessment (NUS Corporation 1989b).

On June 8, 1989, CDM collected one waste oil sample from the waste oil UST (CDM 1990a) and one soil sample from an area adjacent to the Antilles (formerly Gassett) fence on the Ramsay property (CDM 1988a, 1990a). The waste oil sample was analyzed for VOCs by Versar, Inc. The soil sample was analyzed for VOCs, BNAs, pesticides, polychlorinated biphenyls (PCBs), and metals (CDM 1990a). According to a February 2, 1990 letter from CDM to the USEPA, the holding time for VOC analysis was exceeded for the waste oil sample (CDM 1990a).

2.1.4 Previous Investigations at Antilles Auto Parts (formerly Gassett Auto Parts)

On August 17, 1987, one water sample each was collected from a gutter and a storm drain at Antilles Auto Parts by Weston/SPER Division. These water samples were analyzed for VOCs by S-Cubed Laboratories. According to the summary of laboratory results, the holding time for VOC analysis was exceeded (Weston/SPER 1988b).

On September 12, 1988, two soil samples and one water sample were collected at Antilles Auto Parts by CDM. The soil samples were collected behind the open bay garage and at a drum



area adjacent to the open bay garage. The water sample was collected from standing water near the drum storage area (CDM 1988a). All samples were analyzed for VOCs (CDM 1989a).

On June 8, 1989, a sample of oily water was collected by CDM from a drain system leading to Ramsay Motors from Antilles Auto Parts. This sample was analyzed for VOCs by Versar, Inc. (CDM 1988a, 1990a).

On February 15, 1989, a preliminary site assessment was performed at Antilles Auto Parts by NUS. The site assessment consisted of site reconnaissance and a compilation of information related to site operations, waste sources, and waste handling (NUS Corporation 1989c, 1989d).

2.1.5 Previous Investigations at the Texaco Tutu Service Station

Previous investigations at the Texaco Tutu Service Station were performed by several consultants and included sampling and analysis of soil, water, and waste oil; a soil-gas survey; and a preliminary site assessment. Two waste oil samples and four water samples were collected at the Texaco Tutu Service Station on August 17, 1987 by Weston/SPER Division. The waste oil samples were collected from the oil/water separator and the waste oil storage tank. Three water samples were collected from the bay sumps and one was collected from the storm drain system. These samples were analyzed for VOCs by S-Cubed Laboratories. According to a summary of laboratory results, the holding time for VOC analyses of these samples was exceeded (Weston/SPER 1988b).

In 1987, GCL conducted a soil-gas survey at the Texaco Tutu Service Station with a field GC. The study area included both the Texaco Tutu and Esso Tutu Service Stations, and extended as far north as the Curriculum Center. Soil vapors were screened for aromatic hydrocarbons (benzene, toluene, ethylbenzene, and xylenes [BTEX]) and chlorinated VOCs.



On September 14 and 15, 1988, one soil sample, one water sample, and one waste oil sample were collected at the Texaco Tutu Service Station by CDM (CDM 1988a). The soil sample was collected from an area north of the first bay lift, between the concrete pad and the fence at the Texaco Tutu Service Station. The water sample was collected from the cistern located behind the station building. The waste oil sample was collected from the oil/water separator. The samples were analyzed for VOCs by Cenref Laboratories (CDM 1989a, 1989b).

On behalf of Texaco, Lebron & Associates submitted a work plan for UST removal on May 20, 1988. The work plan was approved by the USEPA on June 29, 1988 (USEPA 1988a) contingent on the submittal of a Quality Assurance/Quality Control (QA/QC) Plan. The Final Supplement to the Revised Action Plan is dated August 31, 1988.

The USTs were removed from September 7 to 16, 1988. During the UST excavation at the Texaco Tutu Service Station, CDM collected 11 split soil samples with Lebron Associates. These samples were collected from test holes drilled in the concrete pad south-southwest of the UST excavation, from the excavation pit, and from soil piles generated during the excavation of the USTs. One sample was collected of the rain water that accumulated in the excavation pit following a storm event that had occurred between September 8 and 9, 1988. These soil and water samples were analyzed for VOCs (CDM 1989b).

On February 15, 1989, NUS performed a preliminary site assessment of the Texaco Tutu Service Station. This preliminary site assessment consisted of site reconnaissance, a hazard assessment, and compilation of information related to site operations, waste sources, and waste handling (NUS Corporation 1989e).

In June 1989, after soil ventilation procedures had been implemented, CDM collected split soil samples from the excavated soil piles with Lebron Associates (CDM 1990b). In July 1989, CDM collected seven waste oil samples from the oil/water separator, the middle bay collection pit, and five waste oil drums.



2.1.6 Previous Investigations at Four Winds Plaza

In March 1992, CHT, a consultant to Four Winds, installed four monitoring wells at the Four Winds Plaza (Hydrologic Associates, U.S.A. Inc. 1993a). Composite soil samples were collected at discrete depth intervals in the borings for the monitoring wells. These soil samples were analyzed for VOCs and total oil and grease (TOG). One additional soil sample was collected and analyzed for TOG. Two deep monitoring wells were installed by CHT in May 1992.

From January 7 to 13, 1992, Target Environmental Services, Inc. (Target) conducted a soil-gas survey on behalf of the Four Winds Plaza Partnership. The survey encompassed an area including the Four Winds Plaza, Western Auto, Mike's Paint Store, the animal hospital, the Virgin Islands Telephone Company (Vitelco), the Esso Tutu Service Station, the Harthman property, the Lutheran Church, and the Rodriguez Esso Service Station. Soil-gas samples were analyzed for VOCs (Target Environmental Services, Inc. 1992a). Target conducted a second survey in September 1992. This work focused on the rear of the Four Winds Plaza in the vicinity of the USTs located behind Western Auto (Target Environmental Services, Inc. 1992b).

In December 1992, CHT conducted investigations west of Western Auto near three USTs (Four Winds Plaza Partnership 1993). Two USTs were located behind the Western Auto service bays. The investigation at these USTs is discussed in Section 2.1.7 (Previous Investigations at Western Auto). The third UST (known as the Ramp Tank) was located adjacent to the ramp behind the Four Winds Plaza. The Ramp Tank was not owned or operated by Western Auto; this UST was apparently installed prior to purchase of the property by the Four Winds Plaza Partnership. The Ramp Tank had been filled with sand. A sample of the sand contents in the Ramp Tank was collected by CHT and analyzed for VOCs and polyaromatic hydrocarbons (PAHs).



In December 1992, Hydrologic Associates and CHT conducted an aquifer test involving Supply Wells Four Winds I, II, and III and Monitoring Well CHT-1, located at Four Winds Plaza.

2.1.7 Previous Investigations at Western Auto

Target conducted a soil-gas survey at the UST area located behind Western Auto on September 3, 1992. Soil-gas samples were analyzed for VOCs (Target Environmental Services, Inc. 1992b).

On November 25, 1992, CHT advanced two borings near the abandoned waste oil tank located behind Western Auto (Four Winds Plaza Partnership 1993). One sample of the sand contents of the waste oil tank was collected and analyzed for VOCs, PAHs, TPH, and TOG. A soil sample and a sample of water from the borings were collected and analyzed for purgeable VOCs, TPH, and TOG.

On December 2, 1992, CHT advanced three borings near the former diesel UST located behind Western Auto. A sample of the liquid in the UST was collected on December 8, 1992. The sample was analyzed for purgeable VOCs, PAHs, TPH, and TOG. The UST contents were resampled in March 1993 by CHT (Four Winds Plaza Partnership 1993), and in May 1993 by ENSR (1993) and BB&L (Blasland, Bouck & Lee, Inc. 1993a). On December 8, 1992, a soil sample and a water sample were collected adjacent to the former diesel UST. Both samples were analyzed for VOCs, PAHs, TPHs, and oil and grease by Savannah Laboratories.

2.1.8 Previous Investigations at Tillett Gardens

On September 13, 1988, CDM collected two soil samples from Tillett Gardens. One soil sample was collected between a concrete drainway and a gravel pit, and the other sample was collected at the end of a drainpipe. These samples were analyzed for VOCs (CDM 1989a).



2.1.9 Previous Investigations at the Esso Tutu Service Station

Previous investigations at the Esso Tutu Service Station included sampling and analysis of waste oil, soil, and water; a soil vapor screening survey; a preliminary site assessment, and UST replacement. Waste oil samples were collected from the oil/water separator on August 17, 1987 by Weston/SPER Division. These samples were analyzed for VOCs by S-Cubed Laboratories. According to a summary of laboratory results, the holding time for the VOC analyses was exceeded (Weston/SPER 1988b).

In April 1988, a soil-vapor screening survey was conducted by Belgodere and Associates, consultants to Esso, at 11 points on the Esso Tutu Service Station property and 33 points located outside the facility, primarily in the Four Winds Plaza parking lot. These soil-gas samples were analyzed by field GC for BTEX and chlorinated VOCs (Belgodere and Associates 1988).

Two waste oil samples were collected at the Esso Tutu Service Station on September 12, 1988 by CDM. One sample was collected from a holding tank beneath the floor of the service station center and the other was collected from the oil/water separator (CDM 1988a). These samples were analyzed for VOCs by Cenref Laboratories (CDM 1989a).

In February 1989, NUS performed a preliminary site assessment of the Esso Tutu Service Station. This site assessment included site reconnaissance, a hazard assessment, and a compilation of information concerning site operations, waste sources, and waste handling (NUS Corporation 1989f).

On June 8, 1989, CDM collected two waste oil samples from the UST below the tire service area and from the oil/water separator. These samples were analyzed for VOCs by Versar, Inc. (CDM 1990a, 1990c).

During UST replacement in June 1989, Soil Tech, consultants to Esso, collected soil samples from the excavation pit and excavated soil piles. These soil samples were analyzed for



VOCs, BNAs, TPH, and metals. In addition, one water sample was collected from a 55-gallon drum that contained residues from the USTs, and one sample was collected of the decontamination water. These samples were analyzed for VOCs, BNAs, TPH, and ignitability (Soil Tech 1990). CDM collected split soil samples at the excavation and soil piles. These samples were analyzed for VOCs, BNAs, pesticides, PCBs, TPH, and metals. CDM also collected grab samples for VOC analysis and composite samples for analysis of BNAs, TPH, and metals (CDM 1990b). In December 1989, Soil Tech drilled eight additional soil borings at various locations throughout the Esso Tutu Service Station and analyzed 24 soil samples for VOCs.

Between February and December 1992, CHT sampled various wells throughout the Tutu Wells Site. In February 1992, Subsurface Detection Investigations, Inc. (SDII), conducted a GPR survey at the Esso Tutu Service Station (SDII 1992). BB&L also conducted a GPR survey and a pipe-tracing survey at the Esso Tutu Service Station in January 1993. The report on BB&L's GPR and pipe-tracing surveys was issued in April 1993 (Blasland, Bouck & Lee, Inc. 1993a).

2.1.10 Previous Investigations at O'Henry Dry Cleaners

In September 1988, CDM collected a soil sample from an area near a fuel tank at O'Henry (CDM 1988a). This sample was analyzed for VOCs (CDM 1989a). CDM collected three additional soil samples on June 5, 1989 from an area where filters from the dry cleaning process had reportedly been discarded. These samples were analyzed for VOCs, BNAs, pesticides, PCBs, TPH, and metals (CDM 1990b).

In October 1989, a preliminary site assessment of O'Henry was performed by Pedro Panzardi and Associates, consultants to L'Henri. The site assessment consisted of site reconnaissance, soil sampling, and compilation of information related to site operations, waste sources, and waste handling. The soil samples were analyzed for PCE by Environmental Quality Laboratories (EQ Lab) (Pedro Panzardi & Associates 1989).



In February 1990, GeoCaribe, Inc. was retained by representatives of L'Henri to conduct a sitewide reconnaissance (GeoCaribe, Inc. and Pedro Panzardi & Associates 1990). From June through September 1990, Geo-Cim, Inc. installed four monitoring wells at the O'Henry Dry Cleaners.

2.2 USEPA SUPPLY WELL SAMPLING

Sitewide investigations by USEPA subcontractors have included sampling of 24 supply wells in the Tutu area from July 1987 through August 1989. The first comprehensive sampling and analyses of these 24 supply wells were performed by Weston/SPER Division on October 6 and 7, 1987. These sampling activities have been discussed in Section 1.2.3 (History of Response Actions).

2.3 TEIC SUPPLY WELL SAMPLING PROGRAM

Geraghty & Miller, on behalf of the TEIC, conducted eight rounds of supply well sampling from September 1990 through April 1993. These data were summarized in the Eighth Sampling Report (Geraghty & Miller, Inc. 1993c) and are discussed in Section 5.2 (Groundwater Quality) where relevant. This work was conducted in accordance with the AO, and followed the protocols provided in the Sampling, Analysis, and Monitoring Plan (SAMP) (Geraghty & Miller, Inc. 1990) and the subsequent revised SAMP (Geraghty & Miller, Inc. 1991). Selected wells within the Tutu Wells Site were sampled for analysis of Target Compound List (TCL) VOCs and BNAs, Target Analyte List (TAL) metals, and cyanide. The results of the supply well sampling were presented in a report documenting each event (Geraghty & Miller, Inc. 1993c). The data from the eight sampling events showed consistent analytical results, and in 1993, Geraghty & Miller recommended that the sampling be considered complete because groundwater quality in supply wells in the Tutu area had been characterized.



2.4 PHASE I RI

The scope of work outlined in the Tutu Service Station Investigation Work Plan for the Phase I RI (Geraghty & Miller, Inc. 1992a) included the installation and sampling of ten shallow monitoring wells, seven deep monitoring wells, and 12 soil borings; a fracture trace analysis; and pumping tests at newly installed monitoring wells. Prior to completion of the field investigation, this scope of work was expanded to address the USEPA's concern regarding potential sources of PCE and related compounds (TCE, 1,2-DCE, and vinyl chloride). The expanded scope of work included two additional shallow monitoring wells, five additional soil borings, and eight surface soil samples. These additions to the scope of work were discussed by the USEPA and the TEIC and approved by the USEPA prior to implementation. Details of this investigation were provided in Technical Memorandum II (Geraghty & Miller, Inc. 1993a).

Following submission of Technical Memorandum II and meetings with the USEPA and the DPNR in April 1993, Geraghty & Miller proposed the installation of four additional monitoring wells, two piezometers, and three shallow soil borings, and the implementation of a GPR survey at the UST area located behind Western Auto. The proposed work was designed to address data gaps in understanding site-wide hydrogeology, groundwater quality, contaminant fate and transport, and potential sources of contamination. This proposed work was not implemented during the summer of 1993 because soil and groundwater investigations were being implemented by other consultants for the PRPs and additional site information was being generated. During August and September 1993, the USEPA requested additional information from the other PRPs and held meetings with the other PRPs to encourage formation of a larger PRP committee. The subsequent formation of the Tutu PRP Committee allowed for compilation of investigative results from the PRP consultants, and resulted in the expansion of the RI study area and the preparation of the Phase II RI Work Plan.



3.0 INVESTIGATIVE METHODOLOGY

The following sections present the investigative methods used during both Phase I and Phase II of the RI. These methods were previously described in the Phase I and Phase II Work Plans (Geraghty & Miller, Inc. 1992a, 1992d, and 1993b).

3.1 BASE MAP PREPARATION AND SURVEYING

Because the study area is large (approximately 3.4 square miles), it was necessary to compile base maps from several sources. These sources included aerial photographs, construction and as-built drawings from various properties, existing U.S. Geologic Survey (USGS) topographic maps, and surveying of new and existing structures. As-built drawings of the recently constructed Tutu Park Mall were used to locate the newly constructed buildings and parking lots. The base map showing all monitoring wells and TEIC borings is presented on Figure 1-3. The locations of the properties of interest are shown on Figure 1-4.

During Phases I and II of the RI, newly installed and existing monitoring wells and supply wells were surveyed to a common horizontal and vertical datum by R. Lopez De Azua and Associates of Puerto Rico (R. Lopez De Azua and Associates 1992). During Phase II, the surveying was performed during two distinct events. The first surveying event was conducted in February and March 1994 and included Monitoring Wells TT-1 through TT-6 (installed by GCL) located at the Texaco Tutu Service Station and Monitoring Wells SW-1 through SW-7 and DW-1 and DW-2 (installed by BB&L) located at the Esso Tutu Service Station. The second surveying event was conducted in May 1994 and included sitewide Monitoring Wells MW-13 through MW-25 (newly installed by Geraghty & Miller), Monitoring Wells OHMW-1 through OHMW-4 (installed by Geo-Cim, Inc.) at O'Henry Dry Cleaners, Monitoring Wells CHT-1 through CHT-4 and CHT-6D and CHT-7D (installed by CHT) at Four Winds Plaza, and several supply wells.



Numerous small-scale maps were compiled for the various properties where soil sampling was conducted. These maps were derived from the study area base map and contain detailed features plotted from field measurements or from detailed engineering or architectural drawings for individual facilities.

3.2 CONTAMINANT SOURCE INVESTIGATIONS

Contaminant source investigations have been conducted at various properties at the Tutu Wells Site. Preliminary investigations and site assessments were conducted by various parties, particularly the USEPA and its consultants, between 1987 and 1989. These investigations were summarized in Section 2.0 (Previous Investigations). Geraghty & Miller's contaminant source investigations include all work performed prior to and during this Phase II RI. Prior to and during Geraghty & Miller's Phase II work, other consultants conducted independent contaminant source investigations (described in Section 1.3.2 [Scope of Work Performed by Other Consultants]). The results of the various source investigations are discussed in Section 5.0 (Nature and Extent of Contamination).

3.3 METEOROLOGICAL INVESTIGATIONS

Climatological data were compiled from previous reports and from data supplied by the National Climatic Data Center (NCDC) in Asheville, North Carolina, to develop a general characterization of the weather and hydrology of the Tutu Wells Site.

Meteorological data were compiled for the time periods of the pumping tests conducted in November 1992 and May 1994. The National Weather Service maintains a weather station near the Tutu Wells Site at Mt. Zion. Additional information, including barometric pressure during pumping tests, was obtained from the Cyril E. King Airport (formerly Truman Airport) on St. Thomas.



3.4 SURFACE-WATER AND SEDIMENT INVESTIGATION

The 100-year floodplain of the Upper Turpentine Run Basin was determined using Federal Emergency Management Agency (FEMA) maps. The Upper Turpentine Run, which drains the Tutu Wells Site from north to south, has been channelized in a storm sewer as part of the development of the valley. Conduits for both storm and sewer water were inspected by Geraghty & Miller during site visits in 1991, 1992, and 1994 to evaluate potential migration pathways for the constituents of concern (COCs) at the Tutu Wells Site.

During the Phase II RI, Geraghty & Miller conducted an investigation of the storm sewer system, as specified in the Phase II RI Work Plan (Geraghty & Miller, Inc. 1993b). This storm sewer investigation was designed to evaluate the hydraulic effect of the storm sewer, identify the elevations of the storm sewer inverts and the water table, identify groundwater/storm sewer interaction, and evaluate the impact of the storm sewer on contaminant migration. Geraghty & Miller personnel measured the dimensions of the sewer and identified the locations of drains, manholes, catch basins, and connections from local businesses.

During the Phase II RI, three shallow monitoring wells (Monitoring Wells MW-17, MW-18, and MW-19) were installed adjacent to the storm sewer pipe to measure groundwater elevations and to evaluate the potential for the storm sewer to act as a contaminant migration pathway. Monitoring Well MW-17 was installed east of the storm sewer at the southwestern corner of the Ramsay property to evaluate groundwater conditions downgradient of the Ramsay UST and the Ramsay waste oil storage area and to evaluate the local hydraulic impact of the storm sewer. Monitoring Well MW-18 was installed northeast of the storm sewer in the southern portion of the Four Winds Plaza parking lot, southwest of the Esso Tutu Service Station. Monitoring Well MW-19 was installed east of the storm sewer to the south of the God of Holiness Church. Details of all monitoring well installations are presented in Section 3.7.1 (Monitoring Well Installation). The locations of all monitoring wells are shown on Figure 1-3.



In October 1993, on behalf of Laga, ADL conducted sampling of the sanitary and storm sewers in the Tutu Wells Site. Eight sediment samples (including duplicates) were collected from both sewer systems throughout the Tutu Wells Site. One water sample was collected from the water main located along Route 38, north of the intersection with Route 32. Ten aqueous samples (including duplicates) were collected from the sanitary sewer, the storm sewer, and the water main located immediately north of Kentucky Fried Chicken (Arthur D. Little, Inc. 1994).

In November and December 1993, on behalf of Esso, BB&L conducted an investigation of the storm sewer. Ten samples were collected from the storm sewer system. One sediment sample was collected from the poured concrete open channel at the southern end of Four Winds Plaza. Four aqueous samples were collected from the flow within the main storm sewer pipe. Five aqueous samples were collected from pipes and infiltration observed discharging into the main storm sewer pipe. The samples were analyzed by Lancaster Laboratories for VOCs, BTEX, and BNAs (Blasland, Bouck & Lee, Inc. 1994a).

In December 1993, CHT conducted a study of the bedding material surrounding a portion of the storm sewer pipe beneath the Four Winds Plaza parking lot. Material surrounding the storm sewer pipe was excavated, and sediment and aqueous samples were collected by CHT from the trench. Samples were split with ENSR, GCL, and BB&L.

3.5 GEOLOGIC INVESTIGATIONS

During the investigation of the Tutu Wells Site, numerous activities were performed to develop a detailed understanding of the regional and site-specific geology. These tasks included the following: reviewing previous geological studies, mapping bedrock outcrops, drilling soil borings and coring bedrock, performing petrographic analysis, and conducting borehole geophysical logging.



3.5.1 Review of Previous Geologic Studies

The primary and fundamental reference for the geology of St. Thomas is a detailed description by Thomas W. Donnelly (Donnelly 1966). Donnelly identified the major stratigraphic units and described their lithology. His work interpreted the volcanic and tectonic history of St. Thomas and St. John.

Two reports that described the hydrogeology and groundwater resource availability of St. Thomas provided the majority of the information compiled. The first report was a USGS water resource report by Jordan and Cosner (1973), which provided an overview of the geology of St. Thomas and described the water-bearing properties of the volcanic rocks. The second report, prepared by Geraghty and Miller in 1983, described the groundwater conditions at St. Thomas and the hydrogeologic framework of the Turpentine Run Basin (Geraghty & Miller, Inc. 1983).

3.5.2 Fracture Trace Analysis

During the Phase I RI, a fracture trace analysis was conducted to identify features of the underlying bedrock (such as fractures, joints, and faults) that may influence the rate and direction of groundwater flow at the Tutu Wells Site. In 1992, CDM performed an independent fracture trace analysis (CDM 1992). Fracture traces are linear trends that can be discerned in aerial photographs that reflect variations in topographic features, soil type, and vegetation, and are often surface manifestations of underlying bedrock fractures. The fracture trace study consisted of a detailed analysis of aerial photographs and topographic maps of the area. The aerial photographs examined were pairs of black and white stereographic prints from January 29, 1954, at a scale of approximately 1:28,000 (1 inch equals 2,333 feet), and from February 7, 1971, at a scale of approximately 1:20,000 (1 inch equals 1,667 feet). The USGS (1954) topographic map for the eastern St. Thomas quadrangle, at a scale of 1:24,000 (1 inch equals 2,000 feet), was used to plot the linear trends identified in the Tutu area. Linear trends that were identified at the Tutu Wells Site were used to select locations for monitoring wells. The results of the fracture trace study are discussed in Section 4.5.3 (Fracture Analysis).



3.5.3 Geologic Mapping

Geraghty & Miller conducted mapping of the exposed bedrock in the study area. Bedrock outcrops were examined, measured, and mapped to identify the type of bedrock, texture, fracture spacing, and strike and dip of bedding planes and other structural features. In addition, surficial geologic maps were prepared using field observations, aerial photographs, soil boring logs, and soil data from a 1970 United States Department of Agriculture (USDA) soil survey.

3.5.3.1 Bedrock Outcrop Observations

The bedrock immediately underlying the Turpentine Run Basin is part of the Louisenhoj Formation, which consists of augite andesite tuff, breccia, and debris flows that have undergone varying degrees of low-grade contact metamorphism. The Louisenhoj Formation outcrops in the northwest and southwest portions of the Four Winds Plaza, in an area east of the Seventh Day Adventist School, and near the VIHA. Construction activity at Tutu Park (Harthman property) has recently exposed an outcrop of the Louisenhoj Formation.

In 1987, GCL measured the orientation of bedrock fracture systems at the Four Winds Plaza, the VIHA, and the Seventh Day Adventist School outcrops (Geoscience Consultants, Ltd. 1987). Geraghty & Miller also measured the orientation of fractures and bedding planes at these outcrops and at the Tutu Park exposure in 1992 and 1993. A hand-held Brunton compass was used to measure the strike and dip of major, subsidiary, and vertical fractures observed in the field. The data from these field investigations are discussed in Section 4.5.3.2 (Bedrock Outcrop Fracture Analysis Results).

3.5.3.2 USDA Soil Survey

In 1965, the USDA completed a soil survey of the USVI. Excavations were used to expose soil profiles for description and to obtain soil samples for laboratory engineering analysis. The USDA classified and named St. Thomas soils based on the observed steepness, length, and shape



of slopes, the size and speed of streams, and the observed distribution of native plants, crops, and rock. The USDA used these observations in conjunction with aerial photographs of the island to map the boundaries of individual soil types.

3.5.4 Soil Borings

As part of the Phase I RI, soil samples were collected during the drilling of Soil Borings B-1 through B-13, B-13A, B-14 through B-16, and Monitoring Wells MW-1 through MW-10, MW-14, MW-16, MW-1D, MW-4D, MW-6D, and MW-10D through MW-13D. As part of the Phase II RI, soil samples were collected during the installation of Monitoring Wells MW-13, MW-15, MW-16, MW-17, MW-18, MW-19, MW-24, and MW-25. The sampling and analysis dates, the intervals sampled, and the analytical parameters, are provided in Table 3-1.

Soil samples were collected with a 3-inch diameter, 2-foot long, stainless-steel, split-spoon sampler driven ahead of 3¼-inch inside diameter (ID) hollow-stem augers by dropping a 140-pound (lb) hammer 30 vertical inches. Soil samples were collected continuously from ground surface to the water table or to the top of the bedrock surface, whichever was encountered first. At several locations, the drilling was advanced through asphalt or concrete pavement. Soil boring logs are provided in Appendix D.

The drilling rig, hollow-stem augers, rods, and tools were steam-cleaned before each boring. In addition, the split-spoon samplers were decontaminated in accordance with the following procedure: washed in tap water and detergent, followed by sequential rinses with tap water, 10 percent nitric acid (for metals sampling), deionized water, pesticide-grade methanol, and pesticide-grade hexane. Samples were then allowed to air dry, followed by a final rinse with deionized water. Each split-spoon sampler was wrapped in aluminum foil for later use.



3.5.5 Bedrock Coring

As part of the Phase I RI, the bedrock was cored during the drilling of deep Monitoring Wells MW-1D, MW-4D, MW-6D, MW-10D, MW-11D, MW-12D, MW-13D, and shallow Monitoring Well MW-9. No bedrock coring was performed during installation of the Phase II monitoring wells.

Coring began at the top of bedrock in each borehole. The depth to the top of bedrock encountered at the site varied from less than 1 to approximately 30 feet bls. Bedrock samples were obtained using the wireline NQ core barrel rotary method with a 2¾-inch outside diameter (OD) diamond bit. The removal of cuttings and cooling of the diamond bit were accomplished by recirculating water through the drilling system. A temporary, 5-foot long, 4-inch diameter PVC casing was installed in each 7-inch diameter boring before coring. The 5-foot long casing was used to prevent borehole collapse and to assist in recirculating the water from a holding tank to the boring. The recirculation system consisted of a holding/settling tank, a pump, and the downhole drilling tools. A sample of the drilling water was collected and analyzed for the COCs prior to field activities. Sample cores were obtained in 5-foot sections wherever possible. Downhole drilling pressure, rate of penetration per foot, and water circulation were observed and recorded.

The total length of each core sample was measured and recorded, along with the core recovery percentage and rock quality designation (RQD). These measurements were recorded on a bedrock core log form, along with a description of the core sample. The core descriptions provided information relative to lithology, color, hardness, grain size and shape, sorting, luster, cementation, accessory minerals, inclusions, bedding, weathering, and fracturing. The following information was also recorded on the bedrock coring logs: run number, run depth, run penetration, run duration, penetration rate, downhole pressure, run recovery, percent recovery, and RQD. Rock quality parameters, including Grade of Fracturing (F), Decomposition (D), and Strength (S) were also recorded. Bedrock core logs are included in Appendix D.



Four bedrock samples were obtained from the boreholes of Monitoring Wells MW-4D, MW-6D, MW-11D, and MW-13D for analysis of detailed thin section petrography by Western Atlas. The objective of this analysis was to characterize the texture and mineralogy of rock types. Samples were examined from the following boreholes (and sample depths): Monitoring Wells MW-4D (59.6 to 60 feet bls), MW-6D (51.2 to 51.6 feet bls), MW-11D (73.5 to 74.0 feet bls), and MW-13D (65.0 to 70 feet bls) (Western Atlas International Core Laboratories 1992). A summary of the results of the petrographic study is presented in Section 4.5.2.1 (Inspection of Bedrock Exposures). The petrographic report is presented in Appendix E.

The rock cores were stored in sample core boxes with the boring number, core depth, date, project number, and box number written on the outside of the box cover. The box number, project number, date, depth, run number, recovery percentage, and RQD were recorded on the inside of the box cover. The sample core boxes were stored on-site for further lithologic analysis.

Soil and rock cuttings resulting from the drilling operation were placed in 55-gallon, U.S. Department of Transportation (DOT)-approved drums. Three composite samples were collected from these drums to characterize the soil cuttings for disposal purposes. Drilling equipment and tools were decontaminated by steam-cleaning between each core sampling location.

3.5.6 Borehole Geophysical Logging

Geophysical logging was performed in the bedrock boreholes at Monitoring Wells MW-1D, MW-4D, MW-6D, MW-10D, MW-11D, MW-12D, and MW-13D. The logging program consisted of an acoustic (sonic) log and a caliper log. The primary objective of the geophysical logging was to identify bedrock fractures and fracture zones that may act as preferential migration pathways for groundwater. Results from the logging program have been used with data obtained from rock coring, aquifer testing, drilling observations, and geologic mapping to identify the locations of water-bearing fractures in the vicinity of the site. Borehole geophysical logs are presented in Appendix F.



3.5.6.1 Borehole Preparation

Borehole logging was performed in the open boreholes prior to well installation. The original scope of work included reaming the boreholes with a 3-inch diameter tri-cone bit, followed by collection of core samples. The boreholes were then logged using the sonic and caliper tools. However, a 3-inch diameter borehole proved to be too narrow; many problems occurred with the three-arm caliper tool in small diameter boreholes.

At Monitoring Well MW-13D, a similar problem occurred, compounded by collapse of the borehole. A two-stage logging procedure was therefore initiated and used in the remaining boreholes (Monitoring Wells MW-6D, MW-10D, MW-11D, and MW-12D). This new procedure consisted of sampling and reaming an upper section of the borehole with a 10-inch diameter bit and immediately logging the open hole with the caliper and sonic logs. PVC pipe was then installed in the open hole and the casing was grouted. With this new procedure, the lower interval could then be cored and reamed with a 5½-inch diameter bit and logged without the borehole collapsing. Table 3-2 provides well construction details for all the Geraghty & Miller monitoring wells installed during Phases I and II of the RI.

3.5.6.2 Caliper Logging Procedure

Caliper logs were run at each of the seven boreholes from the bottom of the well upward to land surface. A three-armed caliper tool, COLOG Model 3ARM C004, was used during the Tutu logging program. This tool consists of three, hydraulic, stainless-steel arms that extend and retract against the borehole wall as the tool is slowly drawn upward (at a rate of approximately 10 feet per minute [ft/min]) from the bottom of the borehole to land surface. This slower logging speed allows changes in the borehole diameter to be recorded more precisely (digitally) at the surface. Prior to logging, the caliper probe was calibrated with 3- and 4.5-inch rings for use in the 3-inch diameter boreholes (Monitoring Wells MW-1D and MW-4D) and 6- and 12-inch rings for use in the 10-inch diameter boreholes. Borehole depths recorded during drilling were used to calibrate the caliper depths. Caliper logs were run twice at each borehole



to confirm the data obtained. After completion of the logging in each borehole, the caliper probe was decontaminated with soap and distilled water. The raw data were saved digitally for later processing.

3.5.6.3 Acoustic Logging Procedure

Acoustic, or sonic, logs have historically been used to locate fracture systems in competent formations. The following two types of acoustic geophysical logging were used at the Tutu Wells Site: acoustic velocity logging and acoustic wave-form logging. Both types of logs were obtained through the use of a single sonic probe. For the logging conducted at the Tutu Wells Site, a COLOG Model SONIC 1275 probe was used at all seven boreholes.

The sonic probe contains one transmitter above and one transmitter below two pairs of sonic receivers that record travel time in the formation near the borehole wall. The sonic log records the time required for a compressional sound wave to traverse 1 foot of formation. The amplitude of the sonic wave is large unless the rock is fractured. Over a fractured zone it may be reduced by a factor of as much as 10 or 20 (Schlumberger 1987).

Centralizers were used on the sonic probe to keep it directly in the center of the borehole during the logging of the 10-inch diameter boreholes. These centralizers reduced the occurrence of spurious interval transit times that are calculated when the tool operated at a tilt. The logging of the boreholes for Monitoring Wells MW-1D and MW-4D was performed without centralizers because the sonic probe was only slightly smaller than these 3-inch diameter boreholes.

Sonic logging was performed from the bottom of the borehole to land surface. The sonic data included a tube wave amplitude curve, a transit time curve, and a variable density log. A second logging run was performed at each borehole to confirm the raw data obtained. These data were saved for later processing. After completion of the sonic logging at each borehole, the sonic probe was decontaminated with soap and distilled water.



3.6 SOIL QUALITY INVESTIGATIONS

The following sections describe the methods used to sample and screen soils. Soil samples were screened in the field, using an HNU photoionization detector (PID) and a portable field GC, for selection of samples for laboratory analysis.

3.6.1 Soil Sampling

The following sections describe soil sampling activities. During the Phase I RI, surface soil sampling and subsurface soil borings were performed. During the Phase II RI, soil samples were collected from monitoring well boreholes.

3.6.1.1 Subsurface Soil Sampling

During the Phase I RI, soil samples were collected during the drilling of Borings B-1 through B-13, B-13A, and B-14 through B-16, and the installation of Monitoring Wells MW-1 through MW-10, MW-14, MW-16, MW-1D, MW-4D, MW-6D, and MW-10D through MW-13D. Phase I RI soil samples were collected from June 4, 1992 to August 14, 1992. During the Phase II RI, soil samples were collected during the installation of Monitoring Wells MW-13, MW-15, MW-16, MW-17, MW-18, MW-19, MW-24, and MW-25. A blind field replicate, coded as MW-135, was collected from Monitoring Well MW-16; after receipt of laboratory analytical data, this sample identification was renamed MW-16FR.

Phase II RI soil samples were collected from March 26, 1994 to April 6, 1994. The locations of the soil borings are shown on Figure 1-3. Soil sample intervals and the analytical parameters are listed in Table 3-1. Soil samples were analyzed for TCL VOCs, BNAs, TAL metals, cyanide, and TPH.

Each soil sample was collected by driving the split-spoon sampler through the unconsolidated material by dropping a 140-lb hammer a vertical drop of 30 inches. Each sample



interval was field screened with an HNU PID. The sample interval, blow counts per 6 inches of advancement, sample recovery, HNU reading, and the soil description were recorded in the field by a Geraghty & Miller geologist on sample/core log forms, copies of which are provided in Appendix D. On removal from the subsurface, each split-spoon sampler was placed on a wood table covered by plastic sheeting.

The soil sample that exhibited the highest PID reading was selected for laboratory analysis. If no elevated PID readings were recorded, the soil sample for laboratory analysis was selected from the deepest interval above the water table or the bedrock surface, whichever was encountered first.

3.6.1.2 Surface Soil Sampling

During the Phase I RI, surface soil samples were collected from seven locations on August 19, 1992. Surface Soil Samples SS-1, SS-2, and SS-8 (background samples) were collected north of the Curriculum Center Building; Surface Soil Samples SS-3 and SS-4 were collected from the drum disposal area at the Curriculum Building; Surface Soil Sample SS-5 was collected from Tillett Gardens; and Surface Soil Samples SS-6 and SS-7 (a field replicate) were collected just southwest of O'Henry. Surface soil sampling locations are shown on Figure 1-3.

Surface soil samples were collected in the interval from 1 to 7 inches bls after removing the top 1 inch of vegetation and exposed soil. Surface soil samples were collected with a stainless-steel spatula as specified in the sampling procedures included in Appendix B of the Work Plan (Geraghty & Miller, Inc. 1992a). The spatulas were decontaminated in accordance with the cleaning procedures used for split-spoon samplers.

Various types of quality assurance/quality control (QA/QC) samples were collected. During the Phase I RI, one field blank (commonly referred to as a field rinsate) was collected for laboratory analysis during each day of soil sampling. During the Phase II RI, one field blank was collected for every 20 samples, as specified in the Quality Assurance Project Plan



(QAPP) (Geraghty & Miller, Inc. 1992c). The field blank was prepared by pouring laboratory-supplied deionized water through the precleaned, split-spoon sampler. One trip blank was included in each cooler of samples. Samples were shipped to Enseco East Laboratories (Enseco) in Somerset, New Jersey, via overnight courier. During the Phase I RI, field replicates were collected from Soil Borings B-8 and B-14. During the Phase II RI, a field replicate was collected from the boring for Monitoring Well MW-16.

Soil samples were analyzed for VOCs plus 1,2-dibromoethane (also known as ethylene dibromide or EDB), n-propylbenzene, and MTBE; TCL BNAs; TAL metals, cyanide, and TPH. TCL VOC, TCL BNA, and TAL analyses were conducted in accordance with the March 1990 Contract Laboratory Program (CLP) protocols (USEPA 1990b, 1990c). The TPH analyses were performed using USEPA Method 418.1, which was modified for soil analyses by using Soxhlet extraction.

One field blank, one trip blank, and one replicate were included with the surface soil samples. A replicate sample of Surface Soil Sample SS-6 was collected from the O'Henry Dry Cleaners location and labeled SS-7. Surface Soil Samples SS-1, SS-2, and SS-8 were analyzed for TAL metals and cyanide only. Surface Soil Samples SS-3 through SS-7 were analyzed for TCL VOCs, EDB, n-propylbenzene, MTBE, TCL BNAs, TAL metals, and cyanide using the March 1990 CLP protocols (USEPA 1990b; 1990c).

3.6.1.3 Disposal of Soils

Soils generated during well installation and soil sampling were stored in drums. The drums were submitted for Toxicity Characteristic Leachate Procedure (TCLP) analysis and were determined to be within acceptable TCLP values (i.e., non-hazardous). After approval from the USEPA and the DPNR, the soil, which is a non-hazardous solid waste, will be disposed at the Bovoni Landfill in St. Thomas.



3.6.2 HNU Screening

During both phases of the RI, each split-spoon soil sample was screened with an HNU Model PI-101 PID equipped with a 10.2-electron volt (eV) lamp that was calibrated with isobutylene gas on a daily basis, as specified in Appendix A of the Work Plan (Geraghty & Miller, Inc. 1992a). The PID readings give a real-time indication of total organic vapors present in the sample in parts per million (ppm). The 10.2-eV lamp was selected to match the ionization potential of site-specific VOCs. The HNU readings were recorded on the sample/core logs with the appropriate depth intervals. Copies of the sample/core logs and geologic logs are provided in Appendices D and G, respectively.

During Phases I and II of the RI, the soil sample with the highest HNU reading from each boring was selected for off-site laboratory analysis. During the Phase I RI, if no elevated HNU readings were measured, the deepest sample (above the water table or above the bedrock, whichever was encountered first) was selected for laboratory analysis. During the Phase II RI, the criterion for collecting soil samples was the interval directly above the water table or the bedrock surface, whichever was encountered first. Each soil sample was transferred from the split-spoon sampler to the sample container with a stainless-steel spoon. Soil sample jars were preserved in the field with ice and transported along with the field and trip blanks to the field office for packaging.

During the Phase I RI, several soil samples were split with the USEPA's contractor, CDM, and sent to a separate laboratory for confirmatory analysis. During the Phase II RI, split samples were collected from the borings for Monitoring Wells MW-15 and MW-17 by CEI, consultant to Ramsay Motors, and from Monitoring Wells MW-24 and MW-25 by ENSR, consultant to Western Auto.



3.6.3 Field GC Screening

During the Phase I RI, a portion of each soil sample was collected with a stainless-steel spatula for field GC analysis. The soil was placed in two 40-milliliter (mL) vials containing deionized water, using a stainless-steel spatula, until each vial was filled halfway. Each vial was identified with the boring number, sample number, depth interval, and the date and time of collection. The vials were stored on ice and transported to the field office for GC analysis. No field GC analysis was performed during the Phase II RI. The results of the field GC survey were summarized in the Phase II RI Work Plan (Geraghty & Miller, Inc. 1993b).

3.6.4 Soil-Gas Survey

During the Phase II RI, two soil-gas surveys were conducted, one at the Curriculum Center and one at the VIHA. The purpose of the soil-gas surveys was to provide a screening tool to optimize the location of two monitoring wells (Monitoring Wells MW-13 at the VIHA and MW-16 at the Curriculum Center) and to provide information regarding potential contaminant source areas. The results of the soil-gas surveys are included as Appendix B and are discussed in Section 5.1 (Soil Quality and Potential Sources), where relevant.

3.7 GROUNDWATER INVESTIGATION

The groundwater investigation included the installation of shallow and deep monitoring wells, well development, and groundwater sampling and analysis. The purpose of the groundwater investigation was to define groundwater flow and quality conditions. The groundwater investigation provided information regarding the direction and gradient of groundwater flow, the horizontal and vertical extent of VOCs in groundwater, and the potential migration pathways for petroleum hydrocarbon products and chlorinated VOCs.



3.7.1 Monitoring Well Installation

During Phases I and II of the RI, Geraghty & Miller installed 31 monitoring wells, consisting of 21 shallow and 10 deep wells (see Figure 1-3).

3.7.1.1 Shallow Monitoring Wells

During the Phase RI I, 12 shallow monitoring wells (Monitoring Wells MW-1 through MW-5, MW-6R, MW-7, MW-8, MW-9, MW-9S, MW-10, and MW-14) were installed at the Tutu Wells Site by Geraghty & Miller. During Phase II, seven shallow bedrock monitoring wells (Monitoring Wells MW-13, MW-15, MW-16, MW-20, MW-22D, MW-24, and MW-25) were installed by Geraghty & Miller. The shallow monitoring wells were installed with open intervals that intersect the top of the water table. The methodology for the installation of the Phase I RI monitoring wells was reported in Technical Memorandum II (Geraghty & Miller, Inc. 1993a).

In addition, three very shallow monitoring wells (less than 5 feet into competent bedrock), Monitoring Wells MW-17, MW-18, and MW-19, were installed with 5-foot long screens intersecting the water table adjacent to the storm sewer. These shallow wells were installed in the saturated fill adjacent to the storm sewer or, if no saturated fill was encountered, a maximum of 5 feet into the top of the bedrock underlying the storm sewer.

Monitoring Wells MW-13, MW-15, MW-16, MW-20, MW-22D, MW-24, and MW-25 are open in bedrock below the casing. Monitoring Well MW-22D was originally designed to be a deep well, open in the bedrock at least 20 feet below the water table. However, after this well was installed, Geraghty & Miller determined that the water table at this location was 93 to 106 feet bls. Because the open interval of Monitoring Well MW-22D is from 108 to 128 feet bls, Monitoring Well MW-22D should, therefore, be considered a shallow monitoring well. Monitoring Wells MW-16 and MW-24 were constructed with a double casing through the overburden to prevent contaminated soils, or contaminated perched water in the overburden,



from entering the open bedrock borehole. At Monitoring Well MW-16, a 12-inch diameter borehole was drilled to a depth of 5 feet bls (2 feet into bedrock), and a 10-inch steel casing was grouted into the rock. A 10-inch diameter borehole was then drilled to a depth of 24.6 feet bls and a 6-inch diameter steel casing was installed. At the borehole for Monitoring Well MW-24, a 12-inch diameter borehole was drilled to 12 feet bls (1 foot into bedrock) and a 10-inch diameter steel casing was grouted into the rock. A 10-inch borehole was advanced to 18 feet bls and a 6-inch steel casing was installed. The annulus between the inner and outer casings was filled with grout (bentonite, cement, and water). Monitoring Well MW-24 had to be relocated twice due to obstructions encountered during drilling. Monitoring well construction details are presented in Table 3-2.

All shallow monitoring wells were constructed with 4-inch diameter, stainless-steel casing. Those monitoring wells completed in the overburden (Monitoring Wells MW-17, MW-18, and MW-19) were constructed with 0.020-inch slot, stainless-steel screen. The screen and riser pipe utilized for well construction were steam cleaned before installation. A sand pack was placed into the annulus between the boring and the well screen; a seal consisting of bentonite pellets was installed above the sand pack. The bentonite pellets were hydrated with potable water after placement. A cement-bentonite grout seal was installed from the top of the bentonite seal up to the land surface. The grout slurry was placed in the annulus between the boring and well casing with a $\frac{3}{4}$ -inch diameter tremie pipe from the bottom to the top of the borehole. Each monitoring well was finished with a metal curb box that extended approximately 0.1 foot above the land or pavement surface. Monitoring well construction logs, including diagrams for each shallow monitoring well, are provided in Appendix H.

3.7.1.2 Deep Monitoring Wells

During Phases I and II of the RI, nine deep monitoring wells were installed at the Tutu Wells Site by Geraghty & Miller. The seven deep monitoring wells installed during the Phase I RI were Monitoring Wells MW-1D, MW-4D, MW-6D, MW-10D, MW-11D, MW-12D, and MW-13D. The two deep monitoring wells installed during the Phase II RI were Monitoring



Wells MW-20D and MW-21D. Deep Monitoring Wells MW-1D, MW-4D, MW-10D, and MW-11D were completed as open holes in previously drilled bedrock core holes (see Section 3.5.5 [Bedrock Coring]). The original core hole for Monitoring Well MW-6D was abandoned due to formation collapse. The same situation occurred at the original core hole for Monitoring Well MW-12D where drill tools were lost due to formation collapse. The original core hole for Monitoring Well MW-12D was abandoned and grouted. New holes were drilled at both locations (Monitoring Wells MW-6D and MW-12D) for completion of the monitoring wells. Monitoring Well MW-12D was completed with a 0.020-inch slot screen; all other deep monitoring wells are open in bedrock below the casing.

Before installation of Monitoring Well MW-4D, the 3-inch diameter core hole was reamed with a 7½-inch diameter air-rotary hammer bit. A 10-inch diameter hammer bit was used for the other wells. The core holes were reamed to a predetermined depth based on the groundwater levels encountered during drilling. The depths of the deep wells were selected to have 20-foot long open intervals approximately 35 to 55 feet below the water table, so that there was a 20-foot vertical separation between the bottom of a shallow monitoring well and the top of the adjacent deep well.

Bedrock borings were reamed with the 10-inch diameter hammer bit from land surface to the top of the open hole interval. A 6-inch diameter, stainless-steel casing was then installed in each boring. The annulus between the casing and the boring was grouted from the bottom to land surface using a ¾-inch diameter tremie pipe, and the grout was allowed to harden for 12 hours. The borings were then reamed with a 5½-inch diameter hammer bit through the 6-inch diameter casing. The well depth was measured to verify that the boring remained open after the reaming was completed. Each deep monitoring well was completed with a flush-mounted manhole installed approximately 0.1 foot above land surface, with the exception of Monitoring Well MW-21D, which was completed with a 2.8-foot outer-protective casing. Monitoring well construction logs and diagrams for the deep wells were prepared after well completion and are included in Appendix H.



3.7.2 Well Surveying

All shallow and deep monitoring wells installed during Phases I and II of the RI were surveyed by R. Lopez De Azua and Associates after completion. The land surface, top of the flush-mounted manhole (or outer protective casing), and the top of the stainless-steel casing elevations were measured for each well installed during the RI. In August 1994, eight wells and 11 storm sewer grates were surveyed by Brian Moseley and Associates. This surveying was intended to confirm measuring point elevations for O'Henry monitoring wells, obtain measuring point elevations for four supply wells, and determine the locations and elevations of the storm sewer grates. All surveying data are included in Appendix I.

3.7.3 Well Development

Phase I RI monitoring wells were developed between August 24, 1992 and September 15, 1992. Phase II RI monitoring wells were developed between April 27, 1994 and May 4, 1994. A submersible or centrifugal pump was used for development, except for Monitoring Wells MW-17 and MW-19, where a bailer was used due to the poor recovery of water in these wells. A submersible pump was used to develop Monitoring Wells MW-3, MW-4, MW-4D, MW-6R, MW-13, MW-13D, MW-15, MW-16, MW-20, MW-20D, MW-21D, MW-22D, MW-24, and MW-25. A centrifugal pump was used to develop Monitoring Wells MW-1D, MW-2, MW-5, MW-6D, MW-7, MW-8, MW-9, MW-9S, MW-10, MW-10D, MW-11D, MW-12D, MW-14, and MW-18.

The submersible pump was cleaned with a detergent (Micro) and water solution and rinsed with tap water between each well. The tubing and rope used with the centrifugal pump were replaced between each well. Well development was continued until the discharged water was relatively sediment-free. Water produced during well development was stored in a mobile holding tank and transported to the water treatment system installed by the TEIC at the Esso Tutu Service Station. Treatment consisted of air stripping and granular activated carbon (GAC)



adsorption prior to discharge to the sanitary sewer, as authorized by the USVI Department of Public Works (DPW) and the DPNR.

During the Phase I RI, a water sample was collected from the pump discharge line during well development for field GC analysis in Monitoring Wells MW-1, MW-1D, MW-2, MW-3, MW-5, MW-6R, MW-6D, MW-7, MW-8, MW-9, MW-10, MW-10D, MW-11D, MW-12D, and MW-14. Another sample was collected for field GC analysis prior to discharging treated water to the sanitary sewer system, for preliminary evaluation of water quality.

3.7.4 Water-Level Measurements

During the Phase I RI, water-level measurements were recorded in shallow and deep wells installed by Geraghty & Miller in September, October, and November 1992. Groundwater contour maps were prepared and included in Technical Memorandum II (Geraghty & Miller, Inc. 1993a).

During the Phase II RI, two rounds of water-level measurements were conducted, one on May 10, 1994 and one on May 23, 1994. Water-level measurements from May 10, 1994 were collected as background static conditions for a pump test conducted on May 12, 1994. Area-wide, synoptic water-level measurements were collected on May 23 and 24, 1994, prior to the comprehensive groundwater sampling event.

Depth to groundwater was measured using a calibrated electronic water-level probe. The electronic probe relies on the conductivity of the water, generating a low-voltage electric circuit only when the probe touches water. Water levels were measured from the top of the stainless-steel casing of each monitoring well. Depth-to-water data were converted to water-table elevations relative to mean sea level (msl) by subtracting the depth to water in each well from a surveyed datum (the top of inner casing of each well). Groundwater elevations from May 10, 1994, May 23 and 24, 1994, and July 20, 1994 are discussed in Section 4.0 (Physical



Characteristics of the Study Area). These data were used to prepare groundwater contour maps, which are discussed in Section 4.6 (Hydrogeology).

The water-level elevations for the monitoring well clusters were tabulated for comparison. The vertical gradient of groundwater flow at each well cluster was calculated by dividing the difference of the water-level elevations in the well cluster by the vertical separation of the midpoints of the well screens (or the open intervals).

3.7.5 Groundwater Analytical Parameters

Analytical parameters for groundwater samples collected during the Phase II RI in May and June 1994 included TCL VOCs (plus MTBE, n-propylbenzene, and EDB), TCL BNAs, and TAL metals. All TCL and TAL analyses were performed according to CLP procedures (USEPA 1990b). Supply wells and monitoring wells located on the fringes of the known chlorinated VOC plume were analyzed for VOCs by USEPA Method 524.2 to achieve lower detection limits. Additional analytical parameters included total dissolved solids (TDS), total suspended solids (TSS), sulfate, sulfide, nitrite, nitrate, phosphorous, alkalinity, cyanide, organo-metallic lead (using the California Leaking Underground Fuel Tank [LUFT], Department of Health Services Method), chloride, ferrous iron, ferric iron, manganese, chemical oxygen demand (COD), and hardness.

Field analyses included pH, temperature, dissolved oxygen, oxidation-reduction (Eh) potential, and specific conductance. All field parameter results are included on the sampling logs. The Eh meter was not functioning properly during sampling; the meter did not equilibrate. Therefore, these results are not considered to be valid. Table 3-3 provides a list of the parameters analyzed for the wells sampled.



3.7.6 Monitoring Well Sampling and Analysis

During the Phase I RI, groundwater samples were collected between September 29, 1992 and October 7, 1992 from the 19 monitoring wells installed at the Tutu Wells Site. The results of these analyses were reported in Technical Memorandum II (Geraghty & Miller, Inc. 1993a). During the Phase II RI, groundwater samples were collected between May 23, 1994 and July 28, 1994 from 12 supply wells and 51 monitoring wells at the Tutu Wells Site. The groundwater samples were collected at least 2 weeks after completion of well development. Phase II RI water sampling logs are included in Appendix J.

The water levels and total well depths (sounded depth) were measured in each monitoring well before the wells were purged. These measurements were taken from the top of the stainless-steel casing with an electronic water-level indicator and a steel tape. The instruments were cleaned between each monitoring well with a detergent (Micro) and water solution, and rinsed with tap water. The volume of water in each well was calculated using the following formula:

- For a 4-inch diameter well: Height of water column x 0.65 gallon/foot.
- For a 6-inch diameter well: Height of water column x 1.47 gallon/foot.

Three to five well volumes were purged from each well with either a submersible or a centrifugal pump. The submersible pump was decontaminated between wells with a Micro and water solution and rinsed with tap water. Tubing used with the centrifugal pump was replaced between each well. Monitoring Wells MW-1, MW-1D, MW-8, MW-9S, MW-10, MW-10D, MW-13D, MW-18, MW-19, MW-20, MW-20D, MW-21D, MW-22D, MW-24, MW-25, SW-2, SW-3, SW-7, and KFC-1 went dry during purging operations. Field analyses were collected during purging and sampling of the wells; these data are included in Appendix J.

The groundwater samples were collected with Teflon bailers. The sample was collected by pouring the water directly into the sample container from the bailer; VOC samples were



collected first. Field blanks (field rinsates) were also collected during groundwater sampling activities by pouring deionized water through the Teflon bailer. Groundwater samples from Monitoring Wells OHMW-1 through OHMW-4, CHT-6D, DW-1, MW-8, MW-15, MW-17, MW-24, and MW-25 were split with the consultants contracted by the various property owners and sent to separate laboratories. Samples collected by Geraghty & Miller were preserved in the field according to approved laboratory QA/QC preservation procedures as identified in the Work Plan (Geraghty & Miller, Inc. 1993b), for each specific analyte (see Appendix J). All groundwater samples, along with the field and trip blanks, were preserved on ice and sent to Enseco via overnight courier.

Blind field replicate groundwater samples were collected from two monitoring wells. A sample from Monitoring Well MW-11D was labeled DW-4 and a sample from Monitoring Well SW-7 was labeled DW-6. After analysis, the sample identifications were changed to MW-11DFR and SW-7FR, respectively. The purpose of blind field replicates was to evaluate the reproducibility of sampling and laboratory procedures. Matrix spike (MS) and matrix spike duplicate (MSD) samples were collected from Monitoring Wells MW-3, MW-11D, SW-7, and CHT-6D. MS/MSD samples verify the performance of laboratory instruments.

3.7.7 Supply Well Sampling

In addition to monitoring wells, the Phase II RI comprehensive groundwater sampling event included the following supply wells: Delegarde, Eglin I, Eglin III, Four Winds I, Four Winds II, Harvey, Harthman (Racetrack), LaPlace, Matthias, Gassett (new), Smith, Steele, Tillett, and VIHA I. Various methods were used to obtain samples from the supply wells. Those wells with operable pumps installed were sampled at the nearest available sample port. Since it was not possible to measure depths inside these wells to calculate the volume to be purged prior to sampling, the wells were purged for 15 minutes at the highest sustainable pumping rate. To obtain samples from the Harvey Supply Well, the inoperable submersible pump and discharge piping was removed. The Harvey and Gassett (new) Supply Wells were evacuated using temporary submersible pumps and samples were collected with a bailer. An MS/MSD sample



was collected from the Delegarde Supply Well. Table 3-4 provides available construction details for the known supply wells in the Tutu Wells Site.

3.7.8 Treatment System

A water treatment system was installed by Soil Tech and Geraghty & Miller at the Esso Tutu Service Station to treat groundwater generated during the installation, development, and sampling of monitoring and supply wells during the Phase II RI. The treatment system consisted of 55-gallon drums containing GAC, an air stripper, and two 2,000-gallon water-holding tanks. The water-holding tanks were piped in series across the treatment system to allow the treated water to be recycled through the treatment system until the discharge requirements were met. The treated water was held in the holding tanks. A sample of treated water was taken from the treatment system for VOC analysis by USEPA Method 524.2 prior to discharge into the sanitary sewer system. The DPW was given 48 hours advance notice of the occurrence of a discharge event. Discharge from the system into the sanitary sewer was permitted by both the DPNR and the DPW. The results of the analysis of discharge samples were provided to the DPW.

3.8 PUMPING TESTS

Geraghty & Miller performed pumping tests at the Tutu Wells Site to quantify the hydraulic characteristics of the aquifer and to empirically assess the response of the aquifer during pumping. Aquifer responses were analyzed for both the shallow bedrock and the deep bedrock. Pumping tests were conducted at Monitoring Wells MW-6R and MW-6D at the Four Winds Plaza during the Phase I field investigation, as presented in Technical Memorandum II (Geraghty & Miller, Inc. 1993a). In May 1994, during Phase II RI field activities, Geraghty & Miller conducted a pumpage impact test using the Eglin III Supply Well near Archie's Welding and the Tom Cat Laundromat. The purpose of the pumping test for Monitoring Wells MW-6R and MW-6D at Four Winds Plaza was to estimate the transmissivity (T) and storage (S) parameters in the shallow (Monitoring Well MW-6R) and deep (Monitoring Well MW-6D) portions of the



aquifer. The purpose of the Eglin III pumpage impact test was to observe localized aquifer response to pumpage and determine site-specific aquifer parameters, T and S, if possible.

Transmissivity (T) is defined as the groundwater discharge that would occur through a unit width (assume 1 foot wide) of the aquifer thickness (b) under a hydraulic gradient of 1. T values in a fractured bedrock aquifer will increase if more water-bearing fractures are intersected. Because T values are representative of the entire aquifer thickness, the effect of fractures at various depths and spacing is averaged or assimilated over the aquifer thickness.

Hydraulic conductivity (K) values can be calculated by dividing T by b. T values in a fractured bedrock aquifer will increase if more water-bearing fractures are intersected by a well. K values for the fractured bedrock aquifer underlying the Tutu Wells Site may not be representative of sections of the aquifer that intersect more (or less) fractures than the average for the aquifer.

3.8.1 Phase I Aquifer Test - Four Winds Plaza

Two 24-hour, constant-rate aquifer pumping tests were carried out in shallow Monitoring Well MW-6R and deep Monitoring Well MW-6D to estimate the hydraulic characteristics of the shallow and the deep portions of the bedrock aquifer underlying the study area. These two wells were selected because of their relatively high yield during well development (yields greater than 5 gallons per minute [gpm] versus yields of less than approximately 1 gpm in other Phase I RI monitoring wells). This high yield allowed for sustained pumping during the aquifer test. The constant-rate aquifer tests of Monitoring Wells MW-6R and MW-6D were performed on November 2, 1992 and November 5, 1992, respectively. The USEPA had originally requested that a 72-hour pumping test be conducted, but later approved the 24-hour tests based on initial pumping test results.

Prior to initiation of the 24-hour constant rate aquifer pumping tests, a step-drawdown test was conducted in each well to select an optimal pumping rate. The pumping rates selected for



Monitoring Wells MW-6R and MW-6D were 9.25 gpm and 14.2 gpm, respectively. The maximum pumping rate was limited by the 15-gpm capacity of the on-site treatment system. The length of the step-drawdown tests ranged from approximately 2 to 4 hours at each well. Four to five steps, each with increasing pumping rates, were run for approximately 30 to 60 minutes each.

Recovery tests were conducted immediately after pumping was stopped. Recovery water levels were measured until at least 90 percent recovery was observed in each well.

3.8.1.1 Water-Level Measurements

To provide data regarding background water-level fluctuations, pressure transducers were placed in the pumping and observation wells, as well as in other nearby wells, for several days prior to the step-drawdown and constant rate pumping tests. Pressure transducers were connected by a cable to computerized data loggers that were programmed to record water-level readings every 30 seconds during testing and every 10 minutes prior to testing. Water-level measurements were manually collected from additional observation wells (using an electronic water-level indicator) at average intervals of 30 minutes. After completion of each test, the data from the data loggers were downloaded to a field computer.

Pressure transducers were installed in Monitoring Wells MW-4, MW-4D, MW-5, MW-6R, MW-6D, MW-7, MW-8, and MW-12D. Water levels in Monitoring Wells MW-2, MW-3, MW-6R, MW-6D, MW-9, MW-10, MW-10D, and MW-11D, and in Monitoring Wells CHT-4 and CHT-6D were recorded manually with an electronic water-level indicator. The electronic water-level indicators, transducer cables, and probes were decontaminated by washing in sequence with a detergent (Micro) and water solution, followed by a potable water rinse and a distilled water rinse.



3.8.1.2 Aquifer Pumping Test Procedures

On November 2, 1992, a submersible pump with a capacity of 10 gpm was used to discharge a constant rate of water from Monitoring Well MW-6R. On November 5, 1992, a submersible pump with a capacity of 20 gpm was used for the 24-hour pumping test at Monitoring Well MW-6D. Due to treatment system limitations, the pumping test at Monitoring Well MW-6D did not exceed 15 gpm. The pumps were suspended in the wells with a 1-inch diameter, galvanized pipe connected to the discharge outlets of the pumps. A $\frac{3}{4}$ -inch diameter, threaded, PVC pipe was installed as a drop line for measuring water levels in the pumping wells. This PVC pipe was placed just above the top of the pump to provide accurate water-level measurements in the event that water entered the well from dewatered portions of the bedrock. The pumps were equipped with an in-line valve to adjust the flow rate and an in-line flow meter to measure the actual flow rate. Electric power was supplied to the pumps from an electrical source at the Esso Tutu Service Station.

Prior to each test, the submersible pumps were decontaminated by rinsing the interior and exterior of the pumps with a detergent (Micro) and water solution, followed by a rinse with potable water. A minimum of 25 gallons of potable water was run through the pumps. The galvanized pipes and the PVC drop line were decontaminated by steam cleaning before use.

3.8.1.3 Discharge Water Treatment

The groundwater from each of the wells was discharged to the water treatment system located at the Esso Tutu Service Station through a 1 1/4-inch diameter PVC pipe (see Section 3.7.8 [Treatment System]). This groundwater was stored on-site in holding tanks prior to treatment with an air stripper and carbon absorption units, and was then discharged to the sanitary sewer lines, as authorized by the DPNR and the DPW.



3.8.1.4 Discharge Water Sample Collection and Analysis

Water samples from the pumping wells were collected every 2 hours for field GC analysis and every 12 hours for laboratory analysis throughout the duration of the tests. Water samples for field GC and laboratory analyses were collected before and after treatment of the discharged water to determine the VOC concentrations in the aquifer and the effectiveness of the water treatment system. The temperature, pH, and specific conductance of the water samples were measured every hour using field instruments. Water samples were analyzed for TCL VOCs following the March 1990 CLP protocols (USEPA 1990b).

3.8.2 Phase II Pumping Aquifer Test - Eglin III Pumpage Impact Test

In May 1994, a 24-hour pumping test was performed, using the Eglin III Supply Well, at 31 gpm to (1) observe the local aquifer response and the extent of water-level impacts in the shallow and the deep portions of the bedrock aquifer to a constant-rate pumping event, and (2) to estimate site-specific characteristics T and S. Once full recovery was achieved after the pumpage impact test, the pumping cycle of the Eglin III Supply Well was simulated (i.e., approximately 3 hours of pumping at an unrestricted flow rate) to observe the short-term pumpage impact on the aquifer.

3.8.2.1 Water-Level Measurements

Computerized data loggers (Well Sentinels) and pressure transducers were installed in surrounding observation wells to observe the effects of pumpage on the potentiometric surface. The data loggers were installed in shallow Monitoring Wells OHMW-2, OHMW-3, OHMW-4, and SW-6; in deep Monitoring Wells MW-11D, MW-12D, MW-21D, and DW-2; and in Eglin II, an inactive supply well. Water-level elevation data were collected at 1-minute intervals.

A computerized Hermit 2000 data logger was used in conjunction with a pressure transducer at the pumping well, the Eglin III Supply Well. This supply well currently services



the Tom Cat Laundromat. The pressure transducer was set in a 1-inch diameter, PVC drop pipe to protect the transducer during pumping. The data logger enabled data collection at time intervals shorter than 1 minute at the beginning of a test and longer than 1 minute during the later portions of the test. The frequency of the water-level measurements is presented in Table 3-5. The longest data collection interval in the data loggers was 10 minutes.

Water-level measurements were manually collected at approximately 1-hour intervals with an electronic water-level indicator in the Harvey, Church, and Steele Supply Wells; deep Monitoring Well MW-10D; and shallow Monitoring Wells MW-10, SW-4, and SW-5. During the pumpage impact test, the Harvey and Church Supply Wells were not in operation, and the Steele Supply Well was in operation.

3.8.2.2 Aquifer Pumping Test Procedures

The pumpage impact test began with background data collection from about 17:00 hours on May 10, 1994 until the pump was turned on at 10:07 hours on May 11, 1994. The flow rate was measured using an in-line flow meter and regulated with a gate valve. The pumping rate was maintained at 31 gpm until 08:00 hours on May 12, 1994. At 08:00 hours on May 12, 1994, the pumping rate was increased to 41 gpm to maintain a water supply for the Tom Cat Laundromat. The pump was shut off at 17:15 hours on May 12, 1994, and recovery data were collected until 07:00 hours on May 13, 1994.

A pumping cycle was simulated on May 13, 1994, whereby the pump was turned on for the time period that the pump is normally on (approximately 3 hours) with the pumping rate unrestricted. The duration of pumping was based on the length of the pumping cycles observed on hydrographs of data collected from Monitoring Wells MW-11D and MW-12D during a previous background monitoring test in October 1992. The unrestricted pumping rate at the Eglin III Supply Well started out at about 46 gpm and decreased to about 40 gpm by the end of the pumping cycle. Recovery was monitored until about 12:30 hours on May 13, 1994.



3.9 DATA VALIDATION

Data validation was provided for all data during the Phase II RI to ensure the quality of laboratory data, under Geraghty & Miller's Analytical Quality Assurance/Laboratory Control Program (AQA/LCP) protocols. In general, the data were acceptable, with the qualifiers shown on the tables and figures. For example, in some instances, a result was qualified as estimated (identified as "J" in the tables) because the corresponding analyte was not detected above the CLP contract required detection limit (CRDL). Reported detection limits are approximate and may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in a given sample. A reporting limit is the practical quantitation limit (PQL) for a particular parameter in a given matrix that is attainable, using the specified corresponding methodology, and that can be reliably achieved within specified units of precision and accuracy. The method detection limit (MDL) is the minimum concentration of a parameter that can be measured and reported by a particular analytical system. Summary text and tables for the data validation for soil and groundwater are provided in Appendices K and L, respectively. Due to the large volume of data sheets, complete validation documentation was submitted separately to the USEPA, as approved by Ms. Caroline Kwan via telephone on October 6, 1994.

3.10 HUMAN POPULATION SURVEY

The population and land use information were determined for an area having a 1-mile radius centered in the Tutu Wells Site. This information may be used to assess the current and possible future impacts to public health from releases of hazardous substances.

Geraghty & Miller conducted a search of the most recent information compiled by the National Clearing House for Census Data Services to locate an information service that could perform a radius search of population data in the Tutu area. The standard service of geometric retrieval from a given geographical location, which is needed for a radius search, is not available in the USVI. Instead, Geraghty & Miller used basic population density data from the 1990



Census and calculated the population within a 1-mile radius of the Tutu Wells Site. The results of the population survey are presented in Section 4.2 (Demography and Land Use).



4.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section describes the physical setting of the site and study area. Discussed below are topography and drainage, demography, land use, climate, soils and vegetation, geology, and hydrogeology.

4.1 TOPOGRAPHY AND DRAINAGE

The Tutu Wells Site is located within the Turpentine Run surface drainage basin, which occupies approximately 3.4 square miles in east-central St. Thomas (Figure 1-2). The Turpentine Run Basin is separated into upper and lower basins. The Tutu Wells Site is located in the upper basin, which covers approximately 2.3 square miles upstream of a stream gaging station located near Estate Fort Mylner. The lower basin covers 1.1 square miles downstream of this station (Jordan and Cosner 1973).

The Turpentine Run Basin is a north-south trending basin that is surrounded by relatively steep slopes. The topography of the Tutu Wells Site is depicted on Figure 4-1. Other valleys in the area trend northeast-southwest, such as the valley in front of the VIHA and the Curriculum Center, along which Route 384 runs, and the valley just west of the Benjamin Oliver School. This valley extends southward, where it trends northwest-southeast and continues past the LaPlace, Smith, and Matthias Supply Wells. Land surface elevations within the basin valley decrease from about 200 feet above msl at the northern end of the site to approximately 100 feet above msl at the southern end. Within the study area, the hills are approximately 300 feet above msl near the Curriculum Center in the north and approximately 200 to 235 feet above msl (Mt. Zion) in the south.

The Turpentine Run is an intermittent stream that traverses the length of the basin. In the upper Turpentine Run Basin, the stream generally flows from north to south following Route 38. In the lower basin, the stream turns around Mt. Zion and then trends southeast. Turpentine Run is partially channelized and ultimately discharges into Mangrove Lagoon and the Caribbean Sea.



Surface water at the site drains from the surrounding slopes into the Turpentine Run Basin. Most roads and parking areas are paved in the Tutu Wells Site, and surface-water runoff is collected in a storm-water catchment system. The orientation of the storm-water catchment system is illustrated on Figure 4-2. Storm water and secondary sewage are eventually discharged to Turpentine Run.

4.2 DEMOGRAPHY AND LAND USE

According to the most recent census data (U.S. Census Bureau 1990), approximately 9,100 people live in the Tutu subdistrict of St. Thomas. The Tutu subdistrict, also known as Anna's Retreat, covers 1.5 square miles (4 square kilometers) in the central-eastern part of St. Thomas. Tutu is second to Charlotte Amalie in population density on St. Thomas and contains approximately 20 percent of the island's population. Based on the 1990 census and population densities provided for the Tutu subdistrict and for the entire island, Geraghty & Miller estimates that there are approximately 11,500 people living within a 1-mile radius of the Tutu Wells Site. Based on the 1980 census data, the USEPA previously estimated that 11,000 people were living within a 1-mile radius centered in the Tutu subdistrict (USEPA 1991).

Several two-lane paved roads, including Route 384, Route 38, and Highway 382, are located in the Tutu Wells Site. These roads are generally oriented along the axis of the major valleys described in Section 4.1 (Topography and Drainage). Various commercial establishments line these major roads (see Figure 1-4). There are two large shopping centers (Four Winds Plaza and Tutu Park) and approximately three auto shops, five churches, three service stations, five small stores, and two government buildings located in the area. Private homes (approximately 300) and multi-family housing, such as the VIHA buildings, generally occupy the less heavily traveled roads. At least three schools are also located within the Tutu Wells Site: an elementary school (the Seventh Day Adventist School) to the northeast, Gomez Junior High School to the northwest, and the Benjamin Oliver School to the east. Many paved and unpaved parking areas are located adjacent to the commercial buildings and residences. Overall,



approximately 50 percent of the land area is developed (with buildings and parking areas) and 50 percent is covered with soil and vegetation.

4.3 CLIMATE

The island of St. Thomas is located between 18° 17' and 18° 24' north latitude and between 64° 50' and 65° 03' west longitude. It has an irregular coastline, numerous hills, and little flat land. The climate of the USVI has been described as tropical maritime (Smedley 1961) and semi-humid tropical (Jordan and Cosner 1973).

Some of the data for precipitation and temperature discussed below were collected at the National Weather Service Station at Estate Fort Mylner, which is approximately ½ mile south-southeast of the center of the Tutu Wells Site (18° 20' latitude and 64° 53' longitude). Wind speed data were collected at the Cyril E. King Airport in the southwestern part of the island. Annual climatic data are provided in the following sections to assist in future risk assessments. Barometric pressure data were collected and used in the analysis of water levels during aquifer testing.

4.3.1 Precipitation

Average annual rainfall from 1961 to 1990 at the Estate Fort Mylner weather station was 47.47 inches. This amount represents the greatest annual rainfall of the five National Weather Service stations on the island for which these data are available. The lowest annual rainfall average on St. Thomas for this period was 39.45 inches at the Water Isle station on the southern side of the island. At Estate Fort Mylner, October and November are the wettest months, with each month averaging more than 6 inches of rainfall (Table 4-1). According to the National Oceanographic and Atmospheric Administration (NOAA), February and March are the driest months, each averaging less than 2.5 inches of rainfall (NOAA 1992). These data from Estate Fort Mylner are representative of the relatively wet and relatively dry seasons that are typical



in the USVI. Monthly precipitation totals for 1990 through 1994 and monthly precipitation normals are presented in Table 4-1.

Several mechanisms produce precipitation in the USVI. Most rainfall occurs when moisture-laden air rises over the hilly terrain of the islands (NOAA 1974). As it rises and cools, the air releases its moisture, clouds form, and short, intense showers are produced. Other rainfall-producing mechanisms include "easterly" or tropical waves and cold fronts. Easterly waves are migratory, wave-like disturbances that move from east to west in the upper atmosphere at a slow rate. From May to November, these easterly waves produce weather ranging from cloudiness to significant rainfall (NOAA 1974). The trailing edges of cold fronts that have swept across the continental United States bring occasional rain to the USVI between November and April (NOAA 1974). In the USVI, rainfall accumulations greater than 1 inch within a 24-hour period occur only six or seven times each year. Rainfalls of 4 to 15 inches within a 48-hour period occur only once every 2 years, usually in the hurricane season that occurs from August to November (Jordan and Cosner 1973).

For most of the year, the USVI are outside tropical storm paths. During August and September, the easterly waves occasionally develop into tropical depressions, tropical storms, or hurricanes (Smedley 1961). Major floods have been caused by rainfall associated with storms that passed over or near the islands.

Drought is a principal concern in the USVI. Water shortages due to drought can be severe in St. Thomas because there are few perennial streams and no large storage reservoirs. The last severe drought in the USVI occurred in 1967 (Smedley 1961).

4.3.2 Wind

The prevailing wind is the easterly trade winds. Based on records of wind data collected at the Cyril E. King Airport on St. Thomas, the wind direction is almost always from the east, with a brief daily shift to the east-southeast around 2:00 p.m. From 1953 to 1958, daytime



winds averaged 14.9 mph in the strongest month (usually July) and 9.9 mph in the weakest month (usually October or November); nighttime winds are light. Along the coast, winds are affected by local thermal sea breeze conditions (NOAA 1974).

4.3.3 Temperature

From 1961 to 1990, the average temperature at Cyril E. King Airport was 80.9 degrees Fahrenheit (° F), with an average daily maximum of 87.1° F and an average daily minimum of 74.7° F. The most striking feature about the temperature in the USVI is the small variation from the coolest to the warmest months (4.6° F at Cyril E. King Airport). The daily range in temperature is also small (12.4° at Cyril E. King Airport) because of the proximity of most land areas to the ocean. Few days are hotter than 90° F because the small size of the islands does not allow for extreme heating of the passing winds (NOAA 1974; Smedley 1961). Average monthly temperatures for 1992 through 1993, and normal monthly temperatures are presented in Table 4-2.

4.3.4 Barometric Pressure

Barometric pressure was evaluated during aquifer tests conducted in 1992 and 1994 to assess the pressure effects on water levels in the aquifer. Barometric pressure readings are recorded hourly at the Cyril E. King Airport on St. Thomas. The data are collected as altimeter readings, which correlate directly with barometric pressure when measured at sea level; the airport is nearly at sea level.

One aquifer test was conducted during the week of November 1992. During this month, the average barometric pressure was approximately 995 millimeters of mercury (mm Hg), with a daily fluctuation between approximately 990 and 1,000 mm Hg. Barometric pressure data for the period of November 1 through 7, 1992 are presented on Figure 4-3. Although light rainfall occurred during the aquifer test, water-level fluctuations did not appear to be affected by barometric pressure fluctuations (Figure 4-4).



The barometric pressure during the second aquifer test (May 8 through 14, 1994) fluctuated between 992 and 1,007 mm Hg (Figure 4-5). Light and immeasurable rainfall occurred from May 9 through 13, 1994 (Figure 4-6), followed by a heavy rainfall on May 13, 1994 in which approximately 2 inches of rain fell within 30 minutes (Figure 4-6). There was no correlation between barometric pressure variations as a result of this precipitation event and water-level fluctuations.

4.4 SOILS AND VEGETATION

At least 25 different soil series in the USVI have been described (USDA 1970). These soils vary from a series characterized by steep, well-drained soils with clay loam covering volcanic rock, to a series characterized by gently sloping, poorly drained soils on top of alluvial fans. The Tutu Wells Site is underlain by the following different soil types: Cramer gravelly clay loams (CrC and CrE), Cramer-Isaac gravelly clay loam (CvE), Dorethea clay loam (DoE), Glynn clay loam (GyB), Lavalee gravelly clay loam (LaB), San Anton clay loam (SaA), and Descalabrado clay loam (DeE). Geraghty & Miller used the published USDA soil maps (USDA 1970) to produce a generalized map of the soils of the Turpentine Run Basin. This map is presented on Figure 4-7, and a description of the soil units at the Tutu Wells Site is provided in Table 4-3.

4.5 GEOLOGY

The regional information provided in this section was obtained from published technical reports, USGS publications, and Geraghty & Miller files for previous projects in St. Thomas. The site-specific information was interpreted from boring and well construction data developed during various Geraghty & Miller field investigations, supply well geologic logs in USVI agency files, and information compiled by other investigators.



4.5.1 Regional Geology

St. Thomas is a part of the Greater Antilles, a series of islands consisting of volcanic and intrusive igneous rocks deposited along the Caribbean Island arc. The basal complex of the Greater Antilles consists of igneous rocks of Mesozoic age, which are overlain by Cretaceous marine sediments and volcanic rocks (Back 1988).

The USVI are comprised of about 40 islands, cays, and rocks; the three largest are St. Thomas, St. John, and St. Croix. St. Thomas and St. John are comprised of deep ocean lava flows and shallow-ocean tuffs, breccias, and lava flows. Tectonics and contact metamorphism have lithified the volcanoclastic, angular rubble into hard, dense rocks of low permeability (Back 1988).

The bedrock in the Turpentine Run basin consists of two volcanic formations, the Water Island Formation and the younger Louisenhoj Formation. The Water Island Formation is composed primarily of deep ocean basaltic flows and breccias. It is unconformably overlain by the Louisenhoj Formation, which consists of shallow ocean, and in some cases, subaerial pyroclastic to epiblastic augite andesite tuffs and breccias (Donnelly 1959, 1966). Locally, the base of the Louisenhoj Formation consists of the Cables Point Conglomerate, which contains well-rounded and well-sorted pebbles and cobbles of the older Water Island Formation. A light-colored intrusive plug has been mapped near Mt. Zion. This intrusive rock is a quartz-andesine porphyry (Donnelly 1966).

Both the Water Island and Louisenhoj Formations are present in the upper basin. Geologic logs of wells drilled in the upper basin do not differentiate between rocks of the Water Island and the Louisenhoj Formations. In the lower basin, only the Water Island Formation is found, and it is overlain by as much as 40 feet of alluvial deposits (Jordan and Cosner 1973).



4.5.2 Site Geology

The surficial unconsolidated materials at the Tutu Wells Site consist of thin deposits of artificial fill and stream-transported sediments, which in some places overlie older Quaternary alluvial and colluvial deposits. The unconsolidated deposits overlie volcanic rock. On hills, steep slopes, and artificial cuts on the hillside, bedrock is exposed at land surface (Figure 4-8).

Geraghty & Miller's drilling programs have established that most of the shallow sediment under paved areas of the site consists of fill material and reworked native sediment. Along the axis of the valley, these sediments are underlain by Quaternary alluvial and colluvial deposits that appear to thicken southward. The alluvial and colluvial deposits present in the upper basin are relatively thin, with thicknesses usually varying from zero to 2 feet, although thicknesses as great as 10 to 30 feet have been observed in isolated valley areas. The unconsolidated deposits consist of unstratified, poorly sorted mixtures of clay, silt, sand, gravel, cobbles, and boulders transported from the upper valley and the foothills by gravity and flash floods. The USDA (1970) soil units identified at the Tutu Wells Site consist of clay loam and gravelly clay loam (Table 4-3). Average grain size increases with proximity to valley slopes.

The alluvium/colluvium is underlain by moderately weathered, fractured volcaniclastic rock in which, in some areas, the original rock components have been partially replaced by clay, chlorite, and oxide minerals. Because the unconsolidated deposits grade downward into weathered bedrock, the transition from unconsolidated deposits to weathered bedrock can be difficult to discern during drilling. In addition, the transition from weathered to competent bedrock can be gradual. For example, a thick weathered bedrock zone (14 feet thick) was encountered in the boring for Monitoring Well MW-4D. Weathered rock was encountered from 10.7 to 24.7 feet bls. This interval was characterized by high blow counts (greater than 50 blows per 6 inches or less of penetration); however, auger penetration was still possible. Split-spoon samples contained rock fragments with varying amounts of clay and gravel. More typically, split-spoon blow counts greater than 50 blows per 6 inches (or less) of penetration



coincide with auger refusal, which was interpreted by most investigators as the contact with competent bedrock.

Although weathered bedrock is usually found in the upper part of the bedrock sequence, geologic logs of some supply wells indicate that competent rock at depth is transected by zones of rock that are weathered and soft. Weathered bedrock at depth in borings drilled by Geraghty & Miller was identified based on very fast penetration of coring or drill bit and bedrock core samples that were highly weathered and friable.

The bedrock usually consists of a gray to greenish-gray volcanoclastic tuff and breccia with a fine-grained matrix and occasional clasts ranging in diameter from 1 to 5 centimeters (cm). Visible mineral grains in the matrix include plagioclase, pyroxene, epidote, hornblende, and chlorite. At some locations, a coarse-grained volcanic breccia-debris flow underlies the finer grained tuffs and breccias. The debris flow consists of poorly sorted breccia, slump blocks, and cobbles up to 20 cm in diameter. These units are compositionally similar, with occasional increases in the percent of individual minerals in some areas, but generally, grain size is the primary difference in lithologies. These rocks weather to a very weak, foliated, clay-rich material. This weathered rock consists almost entirely of alteration products, such as kaolinite, sericite, chlorite, and calcite. Usually, the original structure of these rocks is maintained where weathered (relict structure).

The thickness of the overburden at the Tutu Wells Site varies from 0 to approximately 30 feet. In addition, the thickness of weathered bedrock varies from 0 to approximately 6 feet. A consistent relationship was not observed between weathered bedrock thickness and overburden thickness. As seen on the north-south cross section on Figure 4-9, the overburden is thickest along the axis of the Turpentine Run Valley (in which Route 38 generally lies) and thinnest on valley slopes and hilltops. The topography of the Tutu Wells Site is shown on Figure 4-1.

Based on a review of lithologic descriptions and blow counts recorded on available drilling logs, the overburden in the northern portion of the Tutu Wells Site (near the Curriculum Center)



ranges in thickness from 2 to 5 feet. This area is a topographic high and the weathered bedrock is generally thin (Figure 4-8).

In the Turpentine Run valley, in the vicinity of the Texaco Tutu Service Station, the overburden thickness increases from approximately 2.5 feet along the valley edge (Monitoring Well TT-3D) to 16.5 feet within the valley (at Monitoring Well TT-1D). The thickness of weathered bedrock in this vicinity is approximately 6 feet.

At Four Winds Plaza, the overburden increases in thickness from approximately 3 feet (at Monitoring Well MW-2) to 30 feet (at Monitoring Well CHT-4). Weathered bedrock is less than 5 feet thick in this vicinity. Near the Esso Tutu Service Station, the overburden is between 5 and 29 feet thick (Figure 4-8). Weathered bedrock was observed at a depth of 2 to 3 feet, near an inferred geophysical anomaly, in the northeastern portion, and at 12 to 14 feet at the southern portion of the Esso Tutu Service Station. Both Four Winds Plaza and the Esso Tutu Service Station are within the Turpentine Run valley. Examination of available drilling logs indicates that the overburden at the Tom Cat Laundry and O'Henry is between 10 and 20 feet thick (Figure 4-8). West of O'Henry, the overburden thickness in the valley is approximately 24 feet (e.g. near Monitoring Well OHMW-2).

4.5.2.1 Inspection of Bedrock Exposures

Several bedrock outcrops were examined by Geraghty & Miller during the RI, including the following three extensive outcrops: an outcrop located behind the Seventh Day School along Route 38, an outcrop located behind Four Winds Plaza, and an outcrop behind the Tutu Park Plaza. All three outcrops contain the same succession of rock types, a volcanoclastic tuff that in some areas overlies coarser-grained breccias and debris flows. These three lithologies were observed in the subsurface during drilling, as indicated by the Phase I RI bedrock core logs (submitted in Appendix A of Technical Memorandum II [Geraghty & Miller, Inc. 1993a]). These outcrops and other small outcrops are shown on Figure 4-1.



At the outcrop behind the Seventh Day School, bedding planes dip steeply (between 54° and 67°) to the northeast and strike N61°W to N88°W; these orientations agree with the strike and dip measurements reported in the literature (Donnelly 1966). The predominant rock matrix is volcanoclastic tuff, alternating with thin to massive beds of volcanoclastic flow breccias. The breccias include visible, angular to rounded, volcanic and sedimentary clasts that range in size from pebbles to cobbles.

The bedrock is exposed on the northwestern side and the southwestern corner of Four Winds Plaza. The northern outcrop consists of fine-grained, light green andesite. The southern outcrop is composed of green andesite but is more fractured than the northern exposure. The southern portion of the outcrop at Four Winds Plaza consists of volcanic breccias, debris flow, boulders, and slump blocks of the Cables Point Conglomerate (See Figure 4-1).

The rock face exposed at Tutu Park is relatively fresh and illustrates a succession of volcanoclastic rocks from south to north. This succession consists of basal, coarse-grained debris flows and breccias overlain by finer-grained andesitic tuffs. These units strike to the northwest, with measured strikes in the range of N36°W to N50°W, and dip to the southwest at 40° to 85°. The coarse-grained volcanic breccias are massive, with extensive columnar jointing and sheeting. The fine-grained andesitic tuffs are more extensively weathered. On slopes where this finer-grained material outcrops, it has been altered to a light-green, friable talus.

4.5.2.2 Thin Section Analysis

Samples were retained for thin-section petrographic analysis at the following four Phase I RI bedrock boreholes: Monitoring Wells MW-4D (from 59 to 60 feet bls), MW-6D (from 51.2 to 51.6 feet bls), MW-11D (from 73.5 to 74 feet bls), and MW-13D (from 65 to 70 feet bls). These samples provided additional information regarding the petrography of rock types. The thin-section analyses were performed by Western Atlas International (1992). The four samples were identified as gabbro (Monitoring Well MW-4D), basalt (Monitoring Well MW-6D), diorite (Monitoring Well MW-11D), and reworked andesite (Monitoring Well MW-13D).



Detailed petrographic descriptions were provided in Western Atlas International's report, which is provided in Appendix E.

4.5.2.3 Site Stratigraphy

The stratigraphy of the site was interpreted from Phase I RI bedrock core logs, which are included in Appendix B of Technical Memorandum II (Geraghty & Miller, Inc. 1993a). No additional coring was conducted during the Phase II RI. Figure 4-9 presents a north-south cross section through the Tutu Wells Site. Review of Figure 4-9 shows the presence of volcanic breccias and debris flows overlain by the finer-grained andesite tuffs. The Cables Point Conglomerate underlies the volcanic breccias and occurs at a depth of approximately 85 to 90 feet bls, as observed at two wells (Monitoring Wells CHT-6D and CHT-7D). The Cables Point Conglomerate is present at the surface within the southern half of Four Winds Plaza, less than approximately 200 to 300 feet from these two wells (Figure 4-1). Based on the change in depth of the Cables Point Conglomerate and the occurrence of fracture lineaments trending north to south between the two locations, a fault zone is inferred (Figure 4-1). A discussion of the fracture trace analysis is presented in Section 4.5.3 (Fracture Analysis).

Stratigraphic correlation of the rock units between borings is not feasible due to the steep angles (60° to 80°) at which the rock layers dip and the large distances between borings and monitoring wells. Bed thicknesses range from very thin to massive, and strata are reported to dip north to northeast at angles of 60° to 80° (Donnelly 1966). Geraghty & Miller's geologic reconnaissance of the area confirmed these trends. The rocks are reportedly faulted approximately 2,500 feet northeast of the site and are locally cut by steeply inclined joints. Most joints are filled with calcite. The weathered, less competent bedrock noted in core logs can be correlated with the occurrence of volcanoclastic andesitic tuffs. This correlation may be due to the preferential development of joints in the more homogenous lithology and texture of the volcanoclastic tuff as compared to the volcanic breccia. Fracture sets, however, appear to transect all lithologic units.



The matrix of the volcanoclastic rocks shows signs of low-grade, contact metamorphism and hydrothermal alteration. The minerals that compose the rock matrix have been weathered and transformed into clayey sediment in some areas. This matrix, when weathered, maintains its original structure.

Evidence of intrusive rock was observed in Monitoring Wells MW-11D and MW-4D. These intrusive rocks are interpreted to be diorite; dioritic dikes have also been observed in the bedrock outcrop north of Tutu Park Mall. These intrusive bodies are probably the source of heat that caused the localized contact metamorphism. Diorite is a coarse-grained intrusive rock composed mainly of sodic plagioclase and hornblende, with variable amounts of quartz, biotite, and/or pyroxene. Samples of this unit from Monitoring Well MW-11D are described as a very dense, dark green to black rock matrix with visible, abundant plagioclase phenocrysts (large, well-shaped crystals). The diorite contained abundant, thin veins of calcitic minerals throughout the rock matrix.

4.5.3 Fracture Analysis

A fracture analysis was performed during the Phase I RI to evaluate fracture trends in the vicinity of the Tutu Wells Site. In addition, CDM performed an independent fracture trace analysis (CDM 1992). This information aided in the identification of possible preferential groundwater flow directions and the placement of wells. The analysis included aerial photograph interpretation, field reconnaissance, bedrock core fracture analysis, and interpretation of borehole geophysical logging. The fracture traces identified by both Geraghty & Miller and CDM are depicted on Figure 4-1.

4.5.3.1 Aerial Photographic Interpretation Results

In 1992, Geraghty & Miller carried out a fracture trace analysis during the Phase I RI. Forty-seven linear features within an approximate 1-mile radius of the site were identified on aerial photographs (Geraghty & Miller, Inc. 1992b). An azimuth frequency (rose) diagram was



prepared by plotting the azimuth of each fracture trace identified (Figure 4-10). The rose diagram is useful in identifying trends and groupings of fracture traces. As shown by the rose diagram, the lineaments are bimodal with most lineaments trending N48°E or N70°W.

The fracture trace analyses of the Tutu Wells Site confirmed the presence of two major fracture lineaments within the study area. A northeast-southwest lineament is located north of the Curriculum Center Building and intersects the existing supply wells at the VIHA and Ramsay properties (Figure 4-1). A second fracture trace with a north-south trend, near Route 38, intersects the northeast-southwest lineament within the Ramsay property (Figure 4-1). The presence of these two intersecting fracture lineaments may provide zones of preferential groundwater flow. Under natural conditions, groundwater may flow more readily from the vicinity of the VIHA in a southwest direction along the first fracture trace until it intersects the north-south fracture lineament on the Ramsay property. Monitoring Wells MW-1, MW-1D, MW-13, MW-13D, and MW-16 are located within approximately 100 feet south of the northeast-southwest lineament. Preferential groundwater flow may continue southward along the fracture system, which coincides with the axis of the Turpentine Run valley. Monitoring Wells MW-2, MW-6, and MW-6D were located in the vicinity of the north-south lineament near the intersection with the northeast-southwest lineament (Figure 4-1).

The higher intensity of bedrock fracturing along major lineaments has had a controlling effect on site topography. Where the bedrock is more fractured, the rock is more susceptible to erosion. The principal, narrow valleys in the site are developed along these lineaments. The major, north-south trending valley that parallels the stretch of Route 38 between the Texaco Tutu Service Station and the Rodriguez Esso Service Station runs along a major lineament, as do the northeast-southwest trending valley along the stretch of Route 38 between the VIHA offices and the Texaco Tutu Service Station, and the northwest-southeast trending valleys southeast of O'Henry and along the section of Route 32 extending southeast from Rodriguez Esso. Previous aerial photograph analysis by the USGS (1979) identified northwest-southeast lineaments from the northern peninsula at Magen's Bay towards the Turpentine Run. Geraghty & Miller's (1992b) fracture trace analysis was performed without knowledge of this previous



USGS (1979) interpretation. The northwest-southeast lineaments have been corroborated by independent interpretation by Geraghty & Miller (1992b), CDM (1992), and the USGS (1979).

It should be noted that fracture trace analysis from aerial photographs is subject to interpretation and this analysis should not be considered as a definitive identification of all possible fractures present at the site. However, this analysis and other investigative techniques can assist with site characterization.

4.5.3.2 Bedrock Outcrop Fracture Analysis Results

GCL in 1987 and Geraghty & Miller in 1992 and 1993 measured the orientations of bedrock outcrop fractures. These measurements are plotted on Figure 4-1. There are two primary orientations of major bedrock outcrop fractures in the upper Turpentine Run basin. GCL made measurements at outcrops exposed west of Four Winds Plaza (west side of valley) and east of the Seventh Day School (east side of valley). Major fracture systems striking north-northeast were observed on both sides of the valley. However, fractures located on the west side of the valley dip to the southeast, while those located on the east side of the valley dip to the northwest. Consequently, these two systems differ by about 60° in actual fracture orientation. It is not known whether there is an abrupt transition along a defined boundary between these two systems at some point within the valley, or whether the orientation of the fractures rotates gradually from one position to the other across the valley (Geoscience Consultants, Ltd. 1988). The inferred fault zone near the axis of the valley suggests that an abrupt transition is more likely.

GCL also observed a subsidiary fracture system striking N84°W and dipping to the south. Geraghty & Miller's strike measurements at outcrops located east and northeast of the Seventh Day School were similar, with measured strikes of N60°W to N88°W and dips to the northeast (Figure 4-1).



Strike-slip faults oriented northwest-southeast have been observed in the eastern portion of St. Thomas (Donnelly 1966). One of these faults occurs approximately 2,500 feet northeast of the Tutu Wells Site, but none was observed in the immediate vicinity of the site. These faults were located by Donnelly (1966) by mapping the offset of formation contacts.

4.5.3.3 Bedrock Core Fracture Analysis

Bedrock cores collected in June, July, and August 1992 were analyzed by Geraghty & Miller geologists to identify significant fracture zones and lithologic boundaries. Descriptions of the cores were provided in Appendix B of Technical Memorandum II (Geraghty & Miller, Inc. 1993a). Rock quality parameters were assigned to core intervals of similar fracture frequency. Specifically, these parameters included Grade of Decomposition (D), Grade of Strength (S), and Grade of Fracturing (F).

Analysis of bedrock core indicates that the most significant fracturing occurs in the fine-grained andesite tuff unit and the least amount of fracturing occurs in the coarse-grained breccia/debris flow unit. The latter unit is also located lower in the sequence, and hence deeper in the boreholes. Decreased fracturing in this unit may be due to pressure of the overlying rock, rather than lithology.

4.5.3.4 Borehole Geophysical Results

The primary objective of the geophysical logging program was to identify bedrock fractures or fracture zones that may serve as preferential pathways for groundwater flow. Caliper logs and sonic logs were run at the following seven Phase I RI bedrock boreholes: Monitoring Wells MW-1D, MW-4D, MW-6D, MW-10D, MW-11D, MW-12D, and MW-13D. The geophysical logs are provided in Appendix F.



Caliper logs record any deviation in the diameter of the borehole (aperture). These deviations may be attributed to well construction, such as the presence of couplings and casing, or to the presence of fractures or weak zones in the bedrock.

Sonic logs record the time required for a compressional sound wave to traverse 1 foot into the formation (known as interval transit time). The interval transit time is affected by the lithology and porosity of the surrounding rock. A fractured or highly weathered zone will increase the transit time. Sonic logs also record the amplitude of the returning sonic signal. The amplitude is decreased across fracture zones.

The two components, transit time and amplitude, make up the full wave form response, which is recorded on the logs as a Variable Density Log (VDL). The VDL is a three-dimensional velocity log that indicates changes in wave form by variations in the darkness of the log. Low amplitude waves and slower velocities (which are equivalent to greater transit times) occur in fractures or weathered zones and are depicted on the VDL as "cycle-skips" or dark wedge-shaped areas on the log.

Based on the caliper and sonic logs, fracture zones were identified in the boreholes of the seven wells. The interpreted fractures should be verified by either drilling observations (i.e., loss of drilling fluids) or coring observations (direct observation of fractures or weathered zones). Information regarding the identified fracture zones is summarized in Table 4-4.

4.6 HYDROGEOLOGY

Regional hydrogeologic information for the area was obtained from USGS studies and other published reports. The site hydrogeology was evaluated using data collected by Geraghty & Miller and other investigators during the installation of monitoring wells at the Tutu Wells Site.



4.6.1 Regional Hydrogeology

The regional direction of groundwater flow in the Turpentine Run basin, as determined by Graves and Gonzales (1988), is to the southeast (Figure 4-11). As expected, groundwater flows from the highland areas toward and down the axis of the principal valleys. Groundwater in the Turpentine Run basin occurs in two aquifers (Jordan and Cosner 1973). The primary aquifer is the fractured volcanic rock of the Water Island and Louisenhoj Formations and, locally, the Cables Point Conglomerate. The secondary aquifer consists of the alluvial deposits in the lower Turpentine Run basin. The Tutu Wells Site is located in the Upper Turpentine Run basin, which is the portion of the drainage basin upstream of the USGS gauging station near Mt. Zion. Very thin alluvial deposits are also present in the upper basin, with thicknesses varying from less than 2 feet to 30 feet in isolated valley areas. However, these deposits do not constitute an aquifer capable of supplying useable amounts of water because of their limited extent and thickness, and because they are often unsaturated. Most of the alluvial deposits, where saturated, are usually hydraulically connected to the fractured volcanic rock. Saturated alluvial deposits most commonly occur where the bedrock surface was incised by former streams and then filled with sediments or fill. An exception to this condition was observed at Western Auto, where the alluvial deposits were only saturated in a perched zone within a gravel layer.

Groundwater in both units generally exists under unconfined or water-table conditions. Localized low permeability (fine-grained) layers in the alluvial deposits may result in perched water and possible confined bedrock conditions of limited extent. The bedrock aquifer may be partially confined in places by zones of relatively unfractured shallow rock.

Groundwater is stored and transmitted in fractures in the bedrock, which behaves as an unconfined aquifer. The water table occurs at depths of 5 to 106 feet bls, with the greater depths occurring at the higher elevations (in the northern part) of the Tutu area (Geraghty & Miller, Inc. 1993a). Since the groundwater is transmitted principally through fractures and the rock is more fractured along major lineaments, the aquifer demonstrates vertical, as well as horizontal, anisotropy.



In the upper basin, groundwater supply is derived from wells installed in the fractured volcanic rock. Supply well depths in the upper basin range from 73 to 325 feet bls (Stevens et al. 1981). The depths of these wells do not correlate with yield, but rather are an indication of where water-bearing fracture zones were penetrated. Short-term well yields in the upper basin range as high as 100 gpm; sustained yields range between 2 and 21 gpm (Jordan and Cosner 1973).

Very little incident precipitation reaches the saturated zone as groundwater recharge. On St. Thomas, evapotranspiration may consume 95 percent or more of rainfall (Jordan and Fisher 1977). The small fraction of incident precipitation that is not lost to evapotranspiration or storm-water runoff percolates downward through the thin overburden, or where overburden is not present, directly into the interconnecting network of fractures that transect the rock.

Recharge to the fractured volcanic rock in the upper basin results primarily from occasional major rainstorms and is dependent on the frequency and volume of rainfall. As a result of surface runoff and a high evapotranspiration rate, rainfall of at least 2 inches within a 24-hour period is necessary for recharge to occur. Annual recharge to the upper basin due to rainfall is estimated to be 130 million gallons (Jordan and Cosner 1973).

Prior to 1992, few data were available to evaluate the hydraulic characteristics of the Turpentine Run basin aquifers. Of the six pump tests conducted in the basin prior to 1982, only one test (location unknown) indicated a specific capacity greater than 1 gallon per minute per foot (gpm/ft) of drawdown. The specific capacity of that well was between 1 and 2 gpm/ft (Stevens et al. 1981).

Natural groundwater flow is primarily horizontal in the central portion of the Tutu area, but a downward component to groundwater flow was measured in the northern portion. Under pumping conditions, downward flow would be further induced within the zone of influence of the pumping well(s).



The bottom of the Tutu aquifer is not well defined. The physical bottom of the aquifer is the depth at which the fracture intensity diminishes and the fractures are no longer sufficiently interconnected to allow for significant groundwater flow. No information is available to indicate at what depth this phenomenon occurs. Chemically, the bottom of the aquifer could be defined by the transition from groundwater of natural chemistry acceptable for consumption to more mineralized water that can no longer be feasibly used or treated for public or commercial supply. There is limited evidence that groundwater below a depth of about 300 feet in the central and northern portion of the Tutu area is relatively mineralized connate water (Geraghty & Miller, Inc. 1983). In the southern portion of the Tutu area, the freshwater/saltwater interface may occur at shallower depths.

4.6.2 Site Hydrogeology

Supply wells and monitoring wells have been installed throughout the Tutu Wells Site. The supply wells generally consist of open boreholes that extend over a large vertical interval. The supply wells range in depth from 73 to 325 feet bls (Stevens et al. 1981). The monitoring wells installed during Phase I and Phase II of the RI, and most of the monitoring wells installed by other investigators, were constructed to have open intervals of limited vertical extent, usually 10 to 20 feet. Shallow monitoring wells were usually constructed so they would bridge the water table. The monitoring wells designated as "deep" monitoring wells were constructed with 20-foot long, open intervals separated from the bottom of the very shallow monitoring wells by 20 vertical feet. The total depths of the deep monitoring wells generally extend to 45 to 120 feet bls.

Therefore, three general zones or depths are monitored by the existing wells. The shallow monitoring wells monitor the zone extending 8 to 10 feet below the water table; the deep monitoring wells monitor the zone from 30 to 50 feet below the water table; and the supply wells monitor the entire thickness of the aquifer extending down to 200 feet or more bls.



Regional and site-specific groundwater contour maps have indicated that groundwater flows toward and down the axis of the principal valleys (Figures 4-11 through 4-15). The fractures of the upper portion (down to at least 100 feet bls) of the aquifer are interconnected to varying degrees. Based on boring logs for Deep Test Well #1 (Monitoring Well CHT-7D) and Four Winds Plaza Supply Wells, located under the Four Winds Plaza parking lot, the interval between 40 to 90 feet bls is less fractured than the interval from 0 to 40 feet bls (Hydrologic Associates U.S.A., Inc. 1993a). Larger fracture zones occur in the lower portion of the aquifer in the vicinity of Four Winds Plaza from approximately 90 to 200 feet bls, based on the boring log for Deep Test Well #2 (Monitoring Well CHT-6D).

The vertical distribution of fractures observed in the Four Winds Plaza parking lot may not be indicative of the entire Tutu Wells Site. For example, water-level measurements collected during the Phase I RI showed that Monitoring Well MW-1D responded to apparent pumping stress of a nearby supply well, while adjacent Monitoring Well MW-1 did not respond, suggesting that the shallow fractures under the vicinity of the Curriculum Center are not well interconnected with the deeper fractures intercepted by Monitoring Well MW-1D (open from 70 to 90 feet bls) and the deeper supply wells. Observations of water-level responses to pumping are the most useful method of determining interconnectivity of fractures intersected by wells.

In general, the bedrock aquifer at any location and depth contains zones of varying degrees of fracturing. The logs of supply wells indicate that the bedrock consists of alternating zones of softer weathered rock and competent harder rock.

Synoptic water-level data were obtained during the Phase II RI. Measurements were collected from 43 shallow monitoring wells and 14 deep monitoring wells installed at the Tutu Wells Site (see Table 4-5). Of these, nine locations contained clustered monitoring well pairs (Monitoring Wells MW-1/MW-1D, MW-4/MW-4D, MW-6R/MW-6D, MW-8/DW-1, MW-10/MW-10D, MW-13/MW-13D, MW-20/MW-20D, SW-6/DW-2, and TT-1/TT-1D). The locations of the wells are shown on Figure 1-3 and monitoring well construction details are provided in Table 3-2.



The shallow monitoring wells, which range in depth from 15.0 to 128 feet bls, and the deeper monitoring wells, which range in depth from 45 to 120 feet bls, generally penetrate low-yielding sections of the bedrock aquifer. With the exception of six monitoring wells in the northern portion of the Tutu Wells Site (described below), most of the monitoring wells installed by Geraghty & Miller cannot sustain pumpage of even minimal flow rates (i.e., 2 gpm). Most of these shallow wells do not intersect the major water-bearing fractures that provide water to existing supply wells.

Monitoring Wells MW-3, MW-4, MW-4D, MW-6R, MW-6D, and MW-16 are the only monitoring wells that could be pumped continuously during development and sampling. These wells are located in an area where aerial photograph analyses by both Geraghty & Miller and CDM have identified a concentration of intersecting fracture traces (Figure 4-1). Monitoring Wells MW-6R and MW-6D are located in the northern part of the Four Winds Plaza parking lot, where two major fracture traces intersect.

4.6.2.1 Shallow Bedrock Groundwater Flow

Twenty-two shallow monitoring wells were installed by Geraghty & Miller at the Tutu Wells Site. The total depths of the shallow wells range from 15.0 to 128 feet bls. Most shallow wells were installed with screens or open borehole intervals that bridge the water table, with the exception of Monitoring Wells MW-9, MW-24, MW-15, and MW-25. After it was determined that deeper Monitoring Well MW-9 had been constructed with the top of the screened interval slightly below the water table, Monitoring Well MW-9S was installed with the top of the screen above the water table. Monitoring Well MW-24 was constructed with an open interval completely below the water table because this well was installed beneath the location of the former USTs behind Western Auto. To prevent the potential migration of contaminants from saturated fill due to perched water in the former UST excavation (and observed to extend under the Four Winds Plaza), Monitoring Well MW-24 was installed with a double casing, including a 10-inch diameter steel casing into the top of bedrock to seal off the fill/overburden unit prior to drilling and with a 6-inch diameter, stainless-steel casing to 7 feet below the top of bedrock.



Monitoring Well MW-24 has an open interval from 18.0 to 38.5 feet bls (7.0 to 27.5 feet below the top of bedrock). This well was specifically constructed in this manner to allow for evaluation of groundwater quality in the bedrock unit and to prevent the potential for downward migration of contaminants during the drilling and well construction procedures. Shallow Monitoring Wells MW-15 and MW-25 were installed with open intervals below the water table (rather than intersecting the water table) because these wells were intended to assess groundwater quality in the bedrock unit, and the water table at these locations is near the top of bedrock (at Monitoring Well MW-15) or above the top of the bedrock (at Monitoring Well MW-25).

Groundwater flow in the shallow zone is consistently toward the south. Water-level measurements collected from shallow wells on May 10 and May 23, 1994 were used to construct the water-level contour maps shown on Figures 4-12 and 4-13. These figures show that shallow groundwater flow from the east and west converges beneath Route 38, toward what appears to be the axis of the Turpentine Run basin. One of the principal fractures identified in the aerial photograph analysis is oriented along Route 38 (CDM 1992); this fracture zone appears to act as a shallow groundwater discharge zone. The former stream channel of the Turpentine Run was located along this fracture zone. The channel has been filled, and surface drainage is channelized through a storm sewer under the area (Figure 4-2).

Shallow groundwater flow is characterized by a steep hydraulic gradient (see Figures 4-12 and 4-13). This steep gradient may be indicative of the low overall permeability of the zone penetrated by the shallow wells. The gradient is less steep in the area that includes the Texaco Tutu Service Station and the north portion of the Four Winds Plaza parking lot, indicating that the shallow zone may have a higher permeability in this area. This observation agrees with the information collected during well development. Monitoring Wells MW-3, MW-4, and MW-6R could sustain pumpage at pumping rates of approximately 2 gpm. The hydraulic gradient of the shallow portion of the aquifer steepens again in the vicinity of the Esso Tutu Service Station. Monitoring wells at and near the Esso Tutu Service Station have been pumped dry during well development and groundwater sampling. Aquifer test results for Monitoring Well MW-6R also indicate relatively high transmissivity and hydraulic conductivity values compared to other areas.



4.6.2.2 Deep Bedrock Groundwater Flow

Ten deep monitoring wells were installed by Geraghty & Miller during Phases I and II of the RI at the Tutu Wells Site. Total depths of the deep monitoring wells varied from 45 to 120 feet bls. All deep monitoring wells, except Monitoring Well MW-12D, were installed with solid casing above an open borehole interval of approximately 20 feet. Monitoring Well MW-12D was completed with solid stainless-steel casing and slotted screen to avoid borehole collapse. Water levels measured in deeper monitoring wells on May 10 and 24, 1994 were used to construct the water-level contour maps shown on Figures 4-14 and 4-15. These maps indicate that the general gradient of groundwater flow in the deeper zone at the Tutu Wells Site is also to the south, with a southeast component in the southern part of the study area. In the northern portion of the site near Monitoring Well MW-6D, a more gentle gradient may indicate that a more permeable zone in the shallow bedrock also extends downward into the deeper monitored portion of the bedrock. Aquifer test results for Monitoring Well MW-6D indicate relatively high transmissivity and hydraulic conductivity values compared to other areas.

4.6.2.3 Vertical Gradients

Based on the water-level data measured since September 1992 at the nested well locations (where there is a deep well that is appreciably deeper than a shallow well), the vertical hydraulic gradient in the vicinity of the nested wells was determined. In general, there is a slight downward vertical hydraulic gradient throughout most of the study area (Tables 4-6 and 4-7). A slight upward gradient was observed in mid-May and mid-June 1994 in the northeastern portion of the Tutu Wells Site in Monitoring Wells MW-13/MW-13D. This upward gradient may be attributed to the slow recovery of Monitoring Well MW-13 after it was developed on May 9, 1994. Pumpage of supply wells at the VIHA complex may increase the downward vertical hydraulic gradient in the northeastern portion of the Tutu Wells Site, which may explain the steep downward gradient observed at Monitoring Wells MW-13/MW-13D on July 20, 1994. As expected, a generally horizontal or slightly upward gradient is present near the former stream channel of the Turpentine Run (Monitoring Wells MW-6R/MW-6D). A predominantly



downward gradient was observed most often in the Upper Turpentine Run Basin at Wells MW-1/MW-1D, TT-1/TT-1D, MW-4/MW-4D, MW-8/DW-1, MW-10/MW-10D, and SW-6/DW-2. The steepest downward vertical gradient was observed at Monitoring Wells MW-20/MW-20D based on water levels collected at the well pair on May 24, 1994 (Table 4-7). However, this steep downward gradient may be a result of the incomplete recovery of Monitoring Well MW-20D after development on May 17, 1994.

4.6.2.4 Seasonal Groundwater Elevation Fluctuations

A comparison of water-level measurements in September 1992, November 1992, and May 1994 indicates that seasonal water levels at the Tutu Wells Site fluctuate in most wells by approximately 2 to 5 feet. October and November are typically the wettest months, and February and March are usually the driest (NOAA 1992). Review of Table 4-1 shows that 1992 was a year of unusually high precipitation preceded by several dry years; there were nearly 11 inches of rain in November 1992.

Comparison of water-level elevations in November 1992 to both September 1992 and May 1994 indicates the highest water-level elevations occurred during November 1992 (Table 4-5). The greatest fluctuations occurred in wells located in the northern portion of the site. Some extreme fluctuations, such as at Monitoring Wells MW-1D (15 feet), MW-13D (28 feet), and MW-16 (30 feet), were probably due to pumpage of VIHA supply wells. Seasonal variations should be considered during remedial design, but fluctuations caused by pumping will be the more dominant factor locally.

4.6.2.5 Shallow Bedrock Hydraulic Characteristics

In November 1992 as part of the Phase I RI, Geraghty & Miller conducted an aquifer test at Monitoring Well MW-6R located at the Four Winds Plaza. This well was pumped for approximately 24 hours at a rate of 9.25 gpm. Monitoring Well MW-6R was selected for its ability to sustain a high yield, whereas other shallow wells could not.



The water-level data collected from Monitoring Well MW-6R during the aquifer test were analyzed using the computer software AQTESOLV. This program was written by Geraghty & Miller and allows the user to analyze the time-drawdown data using standard industry techniques. The drawdown data from Monitoring Well MW-6R were superimposed on Theis and Bolton type curves before a determination was made that the Cooper-Jacob straight line method was more appropriate. The Cooper-Jacob straight line method was used to determine the aquifer coefficients of transmissivity (T) and storage (S). This method involves plotting the time-drawdown data on semi-log graph paper and was designed for analysis of confined conditions (Cooper and Jacob 1946). To apply this method for analysis of unconfined conditions (such as occur at the Tutu Site), drawdown values may need to be corrected to compensate for the decrease in saturated thickness that occurs as the test proceeds. Because excessive drawdown (greater than 20 percent of the assumed aquifer thickness) was not present during this pumping test, correction of drawdown values was not necessary. The aquifer coefficient of transmissivity was calculated as follows:

$$T = \frac{264Q}{\Delta s}$$

where

T	=	transmissivity, in gallons per day per foot (gal/day/ft)
Q	=	pumping rate, in gallons per minute
Δs	=	slope of the time-drawdown graph expressed as the change in drawdown between any two times over one log cycle.

The aquifer coefficient of storage (or storativity) was calculated as follows:

$$S = \frac{0.3Tt_0}{r^2}$$

where

S	=	storage
T	=	transmissivity, in gal/day/ft
t_0	=	intercept of the straight line at zero drawdown, in days
r	=	distance in feet from the pumped well to the observation well where the drawdown measurements were made.

Figure 4-16 illustrates the semi-log plot for the time-drawdown relationships for Monitoring Well MW-6R and the calculated values of T in units of square feet per minute (ft^2/min) and S. The value for T, as illustrated on Figure 4-16, was calculated from the late time-drawdown data,



because the early data appear to represent the initial dewatering of the well casing and may not be representative of the aquifer materials. Table 4-8 presents a summary of the calculated T and S values for the pumping tests. Because the hydraulic property of S cannot be determined from drawdown data collected at a pumping well, a value for S for Well MW-6R is not included.

Based on the analysis of the water-level data for this well, the transmissivity of the shallow aquifer in the immediate vicinity of the Four Winds Plaza is estimated to be 8.39 ft²/min (90,360 gal/day/ft). This transmissivity value is most likely higher in comparison to representative transmissivity values for the majority of shallow bedrock at the site, since Monitoring Well MW-6R is located near the intersection of the two major fracture zones (see Figure 4-1). Most of the shallow monitoring wells showed much lower yields during development and sampling. Because confining units were not identified at most locations during the drilling program, the shallow portion of the bedrock is unconfined.

4.6.2.6 Deep Bedrock Hydraulic Characteristics

Numerous aquifer tests have been conducted in the Tutu area (Geraghty & Miller, Inc. 1983 and 1993a; Hydrologic Associates U.S.A., Inc. 1993b; and Hamlin 1985). The transmissivity of the aquifer is at least an order of magnitude higher along the valleys than it is in areas removed from the axes of the valleys. The distribution of transmissivity values calculated for the Tutu aquifer is shown on Figure 4-1. The highest transmissivities occur where major lineaments intersect, such as in the north portion of the Four Winds Plaza parking lot (near Monitoring Wells MW-6, MW-6D, and CHT-6D). The pumping tests for which data are shown on Figure 4-1 are discussed in greater detail in the Phase II RI Work Plan (Geraghty & Miller, Inc. 1993b).

Pumping tests were performed during the Phase I RI at Monitoring Well MW-6D and the Eglin III Supply Well during the Phase II RI. In addition to a constant rate aquifer test at the Eglin III Supply Well, a simulated pumping cycle test was performed to evaluate drawdown under these conditions. The aquifer characteristics determined from these tests are shown on



Figure 4-1 and in Table 4-8. Data collected from the deep portion of the bedrock aquifer allowed for calculation of more representative aquifer characteristics.

4.6.2.6.1 Monitoring Well MW-6D Aquifer Test Analysis

In November 1992, Geraghty & Miller conducted a pumping test at Monitoring Well MW-6D (Geraghty & Miller, Inc. 1993a). This well was pumped for approximately 24 hours at a flow rate of 14.2 gpm. Water-level data collected from Monitoring Wells CHT-6D (used as an observation well) and MW-6D were analyzed using AQTESOLV. The drawdown data from Monitoring Wells CHT-6D and MW-6D were initially superimposed on Theis and Bolton type curves before determining that the Cooper-Jacob straight line method was appropriate. As previously stated, the Cooper-Jacob straight-line method involves plotting the time-drawdown data on semi-log graph paper (Cooper and Jacob 1946). After the data were plotted, the aquifer properties of T and S were calculated.

Figures 4-17 and 4-18 illustrate the semi-log plots for the time-drawdown relationships for Monitoring Wells CHT-6D and MW-6D, respectively, during pumping of Monitoring Well MW-6D. Because the hydraulic property of storage cannot be determined from the pumping well drawdown data, a value for S for MW-6D is not illustrated on Figure 4-18.

Based on analysis of the water-level data for these wells, the transmissivity of the deeper parts of the aquifer in the immediate vicinity of Four Winds Plaza is estimated to range from 5.2 to 8.14 ft²/min (56,010 to 87,673 gal/day/ft). Although no confining units were identified during the drilling program, the calculated S of 0.0007 from the CHT-6D time-drawdown relationship is more representative of a partially confined aquifer (see Table 4-8). As previously discussed, less fractured zones in the upper portion of the bedrock may act to partially confine the deeper portion of the bedrock where fractures are more prominent and are interconnected.



4.6.2.6.2 Eglin III Supply Well Aquifer Test Analysis

In May 1994, Geraghty & Miller performed an aquifer test and a pumpage impact test at the Eglin III Supply Well. The Eglin III Supply Well was pumped for approximately 24 hours at a flow rate of 31 gpm. The pumping rate was then increased to 41 gpm for approximately 9 more hours.

Water-level data collected at the pumping well (Eglin III) could not be analyzed for the following reasons: (1) The first portion of the data represents a drawdown rate attributable to well storage; (2) the second portion of the data represents a drawdown rate attributable to dewatering of the upper portion of the aquifer; and (3) the third portion of the data represents a drawdown rate attributable to pumpage of the lower portion of the aquifer. The net effect of the different responses to pumping (i.e., different drawdown rates) is a variable rate pumping test, which, in this case, cannot be analyzed by standard analytical methods. In addition, the recovery data for this well were incomplete due to an equipment malfunction; therefore, recovery analysis could not be performed. The specific capacity of the Eglin III well was calculated to be 0.39 gpm/ft, based on the pumping rate of 31 gpm and the drawdown of 78.8 feet observed at 08:00 hours on May 12, 1994.

Although water-level data from the Eglin III Supply Well (pumping well) could not be evaluated, drawdown data collected from the Eglin II Supply Well, which was used as an observation well, were evaluated using the Cooper-Jacob straight-line method (Cooper and Jacob 1946) and the Theis Recovery Solution (Theis 1935) with AQTESOLV. The Cooper-Jacob semi-log plot is shown on Figure 4-19, and the Theis type-curve is shown on Figure 4-20.

Recovery data collected at the Eglin II Supply Well were analyzed using the Theis Recovery Solution (Theis 1935). The recovery curve is plotted with residual drawdown (d) on the vertical axis and the time that the pump was shut off (t) divided by the elapsed time since the pump was shut off (t') on the horizontal axis (Figure 4-21). As such, the data are depicted in the reverse order from the other time-drawdown graphs. On Figure 4-21, data collected at



the beginning of recovery are plotted on the upper right portion of the curve, and data collected at the end of recovery are plotted on the lower left of the curve.

Based on the data from the Eglin II Supply Well, the T of the deeper portion of the aquifer in the vicinity of the Tom Cat Laundromat and Archie's Welding is estimated to range from 0.177 to 0.2112 ft²/min (1,907 to 2,275 gal/day/ft). The calculated S of the aquifer is 7×10^{-5} (Table 4-8).

The water-level data collected at deep Monitoring Wells DW-2, MW-11D, MW-12D, and MW-21D, and shallow Monitoring Wells SW-6 and OHMW-3 all appear to be influenced by nearby pumping wells in addition to pumpage of the Eglin III Supply Well. The data could not be analyzed for aquifer characteristics because of this interference. A discussion of these water-level data is presented in Section 4.6.2.8.2 (Deep Bedrock Response).

4.6.2.7 Hydraulic Conductivity Values

Aquifer transmissivity values calculated from pumping tests can be used to derive hydraulic conductivity estimates. Transmissivity (T) is the product of the hydraulic conductivity (K) times the aquifer thickness (b). Therefore, b must be known to calculate K values. The aquifer thickness is assumed to be approximately 300 feet bls along the major fracture zones (and perhaps less in less fractured areas). Below a depth of 300 feet the overlying weight of rock, the absence of weathering, and less frequent jointing tend to reduce the fracture openings (Driscoll 1986; Fetter 1980). The only Geraghty & Miller pumping test in a well that fully penetrates the aquifer thickness was the Eglin III supply well aquifer test. Assuming an aquifer thickness of 300 feet, the K value for the Eglin III test (see Table 4-8) is on the order of 6.4 to 7.6 gallons per minute per square foot (gpm/ft²). The other Geraghty & Miller pumping tests were conducted at Monitoring Wells MW-6R and MW-6D. These wells only partially penetrate the aquifer. However, assuming an aquifer thickness of 300 feet, the K values for these wells are in the range of 187 to 302 gpm/ft² at this location, which is probably the most permeable part of the aquifer in the Tutu Valley as evidenced by the highest T values.



These K values should all be viewed as approximations. Unlike aquifers that overlie confining units that clearly mark the bottom of these aquifers, the bottom of the fractured aquifer in the Tutu Valley is gradational as the fractures become less frequent and interconnected with depth. Therefore, the assumed aquifer thickness is an approximation and the resulting calculated K values are also estimates.

4.6.2.8 Pumpage Impact

Pumpage impact was evaluated during the May 1994 testing of the Eglin III Supply Well, as well as during a simulated pumping cycle at Eglin III. Drawdown data in 17 wells were evaluated during these tests. Hydrographs of the data collected during the Eglin III Pumpage Impact Test and simulated pumping cycle are provided in Appendix M (Figures M-1 through M-22). The horizontal axes represent the date and time (in military time). The dashed vertical lines mark changes in the pumping rate of the Eglin III Supply Well. The vertical axes represent the water-level elevation in feet above mean sea level.

Data developed during pumping of the Eglin III Supply Well demonstrated the existence of horizontal and vertical anisotropic conditions in the fractured bedrock aquifer. Water levels in the deeper wells were influenced the most by pumping the Eglin III Supply Well. The most responsive portions of the aquifer can be seen on Figure 4-22, which shows the distribution of the drawdown after the Eglin III Supply Well had been pumping for about 24 hours (1,313 minutes) at a constant rate of 31 gpm. The greatest response to pumpage was seen along a northwest to southeast trending zone that intersects the Eglin III Supply Well. An additional response trend was seen to the north-northwest of the Supply Well Eglin III, while a significant drawdown response was not noticeable to the south or southwest. The effects of pumpage on groundwater flow can be seen when background water-level data (Figure 4-14) are compared with pumping water-level data (Figure 4-23).

The geometry of the cone of depression around a pumping well, at a known time, can be determined using the Cooper-Jacob equation. The Cooper-Jacob equation was used to



approximate the logarithmic decrease in drawdown with increasing distance from the Eglin III Supply Well. Using the following form of the Cooper-Jacob equation:

$$s = [Q/(4\pi T)] * [-0.5772 - \ln((r^2 S)/(4Tt))]$$

where	s	= drawdown in feet
	r	= distance from pumping well in feet
	T (transmissivity)	= 0.201 ft ² /min.
	S (storativity)	= 9 x 10 ⁻⁵
	t (time)	= 1313 minutes
	Q (pumping rate)	= 31 gpm = 4.14 ft ³ /min.

To determine the elevation contours on Figure 4-23, the variable r (radius from pumping well) was set at 10, 50, 100, 200, and 400 feet and the equation was solved for s (drawdown) values (18.2, 12.9, 10.6, 8.4, and 6.1 feet of drawdown, respectively). These values were used to plot the drawdown from the static water table on a cross-sectional graph. The elevation of the static water table was superimposed on the graph so that the elevation of the cone of depression (i.e., pumping groundwater elevation) could be directly determined from the graph. Based on these calculations, the contour spacing between the pumping well (Eglin III) and nearest observation well (Eglin II) were adjusted (i.e., moved closer to the pumping well versus standard [linear] contouring) to illustrate the logarithmic increase of drawdown near the pumping well. The contour lines north of the Eglin II Supply Well were based on field measurements and were not adjusted due to these calculations. By rearranging the Cooper-Jacob equation to solve for distance, the distance of the 50-foot drawdown contour from the Eglin III Supply Well, as shown on Figure 4-22, was calculated.

Increased drawdown in the Church Supply Well and Monitoring Well MW-21D is interpreted to have occurred due to subsurface fracture zones which allow for better hydraulic connection with the pumping well. The conclusion that drawdown in the Church Supply Well and Monitoring Well MW-21D was caused by pumpage of the Eglin III Supply Well is illustrated by the correlatable response on their respective hydrographs (Appendix M) to changes in pumping rates of the Eglin III Supply Well.



4.6.2.8.1 Shallow Bedrock Response

The shallow portion of the bedrock aquifer was monitored with shallow Monitoring Wells SW-4, SW-5, SW-6, OHMW-1, OHMW-3, OHMW-4, and MW-10. The screened intervals of these wells and the depths to bedrock (where known) are reported in Table 3-2. Less than 1 foot of drawdown was observed in shallow monitoring wells in response to pumping of the Eglin III Supply Well.

The hydrographs for Monitoring Wells SW-6 and OHMW-3 are shown on Figures M-1 through M-4. As expected, water-level elevations in Monitoring Wells SW-6 and OHMW-3 decreased after the pump in the Eglin III Supply Well was initially turned on, after the pumping rate was increased, and when the pump was turned on for the simulated pumping cycle. Recovery was observed in these wells after the pump was shut off at 17:15 hours on May 12, 1994 (see Figures M-1 through M-4).

The vertical scales have been exaggerated on Figure M-2 (for Monitoring Well SW-6) and Figure M-4 (for Monitoring Well OHMW-3) to show the slight fluctuations in water levels. The hydrograph for Monitoring Well SW-6 (Figure M-2) shows a more synchronized response to pumpage of the Eglin III Supply Well than the hydrograph for Monitoring Well OHMW-3 (Figure M-4). In addition to the expected responses to pumping, a decrease in water-level elevation was observed prior to commencement of the pumping test, and a rise in water level was observed prior to increasing the pumping rate at 08:00 hours on May 12, 1994. These anomalous water levels are possibly the response to pumpage of another (unidentified) well in the area. The maximum drawdowns in these wells were 0.46 foot in Monitoring Well OHMW-3 (at 16:31 hours on May 12, 1994) and 0.95 foot in Monitoring Well SW-6 (at 17:15 hours on May 12, 1994). There was a greater drawdown in Monitoring Well SW-6 than in Monitoring Well OHMW-3, which is closer to the Eglin III Supply Well. The responses in these wells appear to be influenced by the pumping cycle of another supply well in the area.



Shallow Monitoring Wells OHMW-1, OHMW-4, MW-10, SW-4, and SW-5, shown on Figures M-5 through M-9, respectively, did not show greater than 0.3 foot of drawdown during the pumping of the Eglin III Supply Well.

4.6.2.8.2 Deep Bedrock Response

The deep portion of the bedrock aquifer was monitored by collecting water-level measurements from Monitoring Wells DW-2, MW-10D, MW-11D, MW-12D, and MW-21D, and in the Eglin III, Eglin II, Church, Harvey, and Steele Supply Wells. The total depths, open borehole intervals, and elevations of the monitoring wells are listed in Table 3-2, and the available information for the supply wells is listed in Table 3-5.

As seen on the hydrograph for the Eglin III Supply Well (Figure M-10), the background water-level elevation was about 130 feet above msl. When the pump was turned on (10:07 hours on May 11, 1994), the water level dropped about 40 feet in 10 minutes. At about 23:27 hours (800 minutes into the test) on May 11, 1994, the drawdown rate (i.e., rate of water-level elevation decrease) notably decreased. At 05:00 hours on May 12, 1994 (1,133 minutes into the test), the drawdown began to level off at 78.8 feet of drawdown. When the pumping rate was increased to 41 gpm at 08:00 hours (1,313 minutes into the test), an additional 30 feet of drawdown were observed with a total of approximately 109 feet of drawdown.

The hydrograph for the Eglin II Supply Well, an inactive supply well, is shown on Figure M-11. The Eglin II Supply Well is located 88 feet west-northwest of the Eglin III Supply Well and is the closest deep well to the Eglin III Supply Well. The water level in the Eglin II Supply Well responded simultaneously to the changes in pumping in the Eglin III Supply Well, which suggests that both wells are open to the same set of interconnected fractures. At about 15:30 hours on May 12, 1994, additional drawdown occurred in the Eglin II Supply Well, indicating



that either a fracture was becoming dewatered or another well in the area began pumping. The maximum drawdown observed in the Eglin II Supply Well was 16.88 feet on May 12, 1994 at 17:15 hours.

A minor response to the pumpage of the Eglin III Supply Well was observed at Monitoring Wells MW-11D, MW-12D, and DW-2 (Figures M-12 through M-17). On Figures M-13 (MW-11D), M-15 (MW-12D), and M-17 (DW-2), the vertical scales are exaggerated to show the slight fluctuations in water levels. On Figures M-12 through M-17, the possible responses to a nearby (unidentified) pumping well were also observed: decreases in water-level elevations were observed prior to commencement of the pumping test, and a slight rise in the water levels occurred prior to increasing the pumping rate to 41 gpm. The maximum drawdowns at these observation wells occurred just before the pumping well was shut off after the long-term pumping event on May 12, 1994 at 17:15 hours. Figures M-13, M-15, and M-17 illustrate a small response to pumpage at Monitoring Wells MW-11D, MW-12D, and DW-2, compared to the Eglin II Supply Well. The greatest drawdown (1.2 feet) was observed in Well DW-2, which is closer to the Eglin III Supply Well than Monitoring Wells MW-11D or MW-12D.

Monitoring Well MW-21D, located 510 feet south-southeast of the Eglin III Supply Well, 380 feet southeast of the Steele Supply Well, and about 200 feet north of the LaPlace Supply Well, appears to have a synchronous response to pumping of the Eglin III Supply Well. The hydrograph for Monitoring Well MW-21D (Figure M-18) shows a response to the pumping of the Eglin III Supply Well, with a lag time of approximately 120 to 180 minutes in response. For example, drawdown was not observed in Monitoring Well MW-21D until about 2 hours after the pumping test began. Similarly, about 3 hours after the pumping rate was increased, additional drawdown was observed. In addition, recovery did not occur in Monitoring Well MW-21D until about 2 hours after the Eglin III Supply Well was shut down. A maximum drawdown of approximately 4.5 feet and the great distance (500 feet) from the pumping well suggest that Monitoring Well MW-21D and the Eglin III Supply Well intersect a highly transmissive fracture. Pumpage of the Steele Supply Well does not appear to have affected the water level at Monitoring Well MW-21D. A significant amount of drawdown occurred in the



Steele Supply Well at 10:00 hours on May 12, 1994, but no response was observed on the hydrograph for Monitoring Well MW-21D. There is an indication that water levels in Monitoring Well MW-21D were influenced by another pumping well in addition to the Eglin III Supply Well, based on the increase in water levels at Monitoring Well MW-21D prior to the commencement of the pumpage impact test.

The water-level changes on the hydrograph for the Church Supply Well, which is inactive, coincide with the pumpage of the Eglin III Supply Well (Figure M-19). Drawdown occurred after the pumping test began; drawdown increased after the pumping rate was increased; and recovery occurred after the well was shut down. The actual timing of the response is not known due to the limited frequency of water-level measurements. The maximum drawdown observed was 1.26 feet, just prior to shutting the pump off in the Eglin III Supply Well.

The Steele Supply Well is an active supply well. The water-level changes observed in the Steele Supply Well are not coincident with the pumping events in the Eglin III Supply Well (Figure M-20). Drawdown was observed in the Steele Supply Well during the background monitoring, during the long-term pumping at about 03:00 hours on May 12, 1994, at about 14:00 hours on May 12, 1994, and at about the same time that the simulated pumping cycle began. The limited pumpage of the Steele Supply Well for domestic usage did not appear to impact the Eglin III Supply Well, and the Steele Supply Well was not influenced by the Eglin III Supply Well. The Steele Supply Well is not very deep and it is likely that this well does not intersect any of the same fractures as the Eglin III Supply Well. The observed water-level responses in the Steele Supply Well may be the result of pumpage of the Steele Supply Well or another supply well, because the timing of the responses on the hydrograph for the Steele Supply Well (Figure M-20) does not correspond to the Eglin III Supply Well pumping pattern. A similar lag time was observed in the hydrograph for Monitoring Well MW-21D.

Monitoring Well MW-10D, located to the north-northwest of the Eglin III Supply Well, was not noticeably affected by pumpage from the Eglin III Supply Well, but the background water-level data appear to show that the water levels in Monitoring Well MW-10D may be



influenced by another pumping well, as shown on the hydrograph of Monitoring Well MW-10D (Figure M-21).

No response was observed in the Harvey Supply Well (Figure M-22), which is only about 240 feet to the southwest of the Eglin III Supply Well. The observed fluctuation in water levels at this well was 0.03 foot, which is nearly the accuracy of the electronic water-level meter (0.01 foot). Therefore, the fluctuation cannot be considered drawdown. This result indicates that the Harvey Supply Well is not in good hydraulic connection with the Eglin III Supply Well.

4.6.2.8.3 Aquifer Response to the Simulated Eglin III Pumping Cycle

The normal pumping cycle at which the Eglin III Supply Well operates was simulated by turning the pump on for 3 hours (180 minutes) and then shutting it off. The pump was turned on at 07:00 on May 13, 1994 (see Figure M-10); the initial pumping rate was 46 gpm. The pumping rate decreased to 42 gpm by 07:38 hours (38 minutes into the pumping cycle) and gradually decreased to 40 gpm by 09:00 hours (120 minutes into the cycle). The water level in the Eglin III Supply Well dropped about 60 feet almost instantaneously when the pump was first started. The drawdown rate gradually decreased after a few minutes into the test until the pump was shut off. The maximum drawdown observed in the Eglin III Supply Well during the pumping cycle was about 120 feet.

The distribution of drawdown during the simulated pumping cycle was similar to that observed during the pumpage impact test. Response to the simulated pumping cycle was observed in deep wells Eglin II, DW-2, MW-11D, MW-1D, MW-12D, and the Church Supply Well. Shallow Monitoring Wells OHMW-3 and SW-6 also exhibited a response during the simulated pumping cycle.



4.6.2.9 Current Status of Supply Wells

Although stop-pumping orders were issued in late 1987 to many residential and commercial supply well users, a number of wells are currently pumping. Table 4-9 presents a summary of wells known to have been pumping during the Phase II RI. Since remedial design will depend on hydraulic conditions at the Tutu Wells Site, a determination must be made as to whether some or all of these wells will remain in operation or will cease operation. If these wells cease operation, protocol must be established to ensure that these wells remain inactive so that they do not interfere with remedial activities.

4.6.2.10 Summary of Aquifer Hydraulic Characteristics

Information regarding geology, hydrogeology, and pumping test results has been presented in the preceding sections. Based on the evaluation of these data, the following conclusions have been developed:

- Zones of fracture have a controlling influence on the vertical and horizontal distribution of aquifer permeability and transmissivity. The highest transmissivity zones are located along the major fractures, particularly where major fracture zones intersect (i.e., in the northern part of the Four Winds Plaza parking lot). Transmissivity values calculated from wells in this vicinity range from approximately 20,400 to 90,500 gal/day/ft (with hydraulic conductivities of approximately 70 to 300 gal/day/ft²). In comparison, transmissivity values calculated from wells not located in the fracture zones range from approximately 900 to 2,300 gal/day/ft (with hydraulic conductivities of approximately 3 to 7.7 gal/day/ft²) (Figure 4-1).
- The aquifer's response to the pumpage of deep supply wells appears to be anisotropic in both the vertical and horizontal direction. Drawdown is greater in



deep bedrock observation wells located along major fractures than in directions transverse to the orientation of those fractures.

- Based on the pumping tests of the Eglin III Supply Well, pumpage at a constant rate of approximately 31 gpm creates a zone of influence oriented northwest-southeast. The northeast-southwest extent of the zone of influence is approximately 500 feet and the northwest-southeast extent is approximately 1,045 feet (Figure 4-23).

4.6.3 Conceptual Hydrogeologic Model

The information compiled regarding regional and site-specific geology and hydrogeology has been evaluated to develop a conceptual hydrogeologic model of the Tutu Wells Site. This conceptual hydrogeologic model can be utilized to evaluate the influence of groundwater flow on the behavior and transport of contaminants.

The primary aquifer at the Tutu Wells Site is the fractured volcanic bedrock. This bedrock is overlain in places by overburden consisting of alluvium and colluvium. In most places, the overburden is thin to absent, obtaining its maximum thickness along the principal valleys. The overburden is primarily unsaturated and is only saturated in isolated pockets along these principal valleys. The upper portion of the bedrock aquifer is weathered to varying degrees. The weathered bedrock may be saturated or unsaturated and is in hydraulic connection with the underlying competent bedrock. The bedrock at any one location may consist of alternating zones of weathered and competent rock, both of which are fractured to varying degrees. In some areas, the fractures in the upper part of the bedrock appear to be less interconnected than deeper fractures, possibly due to the presence of abundant clay minerals that served to plug fractures.

Groundwater in the bedrock aquifer is unconfined to partially confined. Groundwater flows preferentially along fracture zones. Despite the presence of well-defined fracture zones, the bedrock aquifer is fractured everywhere to varying degrees. The fractures are interconnected,



at some locations and depths more than others. In zones where there are numerous, interconnected fracture sets (primarily along the principal valleys), groundwater flows through this fracture network under similar forces that prevail in porous media flow (such as unconsolidated sand and gravel). Specifically, groundwater will flow through the fracture network in response to the prevailing potentiometric head distribution, which in many areas is comprised of a primarily horizontal component of flow with lesser vertical components. Pumping of supply wells induces greater vertical components of flow, drawing constituents downward from the shallow portion of the aquifer. The bedrock aquifer, however, is much more heterogeneous and anisotropic than porous media. Transmissivities are typically an order of magnitude or more higher along the fracture zones (i.e. principal valleys) than transmissivity values calculated for areas at higher elevations, away from the fracture zones.

Fluids percolating downward move through the thin overburden and the interconnecting network of fractures until reaching the water table. Once in the water table, water, and fluids lighter than water, would move in a predominantly horizontal direction, in the direction of prevailing groundwater flow. Fluids that are denser than water would tend to move downward under gravity through the network of fractures, becoming adsorbed onto clay particles and weathered bedrock along the edges of the fractures.

Pumping of supply wells alters the dynamics of natural groundwater. Pumping wells draw water from the network of fractures. The area of influence of pumping wells extends in an anisotropic (i.e., non-uniform) fashion. Supply well pumpage induces groundwater flow toward the pumping centers and reverses the horizontal gradient some distance downgradient of the pumping well. The large open vertical interval (as great as 200 to 300 feet) of many of the supply wells may have drawn contaminants present in the groundwater downward in response to pumping stresses.



5.0 NATURE AND EXTENT OF CONTAMINATION

Samples of soil, groundwater, surface water, soil gas, and waste oil have been collected for chemical analysis during the various investigations conducted by the USEPA, Geraghty & Miller, and other consultants. This section provides a comprehensive summary of analytical data that are currently available for the Tutu Wells Site. Soil analytical data are presented and discussed on a property-by-property basis to identify soils impacted by chlorinated VOCs and petroleum-related compounds (i.e., BTEX, MTBE, and BNAs). Groundwater quality data are discussed from an area-wide perspective.

5.1 SOIL QUALITY AND POTENTIAL SOURCES

Soil sampling, soil-gas surveys, waste oil sampling, and site inspections were conducted during the Phase II RI to define where impacted soils exist, and to evaluate whether each individual property is a potential source of petroleum hydrocarbon constituents and chlorinated VOCs to groundwater. Soil quality data collected by Geraghty & Miller, the USEPA, and other investigators are summarized and discussed for each of the following properties:

- VIHA
- Curriculum Center
- Ramsay Motors
- Antilles Auto Parts
- Texaco Tutu Service Station
- Tillett Gardens
- Four Winds Plaza
- Western Auto
- Esso Tutu Service Station
- O'Henry Dry Cleaners
- Fire Station Property
- Vitelco
- God of Holiness Church



- Lutheran Church
- Assembly of God Church

All soil data collected during the Phase II RI by Geraghty & Miller were analyzed for TCL VOCs, TCL BNAs, TAL metals, cyanide, and TPH in accordance with the Phase II RI Work Plan. These results are summarized in Tables 5-1 through 5-5. Historical data (data from the previous investigations, as discussed in Section 2.1 [Individual Site Reconnaissance and Sampling]) are presented in tables in Appendix C. Data collected by other consultants are shown on figures when sampling locations could be determined. These data are tabulated and discussed in varying degrees of detail in the reports prepared by the other consultants; a list of these reports is included in Section 9.0 (References). Please note, in this section (5.1), when a date is presented in brackets following reference to a consultant, this date refers to when the sampling was conducted, rather than to the date of a report. This information is presented to provide the reader with an understanding of when data were collected.

Detected concentrations of organic compounds in soil are plotted on a property-by-property basis on Figures 5-1 through 5-16. These figures present currently available data for each property and specify the source of the information. Some historical data are not presented on these figures because sampling locations were not specified with the analytical results. However, where possible, these data were still used for interpretation. In addition, the results of waste oil sampling conducted at a property are discussed, and recent waste oil sampling results are presented on relevant figures. On Figures 5-1 through 5-16, a symbol has been added to the data to identify those samples where detection limits were elevated above 25 ug/kg for an individual chlorinated VOC or BTEX compound. In addition, the data validation qualifiers provided with an analytical value, such as "J" (estimated result) and "B" (indicating the analyte was also found in the blank sample) were also presented with the data on these figures.

Although no numerical standards for soil quality have been promulgated by the USEPA, soil quality screening levels and objectives have been drafted by several states, and guidance



levels were published by the USEPA as part of the proposed RCRA Corrective Action Rule in 1990. A summary of available guidance and screening levels is provided in Table 5-6.

These levels are not enforceable standards that would necessitate cleanup, but are instead intended to be used as indications of potential adverse impact through direct exposure or by leaching to groundwater. These various screening levels were discussed with the USEPA Region II for potential applicability to the soil data compiled during the Tutu Wells Site RI. The USEPA has directed the TEIC to use the New York State Technical and Administrative Guidance Memorandum (NYS TAGM) levels, in particular the groundwater quality protection objectives, as screening levels for the Tutu RI soil data (USEPA 1994b). The NYS TAGM levels are the most stringent of the soil screening levels presented in Table 5-6.

The soil quality data presented in Tables 5-1 through 5-5 and depicted on Figures 5-1 through 5-16 were compared to the NYS TAGM levels. The presence of chlorinated VOCs or petroleum-related compounds in soil above the NYS TAGM levels identifies an individual property as a potential source of impact to soil quality and indicates that soils may represent an ongoing source of impact through leaching to groundwater. The NYS TAGM levels were not compared to samples collected from excavated soil piles, since these were not in-situ samples and their original location was not known. Exceedences of NYS TAGM levels for chlorinated VOCs or petroleum-related compounds will be a guide to determine which sites warrant consideration for soil remediation in the Feasibility Study (FS). Constituents with concentrations found in soil above the NYS TAGM levels are highlighted in capital letters on Figures 5-1 through 5-16. Tables 5-7 and 5-8 present summaries of soil samples that have exceeded NYS TAGM levels for organic constituents, on a site-by-site basis. These tables include soil data collected by all investigators who provided data to the TEIC.

The absence of soil constituent concentrations in excess of the NYS TAGM levels does not necessarily imply that a particular site was not a source of impact to soil quality. Constituents of concern were detected at several sites at concentrations below the NYS TAGM levels, indicating that releases of these constituents had potentially occurred at these facilities, even



though the residual concentrations detected below the NYS TAGM levels do not currently represent a threat to human health or the environment.

There are no NYS TAGM levels for TPH or MTBE in soil. The presence of TPH or MTBE in soil that did not have any BTEX or BNAs in excess of the applicable NYS TAGM level was not considered to represent impact to soil.

The NYS TAGM recommended soil cleanup objectives for metals are derived from background values for the eastern United States. However, these values do not represent objectives for the protection of groundwater quality because metals do not partition to an appreciable degree into the aqueous phase. Therefore, the most likely potential impact from metals would be from inhalation or direct dermal contact. A complete evaluation of the potential impact of metals in soil through the direct contact or inhalation of dust is presented in the final risk assessment prepared by CDM (CDM 1995). The exposure assessment prepared by CDM indicated that metals concentrations at the individual properties do not pose a risk through direct contact, with the possible exception of manganese at the Tillett property (CDM 1995).

The baseline risk assessment (CDM 1995) does not assess the potential migration of metals to groundwater. The NYS TAGM guidance suggests using available site-specific background metals concentrations. At the Tutu Wells Site, the USEPA directed that soil be considered as potentially impacted from metals and other inorganic compounds if the analytical result exceeded twice the average background value (USEPA 1994b).

Background soil concentrations for the Tutu Wells Site were established by collecting soil samples in areas that were not suspected to have been impacted by human activities. The analysis of these soil samples provided data to evaluate the range of the natural, or background, concentrations of naturally occurring metals in soil. Surface Soil Samples SS-1, SS-2, and SS-8 were collected approximately 150 feet north of the Curriculum Center building to evaluate natural background (non-impacted) metal concentrations. Metal concentrations in these samples were viewed as being representative of naturally occurring, undisturbed surface soils.



In addition to the three background surface soil samples, a sample was collected from Soil Boring B-7, located at the Fire Station, east of the Texaco Tutu Service Station. This sample was collected from a depth of 2 to 4 feet bls for metals analysis. Because metals and other inorganic parameters can leach downward from surface soil, natural concentrations of metals and other inorganic parameters may be greater in subsurface soils than in surface soils. Since no detectable organic compounds were reported in Soil Sample B-7, and no suspected sources of metal contamination are located near this boring, the concentrations of metals in this sample were considered to be representative of natural (background) concentrations in subsurface soils. These four samples (SS-1, SS-2, SS-8, and B-7) provided a range of background metals and cyanide concentrations in soil; the average and maximum background concentrations plus twice the average background concentration for metals and cyanide are summarized in Table 5-9. In the subsections below, only metal and cyanide concentrations that exceed twice the average background values are identified and discussed.

5.1.1 VIHA Soil Sampling Results

Investigations at the VIHA were performed by Weston/SPER [1987], ADL [1993], and Geraghty & Miller (during Phases I and II of the RI). Areas investigated as potential sources included a vehicle maintenance area, a former waste oil UST, and a drum storage area. Weston collected one sample from the waste oil UST, and ADL sampled the contents of 17 out of 35 drums. Geraghty & Miller collected one soil sample from each of the boreholes at Monitoring Wells MW-13 and MW-13D near the vehicle maintenance area and implemented a soil-gas survey to evaluate the former UST and other potential sources.

The soil-gas survey was conducted in March 1994. Sampling locations were distributed throughout the entire site at an approximately 40-foot spacing. The GC was calibrated for trans- and cis-1,2-DCE, TCE, PCE, benzene, toluene, m-xylene, and o-xylene. None of these VOCs was detected in the 26 soil gas samples collected and no additional unidentified compounds were detected. The results of the soil-gas survey are presented in Appendix B.



BTEX compounds were detected in the waste oil sample collected by Weston/SPER in August 1987 at individual concentrations ranging between 97,000 and 2,900,000 micrograms per kilogram (ug/kg). Stained soils were observed by Geraghty & Miller in the vicinity of the vehicle maintenance area. Monitoring Wells MW-13 and MW-13D are located approximately 50 feet west of this maintenance area (Figure 5-1). Analytical results indicated no detectable concentrations of VOCs, BNAs, or TPH in the sample collected from Monitoring Well MW-13D. In the soil sample collected from Monitoring Well MW-13, only bis(2-ethylhexyl)phthalate (210J ug/kg) and TPH (230 milligrams per kilogram [mg/kg]) were detected. No organic constituents were detected above NYS TAGM soil cleanup levels (Tables 5-7 and 5-8). In Soil Sample MW-13, lead and zinc were detected above twice the average background values for these metals. Arsenic in the soil sample collected from Monitoring Well MW-13D was detected slightly above twice the average background concentration. The arsenic concentration was an estimated value and arsenic was also detected in the laboratory blank.

ADL collected liquid samples from 16 waste oil drums (plus one replicate) at VIHA and submitted 11 samples for analysis. In four drums, chlorinated VOCs were detected at concentrations ranging from 393 to 16,112,500 ug/kg and included PCE, TCA, and 1,2-DCE (Figure 5-1). The soil-gas survey did not detect any chlorinated or BTEX VOCs in this area.

The only BNA compound detected in soil at the VIHA property was bis(2-ethylhexyl)phthalate, which is a common laboratory contaminant. Although chlorinated compounds were detected in drum samples and BTEX was detected in the waste oil sample, the soil-gas survey did not detect any VOCs throughout the entire survey area, and the limited in-situ soil sampling did not detect any VOCs. No chlorinated VOCs or petroleum-related compounds exceeded the NYS TAGM levels.

5.1.2 Curriculum Center Soil Sampling Results

Soil sampling was conducted at the Curriculum Center by CDM [1989], ADL [1993], Weston [1994], and Geraghty & Miller (during Phases I and II of the RI). In addition, Geraghty



& Miller performed a soil-gas survey during the Phase II RI to aid in the identification and delineation of potential sources (Appendix B). A soil-gas survey that had been conducted in 1987 by GCL included a portion of the Curriculum Center.

Areas that were considered as potential sources at the Curriculum Center included a former drum disposal area (northwest of the building), the approximate location of a suspected former discharge pipe (along the center of the north wall of the building) alleged to be associated with dry cleaning operations, a sink that discharges water directly outside (along the north end of the east wall of the building), floor drains within the building, and an alleged former waste pit (located in the unpaved area north of the building). Approximately 28 subsurface and ten surface soil samples were collected by the various investigators. Available soil quality data are presented on Figure 5-2; data are not included for some sampling locations either because samples from these locations were analyzed only for metals (SS-1, SS-2, and SS-8) or because the exact sampling locations (for example, locations of samples collected by CDM) were not known.

PCE was detected in eight soil samples collected along the north side of the building in the vicinity of the former discharge pipe and the alleged former waste pit, at concentrations ranging from 3 to 180 ug/kg (Figure 5-2). These concentrations do not exceed the NYS TAGM level of 1,400 ug/kg for PCE. TCE was also detected in three of these samples, at low concentrations ranging from 1J to 7J ug/kg (the NYS TAGM level for TCE is 700 ug/kg). TCE was also detected below the NYS TAGM in Soil Sample TWS-01 at 130J ug/kg. In this area, some BTEX compounds (primarily toluene), BNAs, and TPH were also detected.

Other non-BTEX VOCs, including methylene chloride, acetone, and 2-butanone, were detected below NYS TAGM levels at concentrations ranging from 8 to 35 ug/kg near the former drum storage area at the northwestern corner of the building. Methylene chloride, acetone, and 2-butanone are common laboratory contaminants, and these low concentrations may represent laboratory contamination. In addition, BTEX compounds were detected in this area at low



concentrations ranging from 2 to 19 ug/kg. None of these constituents was above the NYS TAGM levels.

BTEX compounds were also detected in soil samples collected along the northeastern corner of the building in the vicinity of the sink discharge. Surface Soil Samples SS-12 (collected from the top 6 inches of soil) and TWS-03 (collected from the top 4 inches of soil) contained individual BTEX concentrations ranging from 2,700 to 500,000 ug/kg (Figure 5-2). The NYS TAGM level was exceeded for each individual BTEX constituent in these two samples. In addition 1,1,1-trichloroethane exceeded the NYS TAGM level of 760 ug/kg in Sample TWS-03, and numerous BNAs were detected in three surface soil samples collected in the vicinity of the sink (Figure 5-2).

In general, TPH was not detected in most soil samples collected at the Curriculum Center. Low concentrations of TPH were detected in samples along the western side of the building including the loading dock (soil samples from Monitoring Wells MW-1, MW-1D, and MW-14, and Soil Boring B-6) at concentrations ranging from 84 to 220 mg/kg (Figure 5-2). No BNAs were detected in these samples, with the exceptions of diethyl phthalate (40J ug/kg) and di-n-butyl phthalate (890B ug/kg) in Soil Sample MW-14, which was also detected in the laboratory blank; both of these BNAs were detected at concentrations below the TAGM levels.

The highest PCE concentrations in soil were detected on the north side of the building. The highest chlorinated VOC concentrations detected during the 1994 soil-gas survey were also on the north side of the building, however, in accordance with the work plan and correspondence to the USEPA (see Appendix B), soil samples were not collected at the locations of the highest soil-gas readings. Other areas where chlorinated VOCs were detected in soil gas were on the west side of the building and near the northwest corner of the building. One composite oil sample (TWS-06) was collected from two pipes within the floor of the building (Figure 5-2). These abandoned pipes appeared to have been cut to floor level and lag bolts were observed (Shottroff 1995). Sample TWS-06 contained 300,000,000 ug/kg PCE (30 percent PCE) and several BNAs.



Metals concentrations in soil collected from the Curriculum Center property were detected above twice the average background values for arsenic, lead, zinc, copper, silver, and potassium.

The soil analytical results, in conjunction with the results of the soil-gas survey and the detection of PCE in the oil sample collected from the floor of the building, indicate that releases of BTEX constituents and chlorinated VOCs have occurred at the Curriculum Center. BTEX constituents were detected above NYS TAGM levels outside the northeast corner of the building (near the discharge location for the sink). Chlorinated VOCs were detected in excess of NYS TAGM levels in one sample, and chlorinated VOCs were detected in soil gas and shallow soil, indicating that releases have occurred. These releases could have originated from multiple potential sources as described above. In addition, these VOCs may be present at higher concentrations in fractures in the unsaturated bedrock.

At the Curriculum Center, there is a significant thickness of the unsaturated zone within the bedrock, below the unconsolidated soils. The possibility exists that constituents exist at concentrations above NYS TAGM levels within this bedrock above the water table. In accordance with the Phase I and II work plans (Geraghty & Miller, Inc. 1992a and 1993b), samples were not collected from the bedrock above the water table. The most elevated concentrations of chlorinated VOCs in groundwater within the Tutu Wells Site were detected under the Curriculum Center, which confirms that releases of chlorinated VOCs have occurred at this property. Chlorinated VOCs must have migrated, either as pure non-aqueous solvent or in aqueous solution, through the unsaturated bedrock, to reach the saturated zone.

5.1.3 Ramsay Motors Soil Sampling Results

Soil investigations were performed at Ramsay Motors by Weston [1987], CDM [1988 and 1989], CEI [1993 and 1994], and Geraghty & Miller (during Phases I and II of the RI). In addition, Weston [1987] and CDM [1989] sampled the waste oil UST. Areas that were investigated as potential sources included a vehicle painting area, drums containing waste oil,



a reported spill area (along the southern property line), and a former waste oil UST that was reportedly closed in place. Approximately 30 soil samples were collected by various investigators (Figure 5-3). Some of the locations are shown without data because samples were not submitted for laboratory analysis. The exact locations of the three samples collected by CDM are not known.

The chlorinated VOCs detected at the Ramsay property were TCA in one soil sample (4BJ ug/kg, also detected in a laboratory blank), 1,2-DCE in one soil sample (2J ug/kg), and PCE in two soil samples (1J and 6J ug/kg). All these constituents were detected at low estimated concentrations below NYS TAGM levels.

Non-BTEX VOCs, including acetone, methylene chloride, 2-butanone, and MTBE, were detected in soil samples, with the highest concentrations occurring in the five borings located in the vicinity of the UST (Figure 5-3). Acetone exceeded the NYS TAGM level in five samples, but all concentrations were qualified with "B" indicating that acetone was also found in the laboratory blank (Table 5-7). 2-Butanone exceeded the NYS TAGM level of 300 mg/kg in two samples in the vicinity of the UST. The methylene chloride and 2-butanone were attributed to laboratory contamination although they were not qualified with a "B."

BTEX compounds were detected in two soil samples below their respective NYS TAGM levels, at individual concentrations ranging from 7J to 290 ug/kg (Figure 5-3); these samples were collected in the vicinity of the UST. BNAs associated with petroleum compounds (e.g., pyrenes, naphthalenes, fluoranthenes, phthalates, and chrysenes) were detected in most soil samples collected at the property; individual concentrations ranged between 43 and 3,400 ug/kg. Chrysene was found above the NYS TAGM level of 400 ug/kg in one soil sample (Table 5-8). Grab samples of oil and water from ponded water at the concrete slab/soil interface were collected at Soil Boring HB-3 (located along the perimeter of the UST). These results showed the same suite of BTEX and BNA compounds detected in soil samples from this area, but at concentrations two or more orders of magnitude higher. In addition, 2-butanone was detected



at a concentration of 250,000 ppb in the HB-3 oil sample. Because NYS TAGM levels are for soil concentrations, the NYS TAGM levels were not compared for oil and water samples.

TPH was detected in all but four soil samples at concentrations ranging from 24 to 2,000 mg/kg. The highest TPH concentrations were observed in soil samples near the UST and in soil borings along the southern property line, where correspondingly high BNA concentrations were detected. At this southern location, an oil spill originating from the adjacent Gassett property (currently occupied by Antilles Auto Parts) reportedly occurred (NUS Corporation 1989c). Lead, potassium, zinc, barium, and sodium were detected in soil samples above twice the average background concentrations.

Of the constituents detected at the Ramsay property, acetone, 2-butanone, and chrysene were detected above their respective NYS TAGM levels. These samples were all collected from the vicinity of the UST. These data, in conjunction with the presence of stained soil, and oil and water containing the same constituents as the soil, suggest that the UST is the source of impact to the soil.

5.1.4 Antilles Auto Parts Soil Sampling Results

Soil sampling was conducted at Antilles Auto Parts by CDM [1988] and by Geraghty & Miller (during Phases I and II of the RI). Areas that were investigated as potential sources at the Antilles Auto Parts included a vehicle repair area, an AST containing waste oil, and a drum storage area. ADL [1993] and NUS [1989] mentioned a UST in their discussion of site conditions, but there is no evidence to indicate that a UST exists. In addition, NUS reported that there had been a surface release of waste oil that apparently flowed onto the adjacent Ramsay Motors property (NUS Corporation 1989c).

Three soil samples and one waste oil sample were collected at this property. The exact locations of the two soil samples collected by CDM are unknown, except that one sample was collected behind the open bay garage area and the other sample was collected at the drum



storage area. The analytical results for Soil Sample B-5 and Waste Oil Sample WOS, both collected by Geraghty & Miller, are depicted on Figure 5-4.

The non-BTEX VOCs detected in the sample from Soil Boring B-5 were methylene chloride, acetone, and 2-butanone at concentrations ranging from 9J to 92J ug/kg (Figure 5-4). These compounds may be laboratory artifacts, although data validation did not qualify the results with a "B". BTEX compounds and MTBE were detected in the soil samples at low concentrations (less than 6 ug/kg). BNAs were not detected, except for 4-methyl-2-pentanone (33 ug/kg) and styrene (6 ug/kg) in one soil sample collected by CDM. None of these constituents was above NYS TAGM levels. Soil Boring B-5 had a reported TPH concentration of 53 mg/kg, and no metals or cyanide were detected at concentrations greater than twice the average background concentration.

BTEX compounds, PCE, and 1,1,1-trichloroethane (TCA) were detected in the waste oil sample collected (Sample Antilles-WO) by Geraghty & Miller in 1994. The highest individual concentration, total xylenes, was reported at 130,000 ug/kg (Figure 5-4).

Based on the limited sampling conducted, no soils at the Antilles facility had concentrations of chlorinated VOCs, BTEX, or BNAs above NYS TAGM levels. The reported 1989 spill originating at this property (NUS Corporation 1989c) may be a potential source of some of the impact to soils observed at the adjacent Ramsay Motors property.

5.1.5 Texaco Tutu Service Station Soil Sampling Results

Soil investigations at the Texaco Tutu Service Station have been conducted by CDM [1988 and 1989], Geraghty & Miller [1992], BB&L [1993], ENSR [1993], ADL [1993], and GCL [1993]. Some of this work was associated with UST removal and monitoring well installation. Waste oil sampling was also conducted by Weston/SPER [1987]. Areas investigated as potential sources at the Texaco Tutu Service Station included a vehicle repair area, three former USTs, three existing USTs, an oil/water separator, an infiltration gallery, a vehicle maintenance bay,



sumps, and waste oil drums. Approximately 75 soil samples were collected at this property. Some of these soil samples are duplicative, because split samples were collected by BB&L and GCL at approximately 20 sampling locations and by ADL and GCL at approximately four locations. The locations of the soil samples collected in 1988 by CDM during tank excavation from the tank excavation pit, soil piles, and soil borings are unknown. In addition, the locations of samples collected by CDM in 1989 from the soil piles is unknown (the soil had been stored on-site for approximately 9 months for soil venting prior to sampling). Similarly, the locations of the waste oil samples collected by Weston are unknown. The other available soil data and the recent waste oil sampling results are depicted on Figure 5-5.

No chlorinated VOCs were detected in any soil samples above laboratory detection limits, including soil samples collected in the vicinity of the infiltration gallery, oil/water separator, USTs, and sumps (Figure 5-5). Estimated values of PCE (below the laboratory detection limits) reported in the soil samples collected from Monitoring Wells MW-3 (2J ug/kg) and MW-4 (1J ug/kg) can be attributed to volatilization of chlorinated VOCs from groundwater. PCE (160 ug/kg), TCE (39 ug/kg), and 1,2-DCE (10 ug/kg) were detected in one sample collected from the excavated soil piles that had been stored on-site for over 9 months prior to sampling. However, all detected chlorinated VOC concentrations were below NYS TAGM levels. In one of the six waste oil drum samples collected by ADL, PCE and TCA were detected at concentrations of 31,000 and 39,000 ug/kg, respectively (Arthur D. Little, Inc. 1994). The drum storage area is paved with concrete, and the presence of a constituent in a drum does not by itself indicate that an impact to soil quality has occurred.

The only other non-BTEX VOCs detected were acetone, 2-butanone, methylene chloride, and carbon disulfide. These non-BTEX constituents may be attributable to laboratory contamination and were found in some laboratory blanks at comparable concentrations. Only acetone was detected above the NYS TAGM level of 110 ug/kg in three soil samples at concentrations ranging from 120 to 190B ug/kg.



BTEX and MTBE were found in soil samples at individual constituent concentrations ranging from 2.5J to 630 ug/kg (Figure 5-5). The highest concentrations were detected in the vicinity and downgradient, of the former USTs (soil samples from Monitoring Wells TT-1, TT-1D, and TT-4) and at the oil/water separator (OW-SB-1). Of these samples, benzene was detected above the NYS TAGM level of 60 ug/kg in Soil Sample TT-1D (Table 5-7). Higher BTEX concentrations had been detected in samples of soil excavated from the former UST area in 1988 during UST excavation. This soil was taken off-site after UST removal.

Analyses for BNAs and TPH were only performed on the four soil samples collected by Geraghty & Miller. The only BNAs detected in soil samples were benzo(a)pyrene at 130 ug/kg (in Sample MW-4) and an estimated value of di-n-butyl phthalate at 170J ug/kg (in Sample MW-3). Both these concentrations were below their respective NYS TAGM levels. TPH was detected in one of the four samples at 130 mg/kg. Of the samples that were analyzed for metals and cyanide, all were within twice the average background concentrations except for arsenic and potassium in the soil sample collected from Monitoring Well MW-4.

The only constituents that have been detected above NYS TAGM levels at the Texaco Tutu Service Station are acetone and benzene. Higher concentrations were present in excavated soils, and several holes were noted in one of the excavated tanks (CDM 1990b). Benzene exceeded the NYS TAGM level in one soil sample, and BTEX constituents were detected at lower concentrations in many soil samples, confirming that releases of BTEX VOCs have occurred at the Texaco Tutu Service Station.

5.1.6 Tillett Gardens Soil Sampling Results

Work has been performed at Tillétt Gardens by CDM [1988] and Geraghty & Miller [1992]. Areas investigated as potential sources included the silk screening area and the painting, stripping, and varnishing area. Five soil samples were collected. The exact locations of the two surface samples collected by CDM are not known.



Low concentrations of non-BTEX VOCs were detected in the soil samples at concentrations below NYS TAGM levels. PCE was detected in Soil Boring B-8 and its replicate at 2J and 5J ug/kg, respectively (Figure 5-6). These detections are likely the result of volatilization from groundwater. Methylene chloride was detected in Surface Soil Sample SS-5 (10J ug/kg), but this detection is believed to be a laboratory artifact.

BTEX compounds were detected in samples from Soil Boring B-8 at estimated individual concentrations of less than 4 ug/kg, all of which were below NYS TAGM levels. BNAs associated with petroleum products (anthracenes, fluoranthenes, chrysene, and pyrene) were detected in soil samples collected near the Tillett well (Samples SS-5 and B-8) at individual concentrations below NYS TAGM levels, ranging from 55J to 300J ug/kg. However, no BNAs were detected in the Soil Boring B-8 field replicate. TPH was detected in the boring for Monitoring Well MW-5 at 590 mg/kg and in the replicate for Soil Boring B-8 at 77 mg/kg, but was not detected in the sample from Soil Boring B-8. Non-homogeneous distribution of constituents in soil media may be an explanation for the apparently inconsistent TPH and BNA results for the sample and replicate from Soil Boring B-8. Arsenic, barium, copper, potassium, silver, zinc, and lead were detected above twice the average background concentrations for these metals in soil samples from Boring B-8, Surface Soil Sample SS-5, and Monitoring Well MW-5. Pesticides and PCBs were analyzed in the two surface soil samples collected by CDM. Aroclor 1242 was detected above the NYS TAGM level of 10,000 ug/kg in Surface Sample eTT-15s (120,000J) ug/kg.

Based on the limited soil sampling performed at Tillett Gardens, no organic constituents were found above NYS TAGM levels, with the exception of Aroclor 1242 (a PCB). USEPA's baseline risk assessment (CDM 1995) identified Aroclor 1242 and manganese soil concentrations that were above a human health-based risk level.



5.1.7 Four Winds Plaza Soil Sampling Results

Soil investigations have been conducted at Four Winds Plaza by CHT [1992 and 1993], Geraghty & Miller (Phases I and II of the RI), ENSR [1993], BB&L [1993], and GCL [1993 and 1994]. CHT supervised the removal of the diesel tank (also known as the Ramp Tank) in October 1993, concurrent with the UST excavation at Western Auto. In 1993, CHT also dug a test pit between two sewer grates to identify whether there was interaction between the sewers and groundwater. Samples were collected by CHT, ENSR, BB&L, and GCL; these split sample results are provided on Figure 5-7. In addition, Target conducted soil-gas surveys in January and September 1992 and ENSR performed Gore-Sorber vapor surveys in December 1993 and July 1994. Areas where soils were sampled as potential sources at Four Winds Plaza included existing or former USTs. The soil gas and vapor surveys covered a wider area. Approximately 15 soil samples have been collected; available analytical results are shown on Figure 5-7.

No chlorinated VOCs were detected in the soil samples except for PCE at an estimated concentration of 6J ug/kg in the soil sample from Monitoring Well MW-6, and TCA at a concentration of 100 ug/kg in Soil Boring TW-6 (Figure 5-7). No other chlorinated VOCs were detected. Other non-BTEX VOCs detected were acetone, methylene chloride, and 2-butanone; the detections of these compounds were attributed to laboratory contamination. No chlorinated or non-BTEX VOCs were detected above NYS TAGM levels, except for the detection of acetone in the field replicate soil sample from Monitoring Well MW-2 at a concentration of 130J ug/kg (the NYS TAGM level is 110 ug/kg). It should be noted that the soil sample from Monitoring Well MW-2 had an acetone concentration of 58 ug/kg, which is below the NYS TAGM level.

The detection of PCE is likely the result of volatilization from groundwater. The soil-gas survey performed in 1992 by Target identified PCE throughout Four Winds Plaza at concentrations less than 10 ppb. In addition, PCE, TCE, and 1,2-DCE were detected in the liquid sample collected from the storm sewer trench at individual concentrations ranging between 3J and 42 ug/L. Since the storm sewer trench is known to be within the water table at Four Winds Plaza, these VOCs are attributed to infiltration of groundwater into the trench, which



substantiates the interpretation that the soil-gas survey results and the PCE detected in soil are due to volatilization from groundwater.

The TCA was detected in the shallow soil at a loading dock and may either be representative of surface spillage or may be attributed to laboratory contamination as suggested in a letter from CHT to Clifford Crooke of DPNR on March 29, 1993. No documentation was provided by the laboratory to confirm this interpretation.

The only BTEX constituents detected in soil were toluene (1J ug/kg in the sample from Monitoring Well MW-10D), MTBE (190 ug/kg in the sample from Monitoring Well CHT-2), and ethylbenzene and xylenes (7.6 ug/kg and 9 ug/kg, respectively, in the sample from Monitoring Well CHT-3). None of these values was above NYS TAGM levels.

Other than the detection of bis(2-ethylhexyl)phthalate in the soil sample from Monitoring Well MW-18 (which is attributed to laboratory contamination), BNAs were detected in two soil samples from the area of the Ramp Tank at individual concentrations ranging from 340 to 1,600 ug/kg. The results of the Gore-Sorber soil-gas surveys show that the soil gas in the area under Four Winds Plaza under the Cost-U-Less store floor contains diesel constituents and heavy petroleum oil components (ENSR 1994b, 1994c)

TPH was detected in soil samples at concentrations ranging from 61 to 230 mg/kg. Of the soil samples analyzed for metals at the Four Winds Plaza, arsenic, barium, lead, and potassium were detected above twice the average background concentration.

BNAs were detected in the liquid and solid samples collected from the storm sewer trench. Individual concentrations in these samples ranged between 43J and 120J ug/kg and consisted of pyrene, chrysene, and fluoranthenes.

The only constituent found above NYS TAGM levels was acetone in the field replicate for Soil Sample MW-2 (MW-2FR). Because it was found above the NYS TAGM level in Soil



Sample MW-2FR but was below the NYS TAGM level in Soil Sample MW-2, this occurrence can be attributed to laboratory contamination. No other constituents were detected in soil above the NYS TAGM levels in soil samples collected at the Four Winds Plaza. However, potential impact to soils under the Four Winds Plaza buildings cannot be ruled out, due to the detection during the Gore-Sorber survey of elevated soil gas concentrations of diesel and heavy petroleum components under the Cost-U-Less store floor.

5.1.8 Western Auto Soil Sampling Results

The Western Auto property is located in Four Winds Plaza. Soil investigations have been conducted at Western Auto by CHT [1992], BB&L [1993], ADL [1993], ENSR [1993], and Geraghty & Miller during the Phase II RI. Target conducted a soil vapor study at the Four Winds Plaza in September 1992 that included Western Auto. In addition, Gore-Sorber soil-gas surveys were performed in December 1993 and July 1994 that included the Western Auto property (ENSR 1994b, 1994c). Areas investigated as potential sources included vehicle maintenance bays, a former waste oil UST, a former diesel UST, and several underground pipelines including a 4-inch diameter PVC pipeline that was ruptured during excavation of the UST.

The majority of sampling in the area behind Western Auto was performed in conjunction with excavation of the waste oil and diesel USTs in 1993. These USTs were located behind and operated by Western Auto. Soil and liquid/product analytical results are presented on Figures 5-8 and 5-9. Figure 5-8 presents pre-excavation data and Figure 5-9 presents data generated during and after tank excavation. Figure 5-9 also shows the location of a 4-inch diameter PVC pipe that was sampled by various investigators. The discussion below is separated into pre-excavation and excavation/post-excavation sampling results.



5.1.8.1 Pre-Excavation Soil Sampling Results

In 1992, CHT drilled five borings in the vicinity of the waste oil and diesel USTs (Figure 5-8). The waste oil UST was determined to be filled with sand, and the diesel UST was found to contain petroleum product. Two soil samples, two liquid samples from borings, and two product samples were collected near the USTs. All samples were analyzed for VOCs, PAHs (which are a subset of BNAs), TPH, and TOG.

No VOCs or PAHs were detected in either soil sample from Soil Borings TW-1 and TW-4, except for 2-methylnaphthalene at 570 ug/kg in Soil Boring TW-4 (adjacent to the diesel UST). TPH concentrations in Soil Borings TW-1 and TW-4 were 32 mg/kg and 56 mg/kg, respectively; TOG concentrations in these two samples were 40 mg/kg and 240 mg/kg, respectively. A liquid sample was collected from Soil Boring TW-2 (at the waste oil tank) and TW-5 (at the diesel tank). No non-BTEX VOCs were detected. Concentrations of individual BTEX constituents ranged from 1.1 to 24 ug/kg. BNAs (including naphthalene, fluorene, and 2-methylnaphthalene) were detected in a liquid sample from Soil Boring TW-5, located at the diesel tank (see Figure 5-8).

No VOCs or PAHs were detected in the sand sample collected from the waste oil UST. TPH and TOG were reported at concentrations of 14 and 15 mg/kg, respectively. ENSR resampled the waste oil UST in May 1993 (with split samples collected by BB&L) and determined that the UST had not been completely emptied before it was filled with sand (ENSR 1994a). No VOCs were detected in either of the samples collected by ENSR or BB&L at individual detection limits of 10 ug/kg.

The diesel tank product sample collected by CHT in December 1992 contained benzene, ethylbenzene, TCA (700 ug/L), PAHs, TOG, and TPH (Figure 5-8). The diesel UST was resampled in March 1993 by CHT and in May 1993 by ENSR and BB&L. TCA was not detected in any of the three subsequent samples. The initial value for TCA was not adequately substantiated by QA/QC documentation. Therefore, it is not considered valid, especially since



TCA was not detected in the three subsequent samples. CHT submitted a letter to Clifford Crooke of the DPNR on March 29, 1993, asserting the interpretation that the TCA was attributed to laboratory contamination; however, there was no documentation from the laboratory to substantiate this assertion.

The Target soil-gas survey revealed low concentrations of VOCs (less than 10 ug/L) in the vicinity of the USTs, with the exception of the vicinity of the waste oil UST. The low concentrations are likely the result of volatilization from groundwater.

5.1.8.2 Excavation/Post-Excavation Soil Sampling Results

In October 1993, the two USTs, associated piping, approximately 85 cubic yards of soil, and oil-contaminated gravel, concrete, and asphalt were excavated under the direction of ENSR (see Figure 5-9). The waste oil tank was observed to have four small corrosion holes and the diesel tank was heavily corroded (ENSR 1994a). During excavation of the waste oil UST, a 4-inch diameter PVC pipe was ruptured. Water mixed with a black oily substance flowed from this rupture. This pipe was observed to be located within a 2- to 3-inch thick layer of gravel (ENSR 1994a). Representatives of Four Winds Plaza indicated that the pipe apparently led from an underground spring north of Western Auto to a cistern in the southern part of the property (ENSR 1993). This spring appears to be in the approximate location of the vault located at the Cost-U-Less store. Dye tracing performed by CHT in December 1993 revealed that water from the vault discharges to the east, into the storm sewer system.

During tank removal, samples were collected by ENSR, with split samples collected by BB&L and ADL. Approximately 35 soil samples and 14 product/liquid samples were collected from the excavation, ruptured pipe, surrounding gravel layer, and various locations where liquid/product was observed. These results are shown on Figure 5-9. The three soil samples (PE-1, PE-2, and PE-3) collected by ENSR in December 1993 to evaluate the 4-inch PVC diameter pipe are not shown because their exact locations are not known. Review of the data



shows that the only constituent detected above its NYS TAGM level was acetone in Sample PE-3; the acetone was also found in the laboratory blank.

BB&L's laboratory data for samples SS-2, SS-3, SS-4, SS-5, SS-6, SS-9, SS-11, and WS-2 were reported to be outside quality control (QC) limits for the BNA data. However, this evaluation was based on a MS/MSD that was not performed on a sample collected from the Tutu Wells Site. In addition, data validation guidelines do not require the quantification of sample data based on MS/MSD results. Because a degree of uncertainty remains as to the quality of BB&L's data, they were used only in conjunction with other data to determine whether the soil has been impacted by BNAs.

In 1994, Geraghty & Miller installed Monitoring Wells MW-24 and MW-25 at the Western Auto property. The work was observed by ENSR. As described in Section 1.3.1.2 (Sitewide Hydrogeologic and Groundwater Quality Investigation), the same 4-inch diameter PVC pipe was ruptured. No samples were collected from the pipe during well installation. ENSR collected three soil samples from each monitoring well boring, and Geraghty & Miller collected two samples from the Monitoring Well MW-24 boring and one sample from the Monitoring Well MW-25 boring. The analytical results are discussed below and are shown on Figure 5-9.

PCE was detected in one soil sample, SS-1 (160 ug/kg); this concentration is below the NYS TAGM level of 1,400 ug/kg. Review of Figure 5-9 reveals that PCE was not detected in any other soil samples (approximately six) collected in the immediate vicinity of Soil Sample SS-1. However, these other soil samples had elevated detection limits. This soil was subsequently removed and disposed offsite.

PCE was detected in waste oil tank Sample T1-S(A)(Oil) (3,800J ug/kg) and Product Samples PS-1 (product within the waste oil UST), PS-4 (product from the waste oil bin inside the service area), and PS-5 (from the pipe connecting the inside bin to the waste oil UST) at concentrations ranging from 5,900 to 10,000 ug/kg. TCA was also detected in the same three product samples (PS-1, PS-4, and PS-5) at concentrations ranging between 4,600 and 8,000



ug/kg. TCE was detected at a concentration of 3J ug/L in the replicate sample collected at the ruptured pipe (Sample WL-1RE), but was not detected in the original sample. NYS TAGM levels were not compared for these liquid samples.

Acetone and 2-butanone were detected above NYS TAGM levels (Table 5-7). Methylene chloride and carbon disulfide were also detected, but were attributed to laboratory contamination. No other non-BTEX VOCs were detected in the samples.

BTEX compounds were detected in most soil samples from the waste oil UST. The NYS TAGM level for xylenes (1,200 ug/kg) was exceeded in seven samples from the waste oil UST area at concentrations ranging from 2,700 to 34,000 ug/kg. Benzene and toluene exceeded the NYS TAGM levels in one waste oil sample. In general, only ethylbenzene was detected in soil samples from the diesel UST, and no BTEX constituents exceeded NYS TAGM levels in these samples.

BNAs were detected in each sample collected, but there is a difference in the suites of BNAs found in samples from the waste oil UST and the diesel UST. At the waste oil UST, the primary BNAs detected were anthracenes, chrysenes, fluoranthenes, pyrenes, phenanthrene, naphthalene, and fluorene with individual concentrations ranging between 51 and 34,000 ug/kg. At the diesel UST, naphthalene, 2-methylnaphthalene, fluorene, chrysene, and phenanthrene were the primary BNAs detected, with individual BNA concentrations ranging between 1J and 23,000 ug/kg. Benzo(b)fluoranthene and chrysene exceeded their NYS TAGM levels in soil samples from both UST locations.

ENSR performed fingerprinting on liquid and product samples from the two USTs and the ruptured 4-inch diameter PVC pipe, and also on soil samples, to identify the types of petroleum products comprising the contamination in relation to potential sources. The results showed that both the diesel UST and the 4-inch PVC pipe and gravel layer contained heavy and mid-range petroleum product, while the waste oil tank had mainly heavy product constituents with some mid-range components (ENSR 1994a).



The TPH results ranged from 88 to 21,000 mg/kg. The highest concentrations were found in shallow soil, at the locations of the ruptured PVC pipe and gravel zone. Lower concentrations of TPH were observed at depth and within the tank excavations. These results, in conjunction with the fingerprinting performed by ENSR, suggest that the 4-inch diameter PVC pipe and gravel zone are potential sources of impact to soil and groundwater quality.

The results of the Gore-Sorber survey showed the presence of diesel fuel in the vicinity of the former diesel UST, heavy oil components in the vicinity of the former waste oil UST, and both diesel and heavy oil components emanating from the northeast end of the loading dock and the area east of the former USTs (ENSR 1994b, 1994c).

Metals were detected at twice the average background values in many soil samples collected from the vicinity of the tank excavations. These metals included arsenic, lead, barium, sodium, potassium, and zinc. In addition, arsenic, sodium, barium, manganese, and potassium were found at greater than twice the average background concentrations in soil samples from Monitoring Wells MW-24 and MW-25.

NYS TAGM levels were exceeded for xylenes, benzo(b)fluoranthene, and chrysene in numerous soil samples at Western Auto. The observation of corroded tanks, the presence of the 4-inch diameter PVC pipe that was leaking in several locations (ENSR 1994a), the occurrence of an oily gravel zone, the results of the Gore-Sorber surveys (ENSR 1994b, 1994c), and the detection of product within the tanks and the excavations suggest numerous sources for these impacts to the soil. PCE was detected in one soil sample below the NYS TAGM levels, and this soil was disposed off-site.

5.1.9 Esso Tutu Service Station Soil Sampling Results

Soil investigations have been conducted at the Esso Tutu Service Station by CDM [1989], Soil Tech Corporation [1989], Geraghty & Miller (Phase I of the RI), and BB&L [1993 and 1994]. Soil-gas surveys were performed by GCL [1987], Belgodere [1988], and Target [1992].



In addition, waste oil sampling at the oil/water separators was performed by Weston/SPER [1987] and CDM [1988 and 1989]. Areas investigated as potential sources at the Esso Tutu Service Station included two former and two existing gasoline USTs and associated piping, two oil/water separators (the north oil/water separator has previously been identified as a waste oil holding tank), and former vehicle maintenance service bays. Approximately 75 soil samples have been collected. Available analytical results are provided on Figure 5-10, except for the approximately 21 soil samples collected by CDM and Soil-Tech Corporation (Samples SP-1 through SP-7) during the 1989 UST excavations. These results are not shown because these samples were collected from excavated soil piles, rather than in-situ soils, and their original location is unknown.

Soil-gas surveys by GCL, Belgodere, and Target identified PCE and related compounds within the area of the Esso Tutu Service Station. Concentrations of chlorinated VOCs in soil gas are not higher beneath the Esso Tutu Service Station when compared to surrounding areas. Data from the soil-gas surveys identified the presence of BTEX and MTBE in proximity to the gasoline USTs and piping.

Chlorinated VOCs, including PCE, TCE, TCA, 1,2-DCE, and DCA, were detected in the area of the north oil/water separator at individual constituent concentrations ranging from 31 to 3,200 ug/kg (Figure 5-10). PCE was detected in Sample SS-8 at 1,500 ug/kg; the NYS TAGM level for PCE is 1,400 ug/kg (Table 5-7). 1,2-DCE and DCA were detected above their NYS TAGM levels in Soil Sample SS-3. Based on the excavation and inspection of the subsurface near the north oil/water separator by BB&L, the potential releases of chlorinated VOCs from the north oil/water separator appear to be limited to an effluent pipe that extends approximately 11 feet west of the oil/water separator. This interpretation is substantiated by soil samples collected by BB&L (see Figure 5-10).

PCE was detected in two shallow samples collected from Soil-Tech Soil Boring B-103 (394.3 ug/kg in the 0- to 1-foot sample, and 85.1 ug/kg in the 2- to 2.5-foot sample), from one sample at Soil-Tech Soil Boring B-109 (10.46 ug/kg), and from one sample at Monitoring Well



MW-8 (2J ug/kg). These values are all below the NYS TAGM level of 1,400 ug/kg. Soil Boring B-103 was located near the south oil/water separator, which may be the source of this PCE. Sampling conducted by Weston/SPER [1987] and CDM [1988 and 1989] identified the presence of PCE and TCA in oil/water separator samples. PCE was detected at concentrations indicative of soil impact in the two shallow samples from Soil Boring B-103 but not in the two deeper samples (Figure 5-10). Chlorinated VOCs were not detected in any samples collected in 1989 from within the UST excavation pit (Samples TP-1 through TP-13).

The analytical results show that BTEX and BNAs occur in soil in the vicinity of the north oil/water separator and the former UST excavation. In these samples, BTEX constituents and benzo(b)fluoranthene, chrysene, naphthalene, benzo(a)anthracene, and 2-methylnaphthalene were found above NYS TAGM levels (Tables 5-7 and 5-8). Individual BTEX constituents ranged in concentration from 29 to 540,000 ug/kg. Individual BNAs ranged in concentration from 510 to 45,000 ug/kg and consist primarily of fluoranthene, naphthalene, chrysene, pyrene, and phenanthrene. Isolated occurrences of these constituents were found at other sampling locations at concentrations generally lower than at the north oil/water separator and former UST excavation. All metals concentrations in soil samples were within twice the average background concentration, except for arsenic in Soil Sample B-9, which was detected at slightly above twice the average background concentration. The arsenic concentration in Soil Sample B-9 was an estimated value that was also found in the laboratory blank.

The soil-gas surveys identified the highest concentrations of BTEX and MTBE at the Esso Tutu Service Station property, specifically in the vicinity of the excavated USTs. After the USTs were excavated, soil samples were collected, and then an additional 2 feet of soil were removed to accommodate the new USTs (Soil Tech Corporation 1990).

Based on the detection of BTEX, BNA, and chlorinated VOC constituents above NYS TAGM levels, soil at the Esso Tutu Service Station has been impacted by these constituents. Possible sources of BTEX are the pump island, the former USTs, and the north oil/water separator. The known extent of BNAs is limited to the vicinity of the north oil/water separator



and the former UST excavation, although not all soil samples were analyzed for BNAs. There was one detection of PCE at a concentration above the NYS TAGM level, and one detection of 1,2-DCE and DCA above TAGM levels in another sample. Both samples were collected from the vicinity of the north oil/water separator.

5.1.10 O'Henry Dry Cleaners Soil Sampling Results

Soil investigations have been performed at O'Henry by CDM [1988 and 1989], Geo-Caribe [1990], Geraghty & Miller [1992], and ADL [1993]. Areas investigated as potential sources included a fuel tank, a drum storage area, and a reported dry cleaning filter disposal area located at the south corner of the property. Approximately 20 soil samples were collected at the locations shown on Figure 5-11.

PCE was detected in approximately half the soil samples at concentrations ranging from 11 to 440,000 ug/kg (Figure 5-11). The highest concentrations were detected at the southeastern end of the building, where five samples from Soil Boring e02-02, Soil Boring OHSS-1, and Surface Sample e-01 had PCE concentrations above the NYS TAGM levels (Table 5-7). PCE concentrations detected in two soil samples (440,000 ug/kg in sample e-01 and 180,000 ug/kg in sample e02-02) from this southeastern end of the O'Henry building are the highest reported PCE soil values at the Tutu Wells Site.

The USEPA HRS document referred to the VOC in Sample e-01 as tetrachloroethane, instead of tetrachloroethene (PCE). This reference is believed to be a typographical error since tetrachloroethane has not been detected anywhere at the Tutu Wells Site, whereas PCE has been detected in other samples at O'Henry and throughout the Tutu Wells Site. Furthermore, tetrachloroethane is usually presented with the location of where the four chlorine atoms are attached on the ethane chain (e.g., 1,1,1,1-tetrachloroethane or 1,1,2,2-tetrachloroethane), which was not the case in this instance.



Soil Boring OHSS-1 was drilled by Geo-Caribe at the same location as CDM Samples e02-01/e02-02 (Figure 5-11). A review of the vertical profile data for PCE at this location shows that PCE concentrations decrease by several orders of magnitude to 400J ug/kg in the 8.5 to 10-foot deep sample and were not detected in the soil sample collected from 19 to 19.5 feet below grade. However, the detection limit in this sample was elevated (640 ug/kg) due to dilution. ADL (1994) sampled the sanitary sewer in the vicinity of O'Henry and found PCE, TCE, 1,2-DCE, and vinyl chloride. These results are discussed in Section 5.3.2 (Sanitary Sewer Results).

Other non-BTEX VOCs, including methylene chloride, acetone, and 2-butanone were also detected above NYS TAGM levels. These detections are probably attributable to laboratory contamination since most values were qualified with a "B."

BTEX compounds were detected at low concentrations (less than 6 ug/kg) in samples where the constituent was also found in the associated laboratory blank, suggesting blank contamination. The only exception was the detection of xylenes above the NYS TAGM level of 1,200 ug/kg in the field replicate for OHSS-1, which was collected at 5 feet bls (at 4,700 BJ ug/kg). Only two BNAs (phthalates) were detected in two soil samples, at estimated concentrations below NYS TAGM levels. TPH was detected at concentrations ranging between 25 and 41 mg/kg in the four samples in which it was analyzed.

Metals were analyzed only in the six samples collected by Geraghty & Miller. In these samples, arsenic, barium, manganese, potassium, and zinc were detected above twice the average background concentrations for these metals.

Based on the detection of PCE above NYS TAGM levels in soil samples, the O'Henry property has soil impacted by chlorinated VOCs. The highest concentrations of PCE in soil throughout the Tutu Wells Site were detected at this property. One soil sample exceeded the NYS TAGM level for xylene, and its detection was attributed to laboratory contamination.



5.1.11 Soil Sampling Results at Other Properties

To provide additional sitewide characterization of soils, Geraghty & Miller collected soil samples at the Fire Station, Vitelco, the God of Holiness Church, the Lutheran Church, and the Assembly of God Church. Sampling details at each site are summarized below.

One soil boring (Soil Boring B-7) was drilled at the Fire Station in 1992 by Geraghty & Miller during the Phase I RI. One soil sample was collected at 2 to 4 feet bls. No chlorinated VOCs, BTEX, or BNAs were detected in this sample, and TPH was detected at 28 mg/kg (Figure 5-12). Since no detectable organic compounds were reported in Soil Boring B-7 and no suspected sources of metal contamination are located near this boring, this sample was considered to be representative of natural (background) concentrations, as previously described. Based on the limited analytical results, no impact to soil has been identified at the Fire Station because no constituents other than TPH were detected.

One soil sample and one replicate were collected at Vitelco in 1992 by Geraghty & Miller. The samples were collected from 14 to 16 feet bls in the borehole for Monitoring Well MW-7, located at the gravel-covered parking area used for company vehicles (Figure 5-13). With the exception of methylene chloride (12 ug/kg and 18 ug/kg) no other VOCs or BNAs were detected. These values are below the NYS TAGM level of 100 ug/kg for methylene chloride. TPH was detected at a low concentration of 27 mg/kg in Sample MW-7, but not in its replicate. All metal and cyanide concentrations were within twice the average background concentrations, except for potassium. Since no constituents were detected except for methylene chloride and TPH, and methylene chloride did not exceed the NYS TAGM level, no impact to soil has been identified at the Vitelco property.

One soil sample was collected at the God of Holiness Church in 1992 by Geraghty & Miller. The sample was collected from 4 to 6 feet bls in the borehole for Monitoring Well MW-19 (Figure 5-14). No VOCs, BNAs, or TPH were detected in this sample, and all metals and cyanide concentrations were within twice the average background concentrations, except for



potassium. Based on these results, no impact to soil has been identified at the God of Holiness Church.

One soil sample was collected at the Lutheran Church in 1992 by Geraghty & Miller. The sample was collected from 10 to 11 feet bls in the borehole for Monitoring Well MW-11D, which is located in an unpaved area (Figure 5-15). With the exception of methylene chloride (4J ug/kg) and toluene (1J ug/kg), which are attributable to laboratory contamination, no VOCs, BNAs, or TPH were detected. These two constituents were detected at concentrations below their respective NYS TAGM levels (Table 5-7). Barium, copper, potassium, and sodium were detected above twice the average background concentrations. Based on these results, no impacted soil has been identified at the Lutheran Church.

One soil sample was collected at the Assembly of God Church in 1992 by Geraghty & Miller. The sample was collected at 4 to 6 feet bls in the borehole for Monitoring Well MW-12D (Figure 5-16). No VOCs, BNAs, or TPH were detected in this sample, and all metals and cyanide concentrations were below twice the average background concentrations, except for sodium. Based on these results, no impacted soil has been identified at the Assembly of God Church.

5.1.12 Summary of Soil Quality Results

Based on the information provided above, several properties have soil that has exceeded NYS TAGM levels. These properties include, from north to south, the Curriculum Center, Ramsay Motors, Antilles Auto Parts, Texaco Tutu Service Station, Western Auto, Esso Tutu Service Station, and O'Henry. To facilitate comparison to groundwater quality, which is discussed in Section 5.2 (Groundwater Quality), these properties have been divided into the following two groups: properties with soil impacted by BTEX, MTBE, and BNAs and properties with soil impacted by chlorinated VOCs. The properties that have soil that has exceeded NYS TAGM levels are summarized in the following sections.



5.1.12.1 Properties with Soil Impacted by BTEX, MTBE, and BNA Compounds

The soil at the following properties has been impacted by BTEX, MTBE, and/or BNA compounds:

Curriculum Center:	BTEX constituents have been detected in soil and have exceeded NYS TAGM levels along the northeastern corner of the property.
Ramsay Motors:	BTEX, MTBE, and BNA compounds have been detected in soil, water, and oil from a ponded zone near the waste oil UST. 2-Butanone and chrysene were detected above their NYS TAGM levels in soil samples collected near the UST.
Antilles Auto Parts:	No constituents were detected above NYS TAGM levels on the property, but BNA compounds in soil at the adjacent Ramsay property may be the result of a reported oil spill originating from previous operations at Antilles Auto Parts.
Texaco Tutu Service Station:	BTEX- and MTBE-impacted soil has been observed in the vicinity of former USTs and the oil/water separator. Benzene was detected above the NYS TAGM level in one sample, and higher concentrations were previously detected in excavated soil.



- Western Auto:** BTEX- and BNA-impacted soil has been observed in the vicinity of the two excavated USTs, the ruptured 4-inch PVC pipe, and the surrounding gravel layer. Xylenes, benzo(b)fluoranthene, and chrysene have been detected above NYS TAGM levels.
- Esso Tutu Service Station:** BTEX and BNAs have been detected in soil and soil-gas samples in the vicinity of the north oil/water separator and the excavated USTs. BTEX, benzo(b)fluoranthene, chrysene, naphthalene, benzo(a)anthracene, and 2-methylnaphthalene were found above NYS TAGM levels.

5.1.12.2 Properties with Soil Impacted by Chlorinated VOCs

The soil at the following properties has been impacted by chlorinated VOCs:

- Curriculum Center:** Chlorinated VOCs (including PCE) have been detected in soil and soil gas at the north and northwest portions of the building and have been detected above NYS TAGM levels. Based on the presence of PCE in abandoned pipes of the Curriculum Center, chlorinated VOCs may be present at higher concentrations in the relatively thick unsaturated bedrock, which, in accordance with the work plan, was not sampled.
- Esso Tutu Service Station:** PCE was detected above the NYS TAGM level in one soil sample. 1,2-DCE and DCA were detected above the NYS TAGM levels in another soil sample. Both samples were collected from the vicinity of the north oil/water separator.



O'Henry Dry Cleaners: PCE has been detected in soil above NYS TAGM levels at the southeast corner of the building.

5.1.12.3 Properties with Soil Impacted by Other Compounds

One property was identified with soil impacted by Aroclor 1242 and manganese as follows:

Tillett Gardens: Aroclor 1242 and manganese soil concentrations were detected above the USEPA's human health-based risk level (CDM 1995). In addition Aroclor 1242 was detected above NYS TAGM level for PCBs.

5.2 GROUNDWATER QUALITY

Geraghty & Miller collected groundwater samples from 51 monitoring wells and 15 supply wells between May 24 and July 29, 1994. Sampling was conducted in accordance with the procedures established in the Phase II RI Work Plan (Geraghty & Miller, Inc. 1992b) and described in Section 3.7.6 (Monitoring Well Sampling and Analysis) and Section 3.7.7 (Supply Well Sampling) of this RI Report. Groundwater analytical results are provided in Tables 5-10 through 5-14. Field and trip blank analytical results are also provided in these tables.

The analytical results of the comprehensive groundwater sampling event are discussed in detail in this section and are compared to the results of the Phase I RI presented in Technical Memorandum II (Geraghty & Miller, Inc. 1993a). The results of eight rounds of supply well sampling were reviewed; these results provide indications of the variations and degree of stability in groundwater quality over time. A summary of total chlorinated VOC and BTEX concentrations in the supply wells sampled during the eight events is provided in Table 5-15. Where relevant, the eight rounds of supply well groundwater sampling results and the results collected by other investigators are discussed in this section.



Groundwater samples collected during the Phase II RI comprehensive groundwater sampling event were analyzed for TCL VOCs plus MTBE, EDB, n-propylbenzene, TCL BNAs, TAL metals, and various inorganic water quality parameters, as listed in Table 3-3. In addition, four supply wells (Gassett [New], Harthman Racetrack, Delegarde, and VIHA I) were analyzed for VOCs using USEPA Method 524.2, which has lower detection limits than Method 624. Lower detection limits were desired because these wells are on the perimeter of the defined plume of organic constituents.

Split samples were collected by various consultants during the comprehensive groundwater sampling event. At O'Henry, IT collected split samples for VOC analysis from Monitoring Wells OHMW-1 through OHMW-4 on May 24, 1994. At Ramsay Motors, CEI collected split samples from Monitoring Wells MW-15 and MW-17 on June 7, 1994 for analysis of VOCs, BNAs, pesticides/herbicides, total metals, and cyanide. ENSR collected split samples at Western Auto from Monitoring Wells MW-24 and MW-25 for analysis of VOCs, BNAs, total and dissolved metals, and cyanide. ENSR also collected split samples from Monitoring Wells DW-1 and MW-8 for analysis of VOCs and BNAs in May and June 1994. In April 1994, BB&L collected samples from Monitoring Wells SW-1 through SW-7, DW-1, DW-2, CHT-2 through CHT-4, CHT-7D, MW-8, MW-9, MW-10, MW-10D, and MW-12D for analysis of VOCs, BNAs, and inorganic parameters. The samples collected by BB&L were not collected concurrent with the comprehensive sampling event. A summary of wells sampled and parameters analyzed by these investigators is provided in Table 5-16.

Criteria were developed to evaluate whether a property represented a source of impact to groundwater. The following criteria were used:

- If impact to soil at a property was established based on the NYS TAGM values, and similar constituents were found in the groundwater at or downgradient of the property at higher concentrations than upgradient, the property was considered to represent a source of impact to groundwater.



- If organic compounds were detected in groundwater at concentrations in excess of 1 percent of their aqueous solubility at a property, these detections were viewed as an indication of the possible presence of nonaqueous phase liquids (NAPLs) in the unsaturated or saturated zone. The property was therefore considered to represent a source of impact to groundwater.

5.2.1 Organic Compounds

To facilitate discussion, organic constituents of concern in groundwater have been divided into the following categories: BTEX and petroleum-related VOCs (MTBE, EDB, and n-propylbenzene), BNAs, and chlorinated VOCs (Tables 5-10 and 5-11). In addition, the data have been plotted on separate maps for the shallow and deep bedrock zones. On Figures 5-17 through 5-32, a symbol has been added to the data to identify those groundwater samples where detection limits were elevated above 25 ug/L (equivalent to ppb) for an individual chlorinated VOC or BTEX compound.

5.2.1.1 BTEX and Petroleum-Related Compounds in Groundwater

Groundwater analytical data for BTEX compounds collected during the Phase II RI are shown on Figures 5-17 (shallow zone) and 5-18 (deep zone). Total BTEX concentrations have been contoured at intervals of 10, 100, and 1,000 ppb. Review of these figures shows that groundwater from three separate areas, the Texaco Tutu Service Station, the Esso Tutu Service Station, and Kentucky Fried Chicken, has been impacted by BTEX compounds. These BTEX plumes are limited in areal extent in comparison to the chlorinated VOC plumes discussed below in Section 5.2.1.3 (Chlorinated Volatile Organic Compounds). In addition, the only supply well that has shown the presence of total BTEX compounds at concentrations over 3 ug/L during the eight supply well sampling events is the Tillett Well.

Elevated BTEX concentrations in groundwater have been detected in the vicinity of the Texaco Tutu Service Station in both the shallow and deep zones. In the shallow zone, the



highest BTEX concentrations were detected in Monitoring Wells TT-1 (58,700 ppb), TT-4 (58,300 ppb), and MW-5 (1,610 ppb). This plume seems to originate in the vicinity of the former USTs. The shallow plume is similar in areal extent to that observed in 1992 (Geraghty & Miller, Inc. 1993a) except that BTEX constituents have migrated past the Tillett Supply Well to Monitoring Well MW-7. BTEX constituents were not detected in Monitoring Well MW-7 in 1992 but were detected at 21 ppb in 1994.

The highest BTEX concentration in the deep zone in the vicinity of the Texaco Tutu Service Station was one order of magnitude lower than in the shallow zone; BTEX was detected in deep Monitoring Well TT-1D at 1,873 ppb (Figure 5-18). The deep BTEX plume in the vicinity of the Texaco Tutu Service Station was not well defined in 1992 because few deep wells existed. The 1994 BTEX plume has been better defined by installation of deep monitoring wells TT-1D and TT-5D. The Tillett Supply Well, in which 4 ppb of BTEX compounds were detected in 1994, has shown higher BTEX concentrations in the past. Although they have fluctuated, BTEX concentrations in the Tillett well have decreased by approximately one order of magnitude from a high of 91 ppb over the nine times that this well has been sampled since October 1990.

Floating product has been observed in Monitoring Wells MW-4D and MW-5 at the Texaco Tutu Service Station. On September 28, 1992, an oily petroleum liquid was observed floating on the water table in deep Monitoring Well MW-4D. The thickness of this petroleum product was measured (0.01 foot) and then bailed out of the well. No product has been observed in Monitoring Well MW-4D since this occurrence, and no product has been observed in any other deep well. The observation of floating product in Monitoring Well MW-4D may have been due to surface runoff that entered this flush-mounted well. For a short period after installation, the integrity of the sanitary seal at Monitoring Well MW-4D was questionable. Groundwater samples obtained by GCL in December 1993 had low BTEX concentrations, substantiating the interpretation that the one-time observance of product in Monitoring Well MW-4D was the result of surficial runoff. Product sheen or odors were also noted during the comprehensive groundwater sampling event in Monitoring Wells TT-1, TT-1D, and TT-4.



The second area of elevated BTEX concentrations in groundwater occurs at the Esso Tutu Service Station, with the highest concentrations detected in Monitoring Wells SW-3 (39,300 ppb), CHT-3 (5,680 ppb), and SW-2 (2,700 ppb). The shallow plume, which is defined by non-detectable BTEX concentrations in monitoring wells on all sides, is centered in the vicinity of the former USTs and pump island (Figure 5-17). The plume is similar in areal extent to the BTEX-impacted areas identified in the Phase I RI in 1992. One notable difference is that the highest total BTEX concentrations exceeded 100,000 ppb in 1992 (in Monitoring Well CHT-3), but decreased to 39,300 ppb (in Monitoring Well SW-3) in 1994. BTEX constituents were not detected in any deep monitoring wells in the vicinity of the Esso Tutu Service Station (Figure 5-18).

Visual observation indicated the presence of liquid phase hydrocarbon product in shallow Monitoring Wells MW-9 and MW-9S between September and November 1992. Floating product was observed once in Monitoring Well MW-9 (sheen). In Monitoring Well MW-9S, product was measured on four occasions, with product thickness ranging from a sheen on three occasions (September 17, 1992; October 28, 1992; and November 16, 1992) to 0.11 foot on September 28, 1992. Product was not detected in Monitoring Well MW-9S on November 9, 1992. The product in Monitoring Well MW-9S appeared to be a petroleum hydrocarbon that had weathered to a dark-colored, viscous, oily liquid.

On December 20, 1993, 0.01 foot of floating product was measured by BB&L in Monitoring Well SW-7. During a subsequent measurement on April 5, 1994, BB&L identified only a sheen in Monitoring Well SW-7. During the Phase II RI comprehensive groundwater sampling event in May and June 1994, Monitoring Well SW-7 contained product described in the field as having the appearance of a weathered black petroleum hydrocarbon. At the time of sampling, the product thickness could not be measured using a Teflon bailer. Product sheen or odors were also reported in Monitoring Wells SW-3 and MW-9S during the comprehensive groundwater sampling event. The product detected in Esso Monitoring Wells MW-9S and SW-7 is not related to dissolved BTEX concentrations, but rather appears to be derived from waste oil and heavier petroleum hydrocarbons that do not have a significant BTEX content.



An elevated BTEX concentration (148 ppb) was detected in the groundwater sample from shallow zone Monitoring Well KFMW-2 (KFC-1). No other groundwater samples were collected in this area during the Phase II RI to define the extent of BTEX impact. Free petroleum product was reportedly observed in excavations during the removal of leaking USTs at this location in 1990 by Terra Vac (Terra Vac 1990).

Groundwater quality data from downgradient supply wells were reviewed to evaluate the downgradient extent of BTEX compounds. As shown on Figure 5-19, BTEX compounds were not detected in 1994 in the Steele, LaPlace, Smith, or Matthias supply wells. BTEX compounds were also not detected in the off-site downgradient supply wells Dench, Devcon, or Dede. The most recent available data for these wells are plotted on Figure 5-19, and a summary of the data from all eight supply well sampling rounds is provided in Table 5-15.

Other petroleum-related compounds, including MTBE and n-propylbenzene, have been detected at or near the Texaco and Esso Tutu Service Stations. MTBE is one to two orders of magnitude more soluble and mobile than gasoline constituents such as benzene, toluene, and xylene. This higher solubility is demonstrated by the greater extent of the MTBE plume, as compared to the BTEX plume. MTBE also increases the solubility and mobility of benzene, toluene, xylene, and other gasoline constituents (Garrett et al. 1986). There is no federal drinking water standard for MTBE.

In general, MTBE concentrations at both locations have decreased from 1992 concentrations up- and side-gradient of the service stations, but have increased downgradient, particularly south of the Esso Tutu Service Station. As shown on Figure 5-20, concentrations of MTBE in the shallow zone in the vicinity of the Texaco Tutu Service Station are one order of magnitude higher than in the deep zone (Figure 5-21). The highest concentrations in shallow zone monitoring wells are 56,000J ppb at Monitoring Well TT-4 and 28,000DJ ppb at Monitoring Well TT-1, whereas the highest concentrations of MTBE in deep zone wells are 1,900DJ ppb at Well TT-1D and 250J at the Tillett Supply Well.



The areal distribution of MTBE in the shallow zone is similar to the shallow BTEX plume but the MTBE is more widespread. In the deep zone, MTBE appears to extend north (i.e., upgradient) of the Texaco Tutu Service Station, possibly as a result of pumping of the Ramsay Supply Well, where 3.7 ug/L were detected during the most recent sampling event (Figure 5-21). MTBE in the deep zone has migrated further south, possibly accelerated by pumping of the Tillett Supply Well, and has also migrated to the west, as seen by the presence of MTBE in Monitoring Wells CHT-6D and MW-6D.

A second MTBE plume has been mapped near the Esso Tutu Service Station. MTBE concentrations in the shallow zone are as high as approximately 90,000 ppb (Figure 5-20), whereas the highest concentration in the deep zone is 170 ppb (Figure 5-21). In the shallow zone, the MTBE has migrated further downgradient than the BTEX constituents. In the deep zone, MTBE also extends further south than the BTEX constituents.

N-propylbenzene, another petroleum-related compound, was detected at elevated concentrations in shallow Monitoring Wells SW-3 (3,800 ppb) and CHT-3 (1,100 ppb) at the Esso Tutu Service Station and in shallow Monitoring Well TT-1 (450 ppb) at the Texaco Tutu Service Station.

5.2.1.2 Base Neutral and Acid Extractable Compounds

Elevated BNA concentrations were detected in shallow Monitoring Wells SW-3, SW-7, CHT-3, KFMW-2 (KFC-1), TT-1, and MW-5 (Table 5-11). The primary constituents detected were 2-methylnaphthalene, naphthalene, and some phenols. These elevated BNAs occur at the Texaco Tutu Service Station, the Tutu Esso Service Station, and Kentucky Fried Chicken.

Bis(2-ethylhexyl)phthalate was detected in most groundwater samples; this compound is a common laboratory contaminant and was detected in several method blanks. The BNA analytical results are shown for the shallow and deep groundwater zones on Figures 5-17 and 5-18, respectively, and are summarized in Table 5-11.



5.2.1.3 Chlorinated Volatile Organic Compounds

The concentrations of total chlorinated VOCs detected during the comprehensive sampling event are shown on Figures 5-22 (shallow zone) and 5-23 (deep zone). Total chlorinated VOCs have been contoured at intervals of 10, 100, and 1,000 ppb. Non-chlorinated, non-BTEX-related VOCs are also listed for each sample, but are not included in the totals. Chlorinated VOC analytical data are listed in Table 5-10. Samples from nine wells (Monitoring Wells SW-2, SW-3, SW-7, CHT-3, MW-1D, MW-3, MW-16, TT-1, and TT-4) were diluted due to elevated BTEX or chlorinated VOC concentrations; consequently the detection limits were raised. However, samples collected from Monitoring Well SW-7 (shown on Figure 5-22) by BB&L in April 1994 had lower detection limits and helped delineate the extent of chlorinated VOCs. In general, the split samples collected by other investigators had similar results to Geraghty & Miller's groundwater data.

The primary chlorinated VOCs detected in most groundwater samples were PCE, TCE, and 1,2-DCE (the cis/trans isomers were not differentiated by the laboratory). Other detected chlorinated compounds that were less widespread were vinyl chloride, chloroform, and TCA. Total chlorinated VOCs and the relative percentages of PCE, TCE, 1,2-DCE, and vinyl chloride have been plotted on Cross-Section A-A' (Figure 5-24).

As shown on Figures 5-22 and 5-23, there are distinct areas of total chlorinated VOC concentrations above 100 ppb in groundwater. These plumes are enclosed within an area of total chlorinated VOC concentrations greater than 10 ppb that extends from the VIHA-I Supply Well in the north (in both the shallow and deep zones) past the Delegarde Supply Well to the south (in the deep zone). The overall configuration of the area impacted by chlorinated VOCs is apparently controlled by the groundwater flow directions (see Figures 4-12 through 4-15).

During the Phase I RI, Geraghty & Miller identified two separate chlorinated VOC plumes (Geraghty & Miller, Inc. 1993a). One plume originated at the Curriculum Center and was referred to as the northern chlorinated VOC plume. The other originated in the vicinity of



O'Henry Dry Cleaners and was referred to as the southern chlorinated plume. During the Phase I RI, groundwater data from both the shallow and deep zones were plotted on one figure (Geraghty & Miller, Inc. 1993a). As part of the Phase II evaluation, data from these zones were plotted on separate figures to identify trends more clearly. The figures still support the identification of the two separate plumes of total chlorinated VOC concentrations in excess of 100 ppb, although the northern plume appears to be separated into two discrete bodies in both the shallow and the deep zones. These plumes are discussed below.

5.2.1.3.1 Northern Chlorinated VOC Plume

As shown on Figures 5-22 and 5-23, the northern chlorinated VOC plume originates at the Curriculum Center where chlorinated VOC concentrations greater than 1,000 ppb were detected in shallow Monitoring Wells MW-1 (1,363 ppb), MW-15 (1,905 ppb), and MW-16 (3,543 ppb). Concentrations of total chlorinated VOCs greater than 1,000 ppb were not detected in deep zone monitoring wells, but a concentration of 931 ppb of total chlorinated VOCs was detected in Monitoring Well MW-1D (Figure 5-23).

The primary VOCs detected in both the shallow and deep zones were PCE, TCE, and 1,2-DCE; vinyl chloride was also detected at high concentrations, but only in a few wells. In each instance, 1,2-DCE comprised the majority of total chlorinated VOCs detected with a range of 54 to 78 percent (Figure 5-24). The highest concentrations of these primary VOCs were 2,100 ppb of 1,2-DCE (at Monitoring Well MW-16), 1,300 ppb of vinyl chloride (at Monitoring Well MW-16), 360 ppb of PCE (at Monitoring Well MW-1D), and 78 ppb of TCE (at Monitoring Well MW-1). These wells are all located at the Curriculum Center. Monitoring Well MW-16 was installed during the Phase II RI directly downgradient of the area where the highest chlorinated VOCs were detected during the soil-gas survey (see Appendix B). The chlorinated VOCs detected in soil-gas samples at the location of Monitoring Well MW-16 were PCE, TCE, and 1,2-DCE.



In both zones, the northern chlorinated VOC plume mapped in 1994 is elongated in the direction of groundwater flow (Figures 5-22 and 5-23). The extent of the northern plume of chlorinated VOCs in the shallow and deep zones in 1994 is consistent with the extent delineated in the Phase I RI (Geraghty & Miller, Inc. 1993a). The shape, general extent, and concentrations in the northern part of the northern plume have changed slightly over time, indicating that the northern chlorinated VOC plume is relatively stable. This stability suggests that there is a continuing source.

In the shallow zone, the northern and southern plumes appear to have merged, based on the 10-ppb contour. This observation may be explained by the cessation of pumping of the Tillett Supply Well and reduction of pumpage of the Four Winds Supply Wells, enabling chlorinated VOCs that may previously have been contained by the pumping to migrate downgradient. Over 100 ppb of chlorinated VOCs were detected in Monitoring Well MW-12D in 1994, whereas virtually no chlorinated VOCs were detected in this well in 1992.

Concentrations of chlorinated VOCs in both the shallow and deep zones appear to be declining in the downgradient portion of the northern plume. Monitoring wells at the Esso Tutu Service Station and supply wells at Four Winds Plaza showed maximum total chlorinated VOC concentrations of approximately 300 ppb in 1992 (Monitoring Well CHT-3 and the Four Winds I Supply Well), whereas in 1994, wells in that vicinity show maximum total chlorinated VOC concentrations of approximately 200 ppb. Between October 1990 and February 1992 (Supply Well Sampling Rounds 1 through 5 [Geraghty & Miller, Inc. 1993c]), total chlorinated VOC concentrations in the Four Winds II Supply Well fluctuated between 106 and 341 ppb. Although the Four Winds I Supply Well was only sampled four times between October 1991 to March 1993, concentrations of VOCs increased from 135 ppb in October 1991 to around 250 ppb between February 1992 through March 1993. In 1994, the total chlorinated VOC concentration in Four Winds I Supply Well was 89 ppb. The decrease in concentrations in this area may be due to the overall reduction of supply well pumping (e.g., the Tillett and Four Winds Supply Wells); past pumpage of wells in the area may have drawn chlorinated VOCs from north to south more rapidly than is currently occurring.



To provide a more thorough evaluation of potential sources of chlorinated VOCs, individual VOCs were contoured. The concentrations of PCE, TCE, 1,2-DCE, and vinyl chloride were plotted on base maps for the shallow and deep zones (Figures 5-25 through 5-32).

Review of Figures 5-25 and 5-26 shows that the areal distribution of PCE in the shallow zone and deep zones, respectively, coincides with the distribution of the total chlorinated shallow and deep VOC plumes (Figures 5-22 and 5-23, respectively). Differences occur in the deep zone where the 100-ppb contour for total chlorinated VOCs extends from the Tillett Well to Monitoring Well MW-12D, while the 100-ppb contour for PCE is limited to the vicinity of the Tillett Well. In both zones, the concentration of PCE is approximately one order of magnitude lower than total chlorinated VOCs.

Review of Figures 5-27 and 5-28 shows that TCE occurs at relatively low concentrations of less than approximately 80 ppb throughout the Tutu Wells Site. As shown on Figure 5-24, TCE in the northern chlorinated plume accounts for approximately 2 to 8 percent of the total of the four primary chlorinated VOCs.

Concentrations of 1,2-DCE are presented on Figures 5-29 (shallow zone) and 5-30 (deep zone). In both zones, the areal distribution of 1,2-DCE corresponds to the areal distribution of total chlorinated VOCs. In the vicinity of the Curriculum Center, 1,2-DCE accounts for 59 to 78 percent of the four primary VOCs in the shallow zone (Figure 5-24). The variability in the percentage of 1,2-DCE in the deep zone can possibly be attributed to breakdown through dehalogenation of PCE over time.

Vinyl chloride concentrations are plotted for the shallow and deep zones on Figures 5-31 and 5-32, respectively. As shown on these figures, vinyl chloride only appears as a discrete plume in the shallow zone near, and downgradient of, the Curriculum Center. Vinyl chloride has only been detected in Monitoring Wells MW-3, MW-15, MW-16, TT-3D, and TT-5, all of which are located within this plume. Vinyl chloride is probably present due to more complete



dehalogenation of PCE over time. An estimated concentration of 1J ppb was also detected in the Four Winds I Supply Well.

PCE is the predominant VOC in groundwater throughout the Tutu Wells Site. Vinyl chloride is one of the biodegradation products of PCE, and as such, may be expected to be found in groundwater elsewhere in the valley. Its detection in only five wells, all of which are in the vicinity and downgradient of the Curriculum Center, is not readily explained. It is possible that biodegradation conditions in the groundwater are not uniform or that this vinyl chloride may be derived from an older source at the Curriculum Center, upgradient of the building, as evidenced by a vinyl chloride concentration of 1,300 ppb in upgradient Monitoring Well MW-16. Alternatively, vinyl chloride may have been released in the vicinity of Monitoring Well MW-16 as a primary constituent (although it is not likely given that vinyl chloride volatilizes readily at standard atmospheric pressure and temperatures), or as an impurity in other chlorinated solvents (such as PCE) that were released.

5.2.1.3.2 Southern Chlorinated VOC Plume

As shown on Figures 5-22 and 5-23, a separate and distinct area of chlorinated VOCs greater than 100 ppb is located in the southern portion of the study area, with the highest concentration in the vicinity of O'Henry Dry Cleaners. The highest concentrations were detected in shallow zone Monitoring Well OHMW-4 (181 ppb), and in the Steele (173 ppb), LaPlace (173 ppb), Smith (169 ppb), and Harvey (137 ppb) Supply Wells. The chlorinated VOCs detected in the southern plume also consist primarily of PCE, TCE, and 1,2-DCE.

In the shallow zone, total chlorinated VOCs were detected at greater than 100 ppb only in the Monitoring Well OHMW-4. However, there are only three shallow zone monitoring wells downgradient or side-gradient of O'Henry Dry Cleaners (Figure 5-22). The 10-ppb contour was defined by Monitoring Wells OHMW-1 and MW-22D.



In the deep zone, the area enclosed by the 10-ppb contour is delineated on three sides by monitoring or supply wells in which lower concentrations of chlorinated VOCs were detected. The edge of the southern plume is not clearly defined; total chlorinated VOCs in the Delegarde Supply Well were detected at 26.3 ppb. However, chlorinated VOCs were not detected in the Dede, Dench, or Devcon Supply Wells, located more than 0.5-mile downgradient (Figure 5-19). A 100-ppb contour extends from the Harvey Supply Well to the Smith Supply Well. The greater areal extent of chlorinated VOCs in the deep zone suggests that previous and recent pumping of the Harvey, Steele, LaPlace, Smith, and Matthias Supply Wells may have drawn chlorinated VOCs to the south more rapidly in the deep zone.

Overall, chlorinated VOC concentrations in the southern plume seem to be declining over time. Total chlorinated VOC concentrations have been detected in excess of 1,000 ppb; for example, more than 1,400 ppb was detected in a sample collected in August 1990 from Monitoring Well OHMW-4 (IT 1990), more than 1,000 ppb was detected in January 1991 in Monitoring Well OHMW-4 (IT 1993), and more than 1,700 ppb was detected in February 1991 in the Harvey Supply Well (Geraghty & Miller, Inc. 1993c). Higher concentrations of chlorinated VOCs were detected in the Harvey Well in August 1987, when a sample submitted for laboratory analysis showed a PCE concentration of 7,600 ppb (Weston/SPER 1988a and 1988c).

Six supply wells within the southern plume have been sampled nine times since 1990; these data can be used to evaluate temporal trends in total chlorinated VOC concentrations in this area. The supply wells include the Eglin I, Eglin II, Harvey, LaPlace, Smith, and Steele Supply Wells. Total chlorinated VOC concentrations were plotted for these wells for the eight sampling rounds conducted by Geraghty & Miller on Figures 4 through 9, respectively, of the Eighth Sampling Report (Geraghty & Miller, Inc. 1993c). These data, in conjunction with the 1994 data, show a continuous decrease in concentrations of total chlorinated VOCs over time, to below 200 ppb in 1994. The marked decline in VOC concentrations over the last 4 years, particularly in the Harvey Supply Well and Monitoring Well OHMW-4, may be due to a reduction in groundwater pumpage, beginning in 1988.



In the southern chlorinated plume, the 10-ppb contour of total chlorinated VOCs extends south to Monitoring Well MW-22 (Figure 5-22). In the deep zone, the 10-ppb contour extends past the Delegarde Supply Well, and the 100-ppb contour extends from the Harvey Supply Well to the Smith Supply Well (Figure 5-23).

The distribution of the four primary chlorinated VOCs was compared to total chlorinated VOCs in the southern plume. In the shallow zone, the PCE distribution (Figure 5-25) is similar to the distribution of total chlorinated VOCs (Figure 5-22), and accounts for approximately 78 percent of the total chlorinated VOCs at Monitoring Well OHMW-4 (Figure 5-24). Similarly, in the deep zone, the PCE concentration in the Harvey Supply Well (100 ppb) accounts for approximately 75 percent of the total chlorinated VOCs. This well is also located immediately downgradient of O'Henry. Review of the PCE distribution in the deep zone shows a second 100-ppb contour in the vicinity of the Smith Supply Well (Figure 5-26). This elevated concentration may have been caused by differential pumping of supply wells in the southern chlorinated plume which would have accelerated the migration of VOCs.

As with PCE and total chlorinated VOCs, both TCE and 1,2-DCE are more widely distributed in the deep zone than in the shallow zone. Vinyl chloride was not detected in either shallow or deep zone wells in the southern chlorinated plume.

5.2.2 Evaluation of Potential Presence of Nonaqueous Phase Liquids

The high concentrations of BTEX and chlorinated VOCs detected at several properties indicate that there is a potential that light nonaqueous phase liquids (LNAPLs) and DNAPLs may exist in the saturated zone at the Tutu Wells Site. One indication of the possible presence of NAPLs is the detection of a constituent at a concentration greater than 1 percent of its solubility. However, the absence of constituents above 1 percent solubility does not preclude the possibility of free product. For example, direct observations of floating product and sheens in some monitoring wells at the Esso Tutu and Texaco Tutu Service Stations confirmed the presence of



LNAPLs but BTEX concentrations in groundwater samples collected from these wells were not detected above 1 percent of the solubility of these individual compounds.

The solubility of benzene at 25°C is 1,750 milligrams per liter (mg/L). Therefore, 1 percent solubility would be 17.5 mg/L or 17,500 ug/L. Based on their solubilities, 1 percent solubility for the other BTEX constituents is 5,350 ug/L for toluene, 1,520 ug/L for ethylbenzene, and 1,750 ug/L for o-xylene.

The only locations where the concentrations of individual BTEX constituents exceeded 1 percent of the solubility were at Monitoring Wells TT-4 (located at the Texaco Tutu Service Station) and CHT-3 (located at the Esso Tutu Service Station). At Monitoring Well TT-4, benzene was detected at 21,000 ug/L, toluene was detected at 17,000 ug/L, ethylbenzene was detected at 3,300 ug/L, and total xylenes were detected at 17,000 ug/L (Table 5-10). Floating product had been observed in Texaco Tutu Service Station Monitoring Wells MW-4D and MW-5, and product sheen and/or odors had been noted in Monitoring Wells TT-1, TT-1D, and TT-4.

At Monitoring Well CHT-3, ethylbenzene was found at 1,800 ug/L and total xylenes 2,000 ug/L. Floating product has never been documented in Monitoring Well CHT-3, but product, sheen, and/or odors had been reported in Esso Tutu Service Station Monitoring Wells MW-9, MW-9S, and SW-7.

The presence of PCE and other chlorinated VOCs in the groundwater at elevated concentrations indicates that chlorinated VOCs may be present as a DNAPL, and may have migrated into the subsurface, both in the unsaturated zone and below the water table. The available soil and groundwater data were evaluated using the criteria in a USEPA guidance document entitled "Estimating Potential Occurrence of DNAPL at Superfund Sites" (USEPA 1992b). Following the guidance of this USEPA document, the historical use of PCE as a dry cleaning solvent at the former Laga Building (current Curriculum Center) and the O'Henry Dry Cleaners suggests the high probability of a DNAPL release.



Based on the exceedence of NYS TAGM levels at O'Henry and the presence of PCE in soil with the highest concentrations in groundwater at the Curriculum Center, releases of PCE have been interpreted at these two locations. In addition, the detection of PCE at 300,000,000 ug/kg (30 percent PCE) in the oil sample collected from the abandoned pipes in the floor at the Curriculum Center substantiates the interpretation of a DNAPL release.

The highest concentrations of PCE in soil were detected at O'Henry, with concentrations as high as 440,000 ug/kg (CDM 1990c). The highest concentration of PCE in soil at the Curriculum Center was 180 ug/kg in Sample SS-9 (see Figure 5-2). However, neither of these concentrations are high enough (i.e., not greater than 10,000,000 ug/kg [USEPA 1992b]) to conclude that PCE is present as a separate phase in the soil at the locations sampled. These soil concentrations indicate that two of the following situations may exist:

- PCE was released in a dissolved form, rather than a pure-phase form (i.e., no DNAPL is present); or
- PCE as DNAPL is present in isolated pockets or globules that were not encountered during sampling.

According to the USEPA guidance (1992b), another indication of the possible presence of DNAPL is the detection of PCE in groundwater at concentrations greater than 1 percent of the pure phase solubility of PCE. The solubility of PCE is 150 mg/L at 25°C. Therefore, 1 percent solubility would be 1.5 mg/L, which is equivalent to 1,500 ug/L. In August 1987, the PCE concentration in the Harvey Supply Well was 7,600 ug/L (Weston/SPER 1988a). Between September 1987 and January 1988, the Tillett Supply Well (downgradient of the former Laga Building) and the Harvey Supply Well (downgradient of O'Henry) had reported PCE concentrations of 2,040 ug/L and 2,000 ug/L, respectively, that were confirmed by GC/MS analysis (Weston/SPER 1988c). These concentrations exceed 1 percent of the solubility of PCE. In February 1991, the concentration of PCE in the Harvey Supply Well was 1,500 ug/L (Geraghty & Miller, Inc. 1993a), which is 1 percent of its solubility. At Monitoring Well



MW-16, located at the Curriculum Center, the occurrence of even higher concentrations of 1,2-DCE and vinyl chloride (potential breakdown products of PCE) provides additional indication that PCE may have been dissolved at concentrations exceeding 1 percent of its solubility.

Based on the USEPA guidance document (USEPA 1992b) and the available soil and groundwater data, there is a moderate to high probability that DNAPLs are present at the Tutu Wells Site. In the vicinity of the Curriculum Center, there is a sufficient thickness of unsaturated bedrock above the water table in which DNAPL may be present. In the vicinity of O'Henry, there is a sufficient thickness of unconsolidated soil and weathered bedrock overburden above the water table where DNAPL may be present. As stated in the USEPA guidance document, "relatively small volumes of DNAPL can penetrate deeply into fractured [bedrock] systems due to the low retention capacity of the fractures and the ability of some DNAPLs to migrate through very small (< 20 microns) fractures." If DNAPL is present in the overburden or the fractured bedrock aquifer in the form of droplets or globules, it will be the primary source of continued dissolution of chlorinated VOCs to groundwater, greatly exceeding any possible contributions from residual concentrations in VOC-impacted soil. The presence of DNAPL will severely limit the potential effectiveness of the remedial technologies that will be considered during preparation of the FS. At other sites, the complete remediation of DNAPL in fractured bedrock aquifers has been demonstrated to be technically impracticable.

5.2.3 Vertical Distribution of Organic Compounds in Groundwater

The vertical distribution of BTEX and chlorinated VOCs provides information that can be used to evaluate potential sources and migration pathways of groundwater contamination, the likely fate and transport of contaminants, and potential remedial approaches for groundwater contamination.

In areas impacted by BTEX, the shallow monitoring wells show higher concentrations than the deep monitoring wells and supply wells. This is to be expected, since BTEX compounds



are derived from LNAPLs, which are lighter than water and remain near the top of the water table. For example, the total BTEX concentrations in a groundwater sample collected from shallow Monitoring Well TT-1 (58,700 ppb) was much higher than BTEX concentrations in deep Monitoring Well TT-1D (1,873 ppb). Similarly, BTEX constituents in groundwater near the Esso Tutu Service Station were found in samples from shallow monitoring wells but were not detected in any deep monitoring wells.

In the northern part of the northern chlorinated VOC plume, chlorinated VOC concentrations decrease with depth, as seen in Monitoring Well pairs MW-1/MW-1D, MW-4/MW-4D, MW-13/MW-13D, and TT-1/TT-1D. In the southern portion of the northern chlorinated VOC plume, in the area of Four Winds Plaza, concentrations increase with depth, as seen in Monitoring Well pairs MW-6R/MW-6D, MW-8/DW-1, MW-10/MW-10D, SW-6/DW-2, and MW-20/MW-20D. This observation suggests that with distance from the highest total chlorinated VOC concentrations (in the northern chlorinated VOC plume), dissolved chlorinated VOCs are moving downward through the fractures under the influence of a downward hydraulic gradient. Pumpage of supply wells (e.g., Tillett, Four Winds) may have accelerated the downward migration of contaminants. It does not appear that chlorinated VOCs detected in shallow soil samples at Western Auto and the Tutu Esso Service Station have had a measurable impact on groundwater.

In the southern chlorinated VOC plume, the constituents apparently follow a preferential pathway influenced by fractures in the bedrock aquifer. Groundwater flow directions and chlorinated VOC distribution are consistent with the inferred distribution of principal bedrock fractures. No monitoring well clusters are installed in the southern plume area; therefore, limited information is available to indicate the vertical distribution of chlorinated compounds. The only supply well with a known open interval is the LaPlace Supply Well (20 to 80 feet bls). Known total depths of supply wells range from 55 feet bls (Matthias) to 160 feet bls (Harvey).



5.2.4 Inorganic Compounds

Inorganic compounds analyzed in groundwater samples included TAL metals (total and dissolved), TDS, TSS, sulfate, sulfide, nitrate, nitrite, phosphorus, alkalinity, total cyanide, organo-metallic lead, manganese, COD, and hardness. The analytical results for these analyses are presented in Tables 5-12, 5-13, and 5-14.

5.2.4.1 Total Metals

The total metals detected at elevated concentrations in most groundwater samples were aluminum, calcium, iron, magnesium, manganese, potassium, sodium, and zinc. These metals are naturally occurring in the fractured bedrock aquifer, which consists primarily of felsic volcanic rocks. Analytical data for total metals are summarized in Table 5-12.

Total lead was detected above the federal action level of 15 ppb in several monitoring wells. Many of the wells are located in the vicinity of the Esso Tutu Service Station and O'Henry. Chromium was detected above the federal Primary Maximum Contaminant Level (MCL) of 100 ppb in several wells.

5.2.4.2 Dissolved Metals

The dissolved metals detected at elevated concentrations in most groundwater samples were calcium, magnesium, manganese, potassium, and sodium. These metals are expected to be present in the fractured bedrock aquifer, which consists primarily of felsic volcanic rocks. Analytical data for dissolved metals are in Table 5-13.

No dissolved metals values were detected above their MCLs except where the result was qualified with a "B", indicating the constituent concentration was between the instrument detection limit and the contract required detection limit. The only well where dissolved lead was detected above the 15 ppb federal action level was the Gassett Supply Well. The well has been



sampled intermittently over the years, and lead values have been detected above 100 ppb on several occasions. In general, the concentrations of dissolved calcium were slightly higher than total calcium in most groundwater samples.

5.2.4.3 Water Quality Indicators

Analytical data for water quality indicator parameters are summarized in Table 5-14. Nitrite as N (nitrogen) was detected above the federal drinking water standard of 1 ppm in Monitoring Well MW-13D (2.7 ppm). Nitrate as N was detected above the federal primary drinking water standard of 10 ppm in Monitoring Wells MW-1 (12.4 ppm), MW-2 (15.9 ppm), MW-13 (10.6 ppm), MW-17 (22.7 ppm), and MW-24 (13.3 ppm), and in the Gassett (new) Supply Well (11.3 ppm) and the Harthman Racetrack Supply Well (13.6 ppm). Elevated nitrate levels have been documented in the Tutu Valley for at least 15 years and are believed to be related to sanitary sewerage (Jordan & Cosner 1973; Geraghty & Miller, Inc. 1983). Because these nitrate levels are attributed to numerous sources, they cannot be used to correlate transport of chlorinated VOCs or BTEX constituents, which are derived from more specific, rather than widespread sources.

Chloride was detected above the federal secondary drinking water standard of 250 ppm in Monitoring Wells OHMW-1 (354 ppm), OHMW-2 (332 ppm), OHMW-3 (351 ppm), MW-21D (910 ppm), MW-22D (458 ppm), and SW-5 (378 ppm), and in the Harvey Supply Well (1,700 ppm), the Smith Supply Well (335 ppm), the Steele Supply Well (366 ppm), the Eglin I Supply Well (269 ppm), the Eglin III Supply Well (368 ppm), and the Matthias Supply Well (294 ppm). The federal secondary drinking water standard for TDS (500 ppm) was exceeded in all groundwater samples except Monitoring Well MW-11D. The high chloride and TDS concentrations are naturally occurring and have been documented historically (Geraghty & Miller, Inc. 1983). Total cyanide concentrations were below detection limits in all groundwater samples.



As described above, elevated values of nitrate, chloride, and TDS were present above the USEPA drinking water standard in groundwater samples collected throughout the Tutu Wells Site. These parameters were identified in previous studies and are not related to the COCs for the site. However, the presence of these elevated parameters may limit the options for beneficial reuse or discharge permitting of recovered groundwater.

5.2.5 QA/QC Samples

As part of the QA/QC requirements described in the Phase II Work Plan (Geraghty & Miller, Inc. 1993b), field replicates and field blanks were collected. These data are summarized in Tables 5-10 through 5-14. Three field replicates were collected, one each from Monitoring Wells MW-11D and SW-7, and the Four Winds II Supply Well. Field replicates have been designated with an FR added to the sample identification on tables and figures. Four field blanks were collected by rinsing laboratory-supplied water through the sampling apparatus prior to groundwater sampling.

Split samples were collected by ENSR, CEI, IT, and BB&L at selected monitoring wells (see Table 5-16). The analytical data for these samples were consistent with Geraghty & Miller's data, indicating close agreement in laboratory performance. These data are also shown on Figures 5-17 through 5-32, where applicable.

A trip blank, consisting of water supplied by the laboratory, accompanied each shipment of samples to the laboratory. Trip blanks were analyzed for VOCs. If a cooler contained samples designated for TCL VOCs and Method 524.2 VOC analyses, a trip blank was included for each analytical method. Trip blank results are included in Table 5-10 .



5.2.6 Summary and Conclusions

Two separate and distinct BTEX plumes have been mapped in the study area, one in the area of the Texaco Tutu Service Station and one in the area of the Esso Tutu Service Station. Operations at these service stations are apparently the primary source of BTEX and petroleum-related constituents in the groundwater at these locations. These plumes occur in well-defined areas, as shown on Figures 5-17 and 5-18.

The shallow BTEX plume near the Texaco Tutu Service Station is approximately 400 feet in the north-south dimension and approximately 200 feet in the east-west dimension. In the deep zone, the BTEX plume is approximately 300 feet in the north-south dimension and approximately 130 feet in the east-west dimension. The BTEX plume near the Texaco Tutu Service Station is elongated in the direction of shallow groundwater flow and appears to have migrated past the Tillett Supply Well since 1992. Concentrations of BTEX decrease with depth, as seen in Monitoring Wells TT-1 and TT-1D. Direct and indirect evidence of LNAPL has been observed at the Texaco Tutu Service Station.

The shallow BTEX plume near the Esso Tutu Service Station measures approximately 250 feet in its north-south dimension and 175 feet in its east-west dimension. BTEX has not been detected in groundwater samples from deep wells in this area. Direct and indirect evidence of LNAPL has been observed at the Esso Tutu Service Station.

An isolated BTEX concentration was detected in June 1990 in Monitoring Well KFC-1 (also referred to as KFMW-2) (Terra Vac 1990). Since this was the only groundwater sample collected at this time in this area, no recent information is available to define the extent of the elevated BTEX concentrations. The removal of leaking USTs at the location of the present Kentucky Fried Chicken restaurant (former Home Petroleum) were documented by Terra Vac (1990). These former USTs are the likely source of BTEX in this area.



Of the properties identified in Section 5.1 (Soil Quality and Potential Sources) as having soil impacted by BTEX constituents, only the Texaco Tutu Service Station and the Esso Tutu Service Station currently have a corresponding BTEX impact to groundwater quality. This determination was made by the observation of an increase in BTEX concentrations in groundwater on-site and downgradient of the property, in comparison to upgradient of the property.

BNAs were detected only in shallow monitoring wells located in the areas of greatest BTEX concentrations at the Texaco Tutu Service Station and the Esso Tutu Service Station.

Two chlorinated VOC plumes have been defined by the comprehensive groundwater sampling event in May and June 1994. The concentrations within these plumes in both the shallow and deep zones appear to be declining since 1992, with the exception of the area of the northern chlorinated plume near the Curriculum Center where the highest chlorinated VOCs are still present (Figures 5-17 through 5-32). The area immediately north of the Curriculum Center building appears to be one of the main source areas for the northern plume of chlorinated VOCs. This conclusion is supported by the results of both the soil sampling and the soil-gas survey conducted in this area.

A steep concentration gradient is present on the northern edge of the plume. In the shallow zone, the area enclosed by the 100-ppb contour is approximately 800 feet long in the north-south direction and 400 feet in the east-west direction. As described in Section 5.2.1.3 (Chlorinated Volatile Organic Compounds), chlorinated VOC concentrations decrease with depth in the northern part of the plume. In this location, the area enclosed by the 100-ppb contour in the deep zone is 350 feet in the north-south direction and 200 feet in the east-west direction. In the southern part of the plume, chlorinated VOC concentrations increase with depth. These concentrations may have been due to an area of high transmissivity (and most likely higher vertical hydraulic conductivity) near Monitoring Wells MW-6R and MW-6D. In addition, pumpage of deep supply wells in the area of Four Winds Plaza and Tillett Gardens probably drew chlorinated VOCs deeper into the fractured bedrock.



Based on the high chlorinated VOC concentration gradient in the area of the Curriculum Center, the potential exists for the presence of DNAPL in the soil or fractured bedrock. The presence of elevated VOCs detected in the soil gas in the area of Monitoring Well MW-16 and the fact that VOC concentrations decrease with depth in monitoring wells (for example, Monitoring Well cluster MW-1/MW-1D) suggest that if DNAPL is present, it may not have migrated into the deeper portions of the fractured bedrock. It is possible that the DNAPL, if present, is largely within the unsaturated zone and the upper part of the saturated zone. One source of the PCE is from abandoned pipes within the floor of the Curriculum Center Building, where PCE was detected at 300,000,000 ug/kg (30 percent PCE) in an oil sample (Weston 1994).

Of the properties identified in Section 5.1 (Soil Quality and Potential Sources) as having soil impacted by chlorinated VOCs, the Esso Tutu Service Station does not appear to have contributed chlorinated VOCs to groundwater. Review of the individual chlorinated VOC figures (Figures 5-25 through 5-32) does not show a source of chlorinated VOCs emanating from the Esso Tutu Service Station. However, due to the presence of PCE in soil above NYS TAGM levels, the Esso Tutu Service Station cannot be ruled out as a potential source of VOCs to groundwater.

In the southern chlorinated plume, relatively high chlorinated VOC concentrations have been detected in the vicinity and downgradient of O'Henry, which appears to be one of the main source areas for the southern plume. This conclusion is confirmed by the high concentrations of PCE in soil samples from this area. This plume contains lower chlorinated VOC concentrations than the northern plume and is larger and more diffuse. In addition, the plumes have begun to merge. The southern chlorinated plume, as defined by the 10-ppb contour, is approximately 1,000 feet in its northwest-southeast dimension and approximately 300 feet wide. In the deep zone, the area enclosed by the 10-ppb contour is approximately 2,500 feet long and 600 feet wide. The southeast edge of the southern chlorinated plume has not been completely defined. The Delegarde Supply Well is the only data point in the southeastern portion of the plume. The Dede, Dench, and Devcon Supply Wells, located approximately 0.5 mile



downgradient, had no detectable chlorinated VOCs during recent sampling events. Insufficient data are available to define the shallow distribution of chlorinated VOCs in the southern plume.

Based on the high chlorinated VOC concentrations reported in soil samples collected at O'Henry and the high chlorinated VOC results reported in groundwater since 1987, the potential exists for the presence of DNAPL in the soil or fractured bedrock. However, current chlorinated VOC concentrations in the groundwater in the area of O'Henry are not sufficiently elevated to suggest DNAPL is present. This marked decrease in concentrations may be the result of reduced pumping in the area.

No metals of concern other than lead were detected at elevated concentrations during the comprehensive groundwater sampling event in May and June 1994. Total lead was detected above the federal action level of 15 ppb in several wells in the area south of the Esso Tutu Service Station and in the vicinity of O'Henry. Total chromium was detected above the MCL of 100 ppb in several wells. Dissolved lead was the only dissolved metal detected above the federal action level in one well (Gassett Supply Well).

The presence of elevated values of nitrate, chloride, and TDS above the USEPA secondary drinking water standard may limit the options for beneficial reuse or discharge permitting of recovered groundwater. Nitrate contamination has been documented as a historical sewerage-related problem (Jordan and Cosner 1973). The detected chloride and TDS concentrations are natural background values for groundwater.

Based on the comprehensive groundwater sampling event and previous groundwater sampling events, several areas are considered likely sources of impacts to groundwater quality. These areas are summarized in the following sections.



5.2.6.1 Sources of BTEX and Petroleum-Related Compounds in Groundwater

The following properties are sources of BTEX and petroleum-related compounds in groundwater:

- | | |
|--|---|
| Texaco Tutu Service Station: | The highest concentrations of BTEX, BNA, and petroleum-related compounds (MTBE and n-propylbenzene) are present near Monitoring Well TT-4 where USTs were excavated. Direct and indirect evidence of LNAPL has been observed. |
| Esso Tutu Service Station: | The highest concentrations of BTEX and petroleum-related compounds (MTBE and n-propylbenzene) are present near Monitoring Well SW-3 located near the pump island and former USTs. Direct and indirect evidence of LNAPLs has been observed. |
| Kentucky Fried Chicken
(former Home Petroleum): | Although only one groundwater sample was collected in the area of Kentucky Fried Chicken during the Phase II RI, previous investigations consisted of excavation of leaking gasoline USTs. Free product was observed in the UST excavations. Therefore, Kentucky Fried Chicken (former Home Petroleum) is a likely source of BTEX and MTBE impact to groundwater. |



5.2.6.2. Sources of Chlorinated VOCs in Groundwater

The following properties are sources of chlorinated VOCs in groundwater:

**Curriculum Center
(former Laga Building):**

Groundwater quality data indicate that a release of PCE occurred in the vicinity of the Curriculum Center (former Laga Building). The highest chlorinated VOC (PCE, TCE, 1,2-DCE, and vinyl chloride) concentrations in groundwater in the study area are present near Monitoring Well MW-16, which is near one of the main source areas of the northern chlorinated plume, as determined by soil-gas and groundwater data. Another possible source area are the abandoned pipes within the floor of the building, where oil containing 30 percent PCE was detected. Historically, concentrations of PCE have been found in groundwater above 1 percent of its solubility, indicating that DNAPLs may be present.

O'Henry Dry Cleaners:

Groundwater quality data indicate that the highest chlorinated VOC (PCE, TCE, 1,2-DCE, and vinyl chloride) concentrations in the southern chlorinated plume are present near Monitoring Well OHMW-4 and the Harvey Supply Well. Historically, concentrations of PCE have been found in groundwater above 1 percent of its solubility, indicating that DNAPLs may be present. Groundwater and soil analytical data indicate that a release of PCE from O'Henry Dry Cleaners is probably the principal source of the southern chlorinated plume.



Due to the presence of chlorinated VOCs in soil above the NYS TAGM levels, the Esso Tutu Service Station cannot be ruled out as a potential source of chlorinated VOC impact to groundwater. However, no increase in chlorinated VOC concentrations was detected in groundwater up or downgradient of the Esso Tutu Service Station, and shallow groundwater chlorinated VOC concentrations in the southern portion of the northern chlorinated plume are lower than deep concentrations.

5.3 SURFACE WATER, SANITARY SEWER, AND SEDIMENT RESULTS

The surface-water drainage at the Tutu Wells Site is channelized in a storm-water sewer that drains from north to south near the previous location of the Turpentine Run (see Section 4.1 [Topography and Drainage]). The northernmost section of the storm sewer is located to the north of Route 384 and consists of a smooth, concrete box culvert, measuring 4 feet wide by 2 feet deep. A 3-foot diameter, reinforced concrete pipe (RCP) section runs across Route 384 from a catch basin at the northwest corner of the Texaco property. To the south of Route 384 and underlying the Four Winds Plaza parking lot, the storm sewer pipe consists of a 6-foot diameter RCP. The storm sewer in the vicinity of the Four Winds Plaza was constructed in approximately 1978 during construction of the Four Winds Plaza. South of the God of Holiness Church, the storm sewer consists of a concrete box culvert, 5 feet wide by 7 feet deep. The sewer construction remains essentially the same as the storm sewer drains southward beneath Route 38 downstream of the overflow pipes from the Weymouth Rhymer Sanitary Sewer Pump Station (Blasland, Bouck & Lee, Inc. 1993c).

Surface water and sediment samples were collected from the storm-water and sanitary sewer by ADL in October 1993 and BB&L in November and December 1993. Approximately 30 aqueous and sediment samples were collected (Figure 5-33). In December 1993, CHT collected aqueous and sediment samples from a trench excavated in the vicinity of Four Winds Plaza; split samples were collected by ENSR, GCL, and BB&L. The analytical results for the trench sample were discussed in Section 5.1.7 (Four Winds Plaza Soil Sampling Results).



5.3.1 Storm-Water Sewer Results

Total chlorinated VOCs were detected in storm-water samples at concentrations ranging between 5J and 127 ppb. The highest concentrations of total chlorinated VOCs were detected in samples collected in the vicinity of Four Winds Plaza (Samples D-3, W-4, D-2, D-1, and W-5) in the portion of the storm-water sewer that occurs within the water table. BB&L observed groundwater infiltrating into the sewer when Sample D-3 was collected (Blasland, Bouck, & Lee 1994a).

The presence of chlorinated VOCs in the aqueous samples collected near Four Winds Plaza may be attributed to infiltration of contaminated groundwater from the northern plume of chlorinated VOCs. The Four Winds Plaza parking lot is one of the few areas where the storm-water sewer is below the water table and groundwater infiltration can occur. In fact, inflow of groundwater into the storm sewer was observed in this area by Geraghty & Miller personnel during the Phase II RI. North and south of this area, the storm-water sewer is situated above the water table so groundwater infiltration cannot occur. The results of a fluorescent dye study performed by CHT in December 1993 showed that a vault under the Cost-U-Less store at Four Winds Plaza (the store directly north of Western Auto) discharged water to the storm sewer (CHT 1994c). Since this vault was identified by CHT as part of a drainage system to remove seasonally perched water or groundwater from the gravel bedding under Four Winds Plaza, the presence of water in the vault substantiates the interpretation that groundwater infiltrates into the storm-water system. Further downstream, the combined effects of dilution and volatilization result in very low (less than 7J ppb) or no detectable concentrations of chlorinated VOCs in storm sewer aqueous samples collected near O'Henry (see Samples 300 and W-6 on Figure 5-33).

Petroleum-related compounds (i.e., MTBE, BTEX, and BNAs) were detected in aqueous samples collected from the storm-water sewer at individual concentrations ranging between 11 and 210 ppb (Figure 5-33). The detections of MTBE at 12 ppb in Sample W-3; at 210 ppb in Sample D-3; at 70 ppb in Sample W-4; and at 38/60 ppb in Sample W-5 and its replicate are



probably the result of a localized or upgradient source. Toluene was detected at a concentration of 15 ppb in Sample D-5 collected from water discharged to the storm sewer from a 4-inch diameter PVC pipe leading from the Splash and Dash Car Wash. BNA compounds, exclusive of bis(2-ethylhexyl)phthalate which is a common laboratory artifact, were detected in two aqueous samples (Samples D-4 and D-5) of drainage from the Splash and Dash Car Wash (see Figure 5-19). No detectable petroleum-related compounds (i.e., BTEX, MTBE, and BNAs) were reported in downstream Samples 309, W-6, and 300.

5.3.2 Sanitary Sewer Results

Five aqueous samples were collected from the sanitary sewer by ADL in October 1993. The analytical results indicated the presence of trace concentrations (less than 1 ppb) to 556/621 ppb (Sample 316 and its duplicate) of chlorinated VOCs, including PCE, TCE, 1,2-DCE, and vinyl chloride. The highest concentrations of chlorinated VOCs were found in the sanitary sewer samples from O'Henry (Figure 5-33). Based on these results, with the exception of the sanitary sewer samples at O'Henry, the sanitary sewer is not considered a significant factor in the migration of contaminants at the Tutu Wells Site, especially when the much higher concentrations (100 to over 1,000 ppb) of chlorinated VOCs occurring in nearby groundwater are considered.

5.3.3 Sediment Results

In October 1993, ADL collected seven sediment samples from the storm-water sewer (Figure 5-33). Only Sample 405 (replicate for Sample 201), which was collected near the Fire Station, had any detectable concentrations of VOCs. This sample had an estimated concentration of 2-butanone at 5 ppb. No other VOCs were reported in any sediment samples collected by ADL from the storm-water sewer.

BB&L collected one sediment sample (SD-1) from the storm-water sewer at the south end of Four Winds Plaza. This sample contained concentrations of 1,2-DCE (9 ppb), PCE (27 ppb)



and MTBE (8 ppb); these concentrations are most likely derived from infiltration of contaminated groundwater and the subsequent entrainment of contaminated water with the sediment or adsorption to sediments. Twelve BNA compounds were reported in Sediment Sample SD-1; individual concentrations ranged from 600 to 8,300 ppb.

In October 1993, ADL collected an aqueous sample (Sample No. 308) from the water main along Route 38 east of the Rodriguez Esso Service Station. This sample contained trihalomethanes (i.e., chloroform, dibromochloromethane, bromodichloromethane, and bromoform), which are generated during the chlorination of water. Sediment Sample No. 204 from the water main contained trace values of chloroform (3J ppb) and toluene (2J ppb). The presence of chloroform is probably derived from leakage from the water main, and the presence of toluene may be due to roadway runoff.

5.4 AIR QUALITY

Air monitoring was conducted by Geraghty & Miller during both Phases I and II of the RI. During drilling, ambient air was screened for VOCs using a PID for health and safety purposes. In addition, a combustible gas indicator (CGI) was used to detect explosion hazards. No VOCs were detected above action levels identified in the health and safety plan that would have required an upgrade from Level D personal protection equipment. Similarly, CGI values were not detected above action levels.



6.0 CONSTITUENT FATE AND TRANSPORT

Based on the results of soil and groundwater sampling at the Tutu Wells Site, a number of organic constituents were identified as COCs. To evaluate potential fate and transport processes for the COCs at the Tutu Wells Site, the physical and chemical properties of the constituents, the environmental transformation processes affecting the constituents, and the characteristics of the surrounding environment were examined.

The potential impacts to human and ecological receptors was evaluated in the Baseline Risk Assessment for the Tutu Wells Site prepared by CDM (CDM 1995). This section will briefly describe the processes expected to control the fate and transport of the COCs and the primary chemical and physical properties impacting those processes. Table 6-1 summarizes some important chemical and physical properties of the COCs at the Tutu Wells Site. Key chemical and physical properties discussed in this section include water solubility, specific gravity, volatility, organic-carbon partition coefficient (K_{oc}), soil distribution coefficient (K_d), octanol-water partition coefficient (K_{ow}), and half-lives.

6.1 CHEMICAL AND PHYSICAL PROPERTIES

The COCs can be classified into categories according to their similarity in chemical structure and/or physical and chemical properties. Both are factors influencing mobility and persistence in the environment. The categories and the COCs in each category are listed below:

- Chlorinated aliphatic hydrocarbons (CAHs), also referred to as chlorinated VOCs: cis-1,2-DCE, trans-1,2-DCE, TCE, PCE, TCA, DCA, and vinyl chloride.
- Ethers: MTBE.
- Monocyclic aromatic hydrocarbons (MAHs), also referred to as BTEX and n-propylbenzene.



- PAHs, a subset of BNAs that are associated with petroleum constituents: Acenaphthene, anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(a)pyrene, chrysene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene.
- Phthalate esters: Butylbenzylphthalate, diethylphthalate, and di-n-octylphthalate.
- Phenols, acid extractable compounds that are a subset of BNAs: Phenol, 2-methylphenol, and 4-methylphenol.

The chemical and physical properties that affect the fate and transport of a constituent include solubility, specific gravity, volatility, diffusivity, sorption, biodegradation, and persistence. The significance of these properties to constituent fate and transport is discussed in the following sections. Each property is described below.

The water solubility of a substance is a critical property affecting constituent migration in soil and groundwater. The higher the value of the solubility, the greater the tendency of a constituent to dissolve in water; thus a highly soluble constituent is more mobile in groundwater and more likely to leach through soil with infiltrating rainwater. Constituents with high solubilities generally are more susceptible to biodegradation than constituents with low solubilities, because compounds with low solubilities are more likely to be immobilized by adsorption to soil or bioaccumulation.

Solubility is expressed in terms of the number of milligrams of a chemical that can dissolve in 1 liter of water (mg/L) under standard conditions of 25°C and one atmosphere of pressure (atm). Solubilities range from less than 1 mg/L (virtually immiscible) to totally miscible, with most common organic chemicals falling between 1 and 1,000,000 mg/L (Lyman et al. 1990). Of the COCs, MTBE and phenol are the most soluble (4,800 and 93,000 mg/L, respectively). CAHs (chlorinated VOCs) are the next most soluble (150 to 6,300 mg/L). MAHs (BTEX



compounds) are less soluble than CAHs (solubilities range from 60 to 1,780 mg/L). Butylbenzylphthalate and the PAHs are much less soluble than MAHs. The solubility for butylbenzylphthalate is approximately 2.9 mg/L, and the solubility for most of the PAHs ranges from 0.00026 to 3.93 mg/L. Naphthalene and 2-methylnaphthalene are more soluble than the other PAHs, with reported solubilities of approximately 34 mg/L and 25 mg/L, respectively (see Table 6-1).

The specific gravity is the ratio of the density of a chemical in its pure state to the density of water. DNAPLs have a specific gravity greater than one, are denser than water, and will sink through the saturated zone. LNAPLs have a specific gravity less than 1 and will float on the water table (see Table 6-1).

Volatility is another important property affecting the mobility and persistence of organic constituents. Volatilization of a constituent from environmental media will depend on its vapor pressure, water solubility, and diffusion coefficient. Highly water-soluble compounds generally have lower volatilization rates from water unless they also have high vapor pressures. Vapor pressure is a measure of how readily a chemical will volatilize (i.e., form a vapor). Vapor pressure measurements range from about 0.001 to 760 mm Hg for liquids, with solids ranging down to less than 10^{-10} mm Hg.

The Henry's law constant (H) is an indication of the tendency of a chemical to volatilize or "partition" from the aqueous or water phase to the vapor phase and is dependent on the vapor pressure, molecular weight, and solubility of the constituent. Organic compounds with Henry's law constants in the range of 10^{-3} atmospheres-cubic meter per mole ($\text{atm}\cdot\text{m}^3/\text{mol}$) and greater, and molecular weights equal to or less than 200 grams per mole (g/mol) can be expected to readily volatilize from water (i.e., chlorinated VOCs and BTEX); those with values ranging from 10^{-3} to 10^{-5} $\text{atm}\cdot\text{m}^3/\text{mol}$ and a molecular weight of greater than 200 g/mol are moderately volatile (i.e., phthalates and most of the PAHs), while compounds with values less than 10^{-5} $\text{atm}\cdot\text{m}^3/\text{mol}$ volatilize slowly from water (Howard 1989; Lyman et al. 1990). Naphthalene and some of the other lower molecular weight PAHs (i.e., less than 200 g/mol) have Henry's law



constants in the range of 10^{-4} to 10^{-5} atm-m³/mol. These compounds are expected to undergo some volatilization from soil and water. Volatilization is not an important transport mechanism for butylbenzylphthalate and phenol, but is expected to be an important fate mechanism for the CAHs, MAHs, and MTBE.

The diffusion coefficient can be used to predict the rate at which a compound moves through the soil. Molecular diffusion is determined by molecular properties (e.g., size and weight) and by the presence of a concentration gradient, which means that molecules of a chemical will migrate to areas deficient in molecules of that compound. Diffusivity is measured in square centimeters per second (cm²/sec).

The potential for a constituent to sorb to soil particles will affect migration through soil and aquifer materials. When a constituent enters the soil/sediment environment, some of it will bind with particles through the process of sorption and some will dissolve in the water contained in the spaces between the soil particles (pore water). The term sorption includes adsorption (constituents bound to the outside of soil particles) and absorption (constituents distributed throughout the particle matrix). Sorption to soil reduces volatilization, leaching, and biodegradation. A constituent that is absorbed may not be mobile because it is not easily released from the particle, but it may be transported with the soil particle.

Adsorption potential typically is expressed in terms of a partition coefficient, K_{oc} or K_d . A partition coefficient is the ratio of the concentration of adsorbed constituent to the concentration of aqueous phase constituent and is expressed in units of milliliters per gram (mL/g). The K_{oc} may be determined empirically or may be estimated using constituent-specific and soil-specific parameters. The parameters most often used to calculate K_d for organic constituents are the K_{oc} , which measures the selective affinity for soil organic carbon versus water, and the fraction of organic carbon (f_{oc}) in soil. In the absence of site-specific data, the K_d is expressed as the product of the K_{oc} and the f_{oc} (USEPA 1989a). Higher values of K_{oc} (greater than 10,000 mL/g) indicate a greater potential for the constituent to adsorb to organic carbon in soil and aquifer materials. Constituents with low K_{oc} values (less than 1,000 mL/g)



do not adsorb strongly to soil and aquifer materials (Ney 1990). The values of K_{oc} shown in Table 6-1 typically are based on several different types of studies. For the nonpolar, relatively insoluble, organic COCs at the Tutu Wells Site with high values of K_{oc} (PAHs and phthalate esters), sorption is dependent primarily on the organic carbon content of soil and sediments, with less sorption occurring in soils with high clay or mineral content (Hassett and Banwart 1989). All of the VOCs (i.e., CAHs, MAHs, and MTBE) and phenol are characterized by low K_{oc} s. These constituents do not tend to adsorb readily to soil or aquifer materials, and thus are characterized by high mobility in the environment. The PAHs have large K_{oc} values and are predicted to adsorb readily, which will limit their mobility in soil and water.

The ability to volatilize from an environmental medium is an important property affecting the mobility and persistence of organic constituents. Vapor pressure, K_{oc} , and water solubility govern the extent to which a chemical will volatilize into the air under ambient environmental conditions. Solubility and vapor pressure generally decrease with molecular weight, and K_{oc} increases with molecular weight. A constituent with a low vapor pressure, high K_{oc} , and/or high water solubility volatilizes more slowly than a constituent with a higher vapor pressure, lower K_{oc} , and/or lower water solubility (Ney 1990). Generally, the VOCs are characterized by relatively high solubilities, high volatilities, and weak sorption characteristics. Butylbenzylphthalate is characterized by relatively low volatility, low solubility, and strong sorption characteristics. Phenol is highly water soluble and absorbs poorly to organic matter. Generally, the PAHs have low solubilities, low volatilities, and strong sorption characteristics.

The K_{ow} , a measure of the selective affinity for octanol versus water, is often used as an indication of a constituent's ability to accumulate in the lipophilic tissues of organisms. The fish bioconcentration factor (BCF) is a measure of a constituent's potential to accumulate in fish tissue.

Biodegradation is the biological process by which microorganisms break down organic chemicals. Environmental factors such as moisture, pH, temperature, and available nutrients will affect the rate of biodegradation. Constituents with high water solubility, low K_{oc} , and low



K_{ow} values likely will biodegrade (Ney 1990). Most of the VOCs and phenol have these properties.

Persistence is the lasting power of constituents and is commonly expressed in terms of half-lives ($T_{1/2}$) for specific environmental media. The half-life of a constituent is the period of time required for one-half of the mass of a compound to be transformed into other constituents due to chemical, physical, or biological processes beginning from the time of its introduction to the environment. Half-lives of the COCs are presented in Table 6-1 in ranges because the rate of degradation varies according to environmental conditions and concentration. Half-lives may be used to characterize the relative persistence of a constituent in various environmental media.

6.2 MECHANISMS OF MIGRATION

There are several mechanisms by which constituents may migrate through environmental media at the Tutu Wells Site. The constituent-containing soils can act as a source of constituents to other environmental media. Migration into air can potentially occur via volatilization or fugitive dust emissions; migration into groundwater can potentially occur by direct vertical migration of DNAPLs and LNAPLs or by percolation of infiltrating rain water that dissolves the COCs present in soil; and transport into Turpentine Run can potentially occur via groundwater discharge. The significance of each of these migration or transport pathways is dependent on several factors, including the properties of the environmental media, the constituent concentration, and the physical and chemical properties of the constituent. Figure 6-1 presents a flowchart demonstrating the conceptual site model for potential exposure pathways.

Constituent fate processes are closely linked with transport processes. The COCs at the Tutu Wells Site may undergo the following major types of reactions in the environment based on the environmental medium: volatilization and biodegradation/biotransformation. Hydrolysis, which includes bond-breaking and bond-forming reactions with water, and photolysis, a process by which chemical bonds are broken by light energy, are not likely to be significant fate



processes for the COCs. These processes will not be discussed further because many of the organic constituents do not contain hydrolyzable functional groups, and most of the organic constituents do not absorb light energy at wavelengths exceeding 290 nanometers, which is necessary for photolysis to occur (USEPA 1979). Those constituents containing hydrolyzable groups undergo hydrolysis extremely slowly. The PAHs may be subject to degradation by these reactions.

These fate processes may result in mineralization (total destruction of the organic constituent to carbon dioxide and water), transformation into other products, or simply a change from one phase to another. Sorption is an extremely important factor in most of the fate processes.

6.2.1 Migration in Air

Constituents released into the atmosphere are subject to transport and dispersion by prevailing winds. Constituents may be transported in the form of gases or airborne particulates, depending on their physical and chemical properties. Two processes control the migration of constituents into air: volatilization and generation of dust, either through wind erosion or mechanical means.

Volatilization may result in the transfer of organic constituents from soil or groundwater into the atmosphere. Gas-phase VOCs may then be subject to atmospheric processes such as oxidation and rainout. For the CAHs, MTBE, and MAHs at the Tutu Wells Site, volatilization is expected to be the primary removal mechanism from surficial soils and surface water. Except for naphthalene and 2-methylnaphthalene, volatilization is not expected to be a significant removal process for the PAHs.

Fugitive dust emissions from wind or vehicle disturbances may occur from unpaved or unvegetated areas of the Tutu Wells Site. Approximately 50 percent of the study area at the Tutu Wells Site is paved; almost all of the suspected source areas are paved. The suspected



source areas that are not paved are the areas behind (north of) the Curriculum Center (former Laga facility), the Tillett Gardens property, and south of O'Henry. During hypothetical future construction activities, the potential exists for some of the pavement or vegetative cover to be removed. The environmental factors that influence wind erosion are wind speed, moisture content, vegetative cover, and soil composition. Factors affecting vehicle-related dust emissions include soil composition and moisture content, vehicle design (e.g., weight and number of wheels), and speed of travel. Because many of the sources of contamination are USTs, the constituents occur at depth and are unlikely to be emitted in dust, unless excavation activities were to occur.

Most of the PAHs at the Tutu Wells Site have relatively low volatilities; therefore, wind erosion and airborne particulate transport as fugitive dust are expected to be the major atmospheric transport processes for these constituents in air from uncovered soils. Constituents sorbed to soil particles may be carried varying distances from the Tutu Wells Site depending on the size of the particle and the magnitude of the winds. High winds and/or small particle sizes result in greater dispersion and transport. However, airborne particulate transport is not expected to be a significant migration pathway for surficial soil COCs at the Tutu Wells Site because most of the suspected source areas are either paved or occupied by buildings.

6.2.2 Migration in Groundwater

The potential for COCs to migrate (leach) into groundwater depends on the various physical and chemical properties of the constituents and the environmental medium including solubility, specific gravity, sorption characteristics, bedrock fracture patterns, soil properties, topography, climate, and vegetation.

The more soluble constituents may migrate from soil with infiltrating precipitation to the groundwater. Typically, organic constituents with high water solubilities and low K_{oc} s are particularly susceptible to this phenomenon. The more volatile constituents or those strongly adsorbed to soil may migrate into air, as discussed in the previous section. Solubility in water



and the tendency to bind to soil and/or organic carbon are two of the most important properties affecting constituent migration from soil to groundwater. Most of the COCs at the Tutu Wells Site, except for the PAHs and butylbenzylphthalate, are expected to migrate to groundwater or volatilize. The depths to groundwater range from approximately 7 to 106 feet bls, with an average of 10 feet bls (Geraghty & Miller, Inc. 1993a).

The migration of constituents into site groundwater is influenced by soil characteristics. Clays and minerals exhibit adsorptive behavior, while organic matter is capable of both adsorption and absorption. Coarse sands and gravels are generally poor at sorbing chemicals, while clays and organic matter have much higher sorptive capacities. The soils at the Tutu Wells Site are primarily clays and silts with a low organic carbon content.

In addition to the leaching of dissolved constituents, COCs can migrate to and through groundwater as NAPLs. LNAPLs, such as gasoline, waste oil, and diesel fuel, can migrate vertically through soil and fractured bedrock, and can also migrate from a layer of LNAPL floating on the capillary fringe and water table in the direction of groundwater flow. DNAPLs, primarily the CAHs (chlorinated VOCs), can migrate vertically through soil and fractures in the bedrock. On encountering the water table, DNAPLs will tend to continue migrating downward through the network of fractures, under the influence of gravity. As the DNAPLs migrate downward, they become disaggregated, forming globules and droplets, and adhere to fracture surfaces, rock fragments, and clay minerals present in the fractures. The amount of DNAPL present in the subsurface, the size of the individual DNAPL, and the depth of penetration into the aquifer depends on the amount of product released and the timing of the release.

Once present as globules or droplets below the water table, DNAPL will serve as a source of COCs to be dissolved in groundwater. Typically, a steep concentration gradient forms in a downgradient direction from the DNAPL below the water table, as groundwater migrates through the DNAPL and dissolves the DNAPL constituents. Near the DNAPL, concentrations approach the solubility limits similar to individual COCs (in the case of CAHs, solubilities are on the order of 100 to 7,000 mg/L); concentrations typically drop off rapidly in the



downgradient direction. An equilibrium typically becomes established; however, the stability of this equilibrium and the distribution of dissolved CAHs in groundwater can be greatly impacted by pumping stresses.

6.2.3 Migration in Surface Water

The potential for COCs to migrate in surface water depends on many of the same factors that affect groundwater migration. A major difference, however, is that particle-bound as well as dissolved constituents are transported by surface water. Because a majority of the source areas are paved or covered by buildings or the contamination occurs at depth, there is a low potential for particle-bound constituents to enter the storm sewers or open surface-water channels by surface-water runoff.

Groundwater from the Tutu Wells Site may discharge to Turpentine Run. This creek is contained in a culvert beneath the Tutu Wells Site and, in some portions of the site, this culvert is above the water table. Groundwater could only discharge to this culvert when the invert of the culvert is below the water table and where there is a break in the culvert. COCs have been detected in water and sediment samples from the storm-water sewer near the Four Winds Plaza, but no COCs were detected in storm-sewer samples collected further downstream (near O'Henry).

In the southeast portion of the study area, the Turpentine Run flows in an open stream channel (southeast of the Smith and Matthias residences). Due to the USEPA's identification of a forested wetland ecosystem along Turpentine Run in the southeast portion of the study area (USEPA 1994b), Geraghty & Miller reviewed the existing shallow groundwater contour maps (Figures 4-12 and 4-15) to determine the potential for groundwater to discharge to the Turpentine Run. The Turpentine Run in the southeast corner of the study area is at a land surface elevation of approximately 64 feet msl. The nearest water-level elevation data were collected from Monitoring Well MW-22D which is too distant for direct comparison with the estimated surface-water elevation in Turpentine Run. Comparison of the 1987 groundwater



potentiometric map prepared by the USGS (Graves and Gonzales 1988) (which showed a groundwater elevation of approximately 60 feet above msl, about 4 feet below the stream elevation) with the estimated surface-water elevation is also inconclusive regarding the potential for discharge. It is likely that at times this portion of the Turpentine Run may behave as either a gaining or losing stream. This interpretation is supported by other work by the USGS (Jordan and Cosner 1973). In a discussion of flow in Turpentine Run at the Mt. Zion stream gauging station (located approximately 300 feet southwest of the Delegarde Supply Well and the forested wetland), Jordan and Cosner (1973) state that "[b]ase flow (groundwater outflow) of the stream is meager and, at times, ceases altogether".

Based on the above discussion, it appears that surface-water drainage provides most, if not all, of the input to Turpentine Run in the southeast portion of the study area. Migration of contaminants to the forested wetland via the surface-water pathway is not likely, based on surface-water (i.e., storm-water sewer) sampling results for the Tutu Wells Site (see Section 5.3.1 [Storm-Water Sewer Results]) and the significant dilution that would occur due to contribution of surface-water runoff from areas outside of the Site. Even if low concentrations of VOCs (less than 30 ppb) were present in the groundwater discharging to surface water, estimated bioaccumulation factors (BCFs) for these compounds indicate that bioaccumulation is unlikely (Howard 1990). Because these compounds do not readily bioaccumulate, other potential impacts progressing up the food chain are not expected.

6.2.4 Biodegradation/Biotransformation

Naturally occurring microorganisms in soils are able to use several organic compounds as a food source. Biotransformation of organic constituents usually results in degradation products that may then be mineralized (i.e, converted to carbon dioxide, water, and, in the case of the chlorinated aliphatics, chloride ions) or may not be degraded further. During the degradation process, the transformation products and intermediates produced are generally more soluble than the parent compound and are therefore more mobile. The metabolites isolated depend primarily on the time at which the reaction is stopped. The extent and rates of these



reactions, however, are difficult to predict. Constituents that are strongly sorbed to particles are less available for biotransformation.

Most naturally occurring and synthetic organic molecules are capable of being transformed or degraded by microorganisms. Several of the COCs at the Tutu Wells Site may be degraded aerobically (in the presence of oxygen) in soil and water. These COCs include benzene, ethylbenzene, toluene, xylenes, phthalate esters, two- and three-ring PAHs (e.g., naphthalene, acenaphthene), and phenols (Howard 1990, Howard 1991, USEPA 1979, Park et al. 1990). Biodegradation can occur relatively rapidly, provided adequate amounts of oxygen, moisture, and nutrients (e.g., nitrogen, phosphorous, and enzyme cofactors) are available. For VOCs, volatilization may compete with biodegradation as the primary removal process. In subsurface soil, sediments, and groundwater, aerobic biodegradation may be limited by the availability of oxygen. Aerobic metabolism of constituents under these conditions may result in the total depletion of oxygen. When this happens, the microorganisms may begin utilizing inorganic anions (such as nitrate or sulfate); they may either continue anaerobic respiration, or other types of microorganisms may become active in metabolizing the constituent. Other factors influencing biodegradation/biotransformation include constituent solubility, toxicity to microbial populations, availability of nutrients, and pH.

Degradation of the MAHs is primarily a result of reaction with hydroxyl radicals in the atmosphere or hydroxylation and mineralization by a large number of bacteria and fungi found in the environment. Biotransformation studies involving benzene, ethylbenzene, and toluene in soils have indicated extensive biotransformation (measured as loss of parent compound); however, low concentrations persisted (with the exception of ethylbenzene, which was degraded to non-detectable levels) after 4 weeks of incubation (Thomas et al. 1988). Phenolic compounds are the product of hydroxylation of the MAHs.

Many of the CAHs (cis- and trans-1,2-DCE, TCE, and PCE) are more readily biotransformed under anaerobic (oxygen-deficient) reducing conditions typical of groundwater and sediment. Under these conditions, microbially mediated reductive dehalogenation will be



a major environmental fate process for the CAHs, yielding a variety of transformation products, including vinyl chloride (Bouwer et al. 1981, Kobayashi and Rittman 1982, Parsons et al. 1984, Vogel et al. 1987). This process is most likely occurring in site groundwater because several of these degradation by-products (cis- and trans-1,2-DCE and, to a lesser extent, vinyl chloride) were detected in groundwater samples.

Biodegradation is the primary removal mechanism for butylbenzylphthalate in aerobic soils, but biodegradation is slow under anaerobic conditions. Biodegradation and photolysis are important attenuation processes in the removal of phenol in aquatic environments and soils.

The COCs at the Tutu Wells Site that are generally considered resistant to biotransformation (recalcitrant) include PAHs with more than three aromatic rings (with the exception of naphthalene, acenaphthene, anthracene, fluorene, and phenanthrene). PAHs with three or fewer aromatic rings have shorter half-lives than those with greater numbers of rings and may be expected to be biodegraded relatively rapidly (Park et al. 1990).



7.0 SUMMARY OF THE BASELINE RISK ASSESSMENT

The baseline human health risk assessment document for the Tutu Wells Site was prepared for the USEPA by CDM (CDM Federal Programs 1995). That document provides quantitative estimates, in accordance with current USEPA policy and guidance, of the carcinogenic risks and noncarcinogenic health effects from human exposure to chemical contaminants in site environmental matrices in the absence of any site remediation and assuming no further institutional controls are put into place. This risk assessment process included data evaluation, exposure assessment, toxicity assessment, risk characterization, and uncertainty evaluation.

7.1 RISK ASSESSMENT PROCESS

Chemicals of potential concern were selected for each sampled matrix, based on criteria outlined in the USEPA's Risk Assessment Guidance for Superfund (RAGS) document. The selected chemicals are expected to be most representative of site conditions and the greatest contributors to potential human health impacts.

Surface soil, subsurface soil, and groundwater quality data were quantitatively evaluated for potential health threats to human receptors via the ingestion, dermal contact, and inhalation routes of exposure. Receptors including residents (adults and children), site workers (employees), and construction workers were evaluated under present and potential future land use conditions, as appropriate. The exposure point concentration for each chemical to which a person may be exposed was estimated by using the 95 percent Upper Confidence limit (UCL) on the mean calculations defined by USEPA guidance. Potential chronic and subchronic daily intakes for the ingestion, dermal contact, and inhalation routes were then calculated for the reasonable maximum exposure (RME) (using 95 percent UCL concentrations and 90th and 95th percentile exposure parameters).

In the toxicity assessment, current toxicological human health data (i.e., reference doses, reference concentrations, and slope factors) were obtained from various sources and were utilized in the order specified by the RAGS document. Toxicity profiles for the chemicals of



potential concern were developed. Chemicals with insufficient toxicological data were qualitatively addressed.

Risk characterization involved integrating the exposure and toxicity assessments into quantitative expressions of risks/health effects. Specifically, chronic and subchronic daily intakes were compared with concentrations known or suspected to present health risks or hazards. The carcinogenic risks and noncarcinogenic hazard index (HI) values calculated at the site were based on the RME. The intent was to estimate a conservative exposure case that is still within the range of possible exposures. These estimates were then compared to acceptable USEPA target levels for carcinogens (10^{-4} to 10^{-6}) and noncarcinogens (1). A risk greater than these values was considered an exceedance.

In accordance with standard risk assessment practice, uncertainty in the risk assessment was evaluated both qualitatively and quantitatively. A quantitative evaluation, involving the calculation of central tendencies, was performed for those exposure scenarios showing carcinogenic risks or noncarcinogenic HI values above the USEPA target levels.

7.2 RESULTS OF THE RISK ASSESSMENT

The results of the risk assessment are discussed below.

7.2.1 Groundwater

Risks associated with exposure to groundwater were evaluated on a site-wide basis. The risk assessment indicated that ingestion of site groundwater would result in both carcinogenic risks and noncarcinogenic hazards in exceedance of the USEPA's target levels. Present and potential future exposure of residents (adults and children) and site workers (employees) to groundwater via ingestion resulted in carcinogenic risks exceeding the target risk range of $1.0\text{E-}04$ (Table 7-1). The USEPA's target level of 1 for noncarcinogens was exceeded for groundwater ingestion for all receptor populations including present and potential future



residents, site workers (employee), and future construction workers (future-use only) (Table 7-2). Carcinogenic risks were due mainly to the combined risks of PCE and vinyl chloride, while noncarcinogenic hazards were due mainly to 1,2-DCE (total), PCE, antimony, manganese and vanadium.

The range of detections for the chemicals of potential concern selected in groundwater were compared to Applicable or Relevant and Appropriate Requirements (ARARs), which include federal MCLs. Available MCLs for the chemicals of potential concern in groundwater are shown in Table 5-6. The maximum concentrations of benzene, trichloroethene, toluene, vinyl chloride, antimony, arsenic, beryllium, chromium VI, and nickel exceed established MCLs. Risk-based preliminary remediation goals (PRGs), as defined by the USEPA guidance, were developed for the residential groundwater exposure scenario for chemicals not having established MCLs. PRGs of 0.33 mg/L and 0.18 mg/L were developed for the noncarcinogens 1,2- DCE (total) and manganese, respectively, in groundwater.

7.2.2 Soils

Risks associated with exposure to surface and subsurface soils were evaluated on a property-by-property basis. In general, exposure to soils under present and potential future-use scenarios did not result in risks or hazards exceeding the USEPA's target levels. However, carcinogenic risks for present and potential future residential exposure to surface soil at Tillett Gardens exceeded the USEPA's target risk range (Table 7-1) via ingestion and dermal contact. These exceedances were due mainly to Aroclor 1242, which was detected in a single soil sample collected in 1988. Noncarcinogenic HI values for present and potential future residential exposure of children to surface soil at Tillett Gardens were above the USEPA's target level of 1 via ingestion and inhalation of particulates. The exceedances were due mainly to manganese.

Soil PRGs were developed for manganese for residential and commercial/industrial combined ingestion and inhalation exposures (1,360 mg/kg and 9,900 mg/kg, respectively). Because site soils are potential sources of groundwater contamination, they may contribute



indirectly to the risks/hazards caused by exposure to groundwater. However, the potential health risks/effects caused by soils via the migration to groundwater pathway are not evaluated in a baseline risk assessment.



8.0 SUMMARY AND CONCLUSIONS

Based on the data presented in this RI Report, the following summary and conclusions for the Tutu Wells Site have been developed.

8.1 SITE GEOLOGY

The geology of the Tutu Wells Site is characterized by a thin veneer of overburden, consisting of silty clay soil and/or fill (with a thickness commonly less than 5 feet and an overall range of 0 to approximately 30 feet), overlying fractured bedrock known as the Louisenhoj Formation. The bedrock is transected by several sets of fractures. The fractures have a controlling influence on topography; valleys have been eroded along the major fractures. Major fractures intersect near the intersection of Routes 38 and 384.

8.2 SITE HYDROGEOLOGY

During the Phase II RI, the depth to the water table at the Tutu Wells Site was observed to vary from approximately 7 to 106 feet bls. The overburden deposits are unsaturated at almost all locations. The fractured bedrock unit is the principal aquifer underlying the site; groundwater is stored in and flows through a network of interconnected fractures. Groundwater at the Tutu Wells Site generally flows from north to south, with a major component of flow turning towards the southeast in the southern portion of the site.

The hydraulic conductivity of the bedrock aquifer is much greater in both the horizontal and vertical directions along and within fracture zones than in less fractured areas. Aquifer hydraulic conductivity is greatest at locations of intersecting fractures, most notably at the northern end of the Four Winds Plaza parking lot near the intersection of Routes 38 and 384.

Pumpage of the Eglin III Supply Well at a constant rate of 31 gpm generated an asymmetrical zone of influence ranging from 500 to 1,045 feet wide. The asymmetry is due to greater drawdown along fractures interconnected with the pumping well. Anisotropic and



heterogeneous conditions due to the distribution of fractures and varying degree of interconnection of these fractures have a controlling influence on the capture zones generated by pumping wells.

The observed groundwater level changes in the vicinity of the Eglin III Supply Well during pumping represents the aquifer response at this specific location. Due to the anisotropic and heterogeneous nature of the fractured bedrock system, accurate predictions of aquifer response at other locations is not possible. Potential remedial alternatives should consider the following:

- Results from pumping tests indicate a wide range of aquifer transmissivity values depending on the number and interconnection of fractures intersected by a particular well. Due to the limited distribution of significant water-bearing fractures, the yield of supply wells at the Tutu Wells Site can vary greatly over a short distance (less than 150 feet).
- Because predictive remedial design will not be accurate, a detailed design of groundwater remedial alternatives will require empirical methods (through aquifer testing and observation at specified locations). A series of pumping tests at alternate locations for potential recovery wells may be necessary, if initial test results are undesirable or ineffective. If pumping of groundwater is part of the selected remedial alternative for the Tutu Wells Site, pumpage of existing monitoring wells and/or supply wells should be considered.
- Due to the complexity of aquifer characteristics, and a moderate to high probability that DNAPLs are present, the groundwater remedial design objectives should be as simplified as possible to allow for 1) more effective implementation and 2) better evaluation of the effectiveness and optimization of the remedial action.



8.3 SOIL QUALITY

Soil sampling and analysis at the Tutu Wells Site have been performed by several investigators, including Geraghty & Miller during the Phase I and Phase II RI. Review of the existing data indicates that the following properties have soil that has been impacted by petroleum-related compounds (i.e., BTEX, BNAs, and/or MTBE):

- Curriculum Center (former Laga Building)
- Ramsay Motors
- Antilles Auto Parts
- Texaco Tutu Service Station
- Western Auto
- Esso Tutu Service Station

In addition, due to the detection of elevated levels of diesel and heavy petroleum components in a Gore-Sorber vapor survey conducted at the Western Auto and Cost-U-Less properties located at the Four Winds Plaza, the Four Winds Plaza cannot be ruled out as a potential source of petroleum-related impact to soil quality.

Based on the soil-quality data, the following properties have soil that has been impacted by chlorinated VOCs:

- Curriculum Center (former Laga Building)
- Esso Tutu Service Station
- O'Henry Dry Cleaners

In addition, the Tillett property has soil that has been impacted by PCBs, based on the results of one surface soil sample collected by CDM in 1988.



8.4 GROUNDWATER QUALITY

Review of groundwater quality data collected from 1990 through 1994 (including nine sampling events of supply wells and two sampling events of monitoring wells) has identified distinct plumes of impacted groundwater. This observation is consistent with a similar observation presented after completion of the Phase I RI. Based on the current and historical groundwater quality data, the following properties have been identified as sources of petroleum-related impacts to groundwater quality:

- Texaco Tutu Service Station
- Esso Tutu Service Station
- Kentucky Fried Chicken (former Home Petroleum)

Based on the current and historical groundwater quality data, the following two properties are identified as sources of chlorinated VOC impacts to groundwater quality:

- Curriculum Center (former Laga Building)
- O'Henry Dry Cleaners

Due to the presence of chlorinated VOCs in soil above NYS TAGM levels near the north oil/water separator, the Esso Tutu Service Station cannot be ruled out as a potential source of chlorinated VOC impact to groundwater. However, no increase in chlorinated VOC concentrations in groundwater was observed up or downgradient of the Esso Tutu Service Station.

There is a moderate to high probability that DNAPL in the pure phase historically migrated through the unsaturated zone and is present as droplets or globules in fractured bedrock both in the unsaturated and saturated zones. If this is the case, the presence of the DNAPL will be the overriding factor determining the duration required for aquifer remediation. Furthermore, the



presence of DNAPL in fractured bedrock may preclude the complete restoration of aquifer groundwater quality in the vicinity of the DNAPL.

Total and dissolved lead were detected in groundwater above the federal action level, primarily at wells near the Esso Tutu Service Station and O'Henry. Dissolved lead was only detected above the federal action level in one well. Dissolved chromium was detected in several wells above the USEPA MCL. Nitrate, chloride, and TDS were present above the USEPA secondary drinking water standard in groundwater samples collected throughout the Tutu Wells Site. These secondary parameters were identified in previous studies and are not related to the COCs for the site. However, because of the presence of these elevated parameters, the groundwater may require pretreatment for beneficial reuse.

8.5 REMEDIAL OBJECTIVES

Concentrations of COCs in soil at the Tutu Wells Site have been identified above the NYS TAGM levels for protection groundwater quality and also above the health-based action levels derived in the USEPA risk assessment. Groundwater concentrations of chlorinated VOCs and BTEX constituents exceed the USEPA MCLs. As required by the AOC, a Remedial Alternatives Analysis (RAA) was submitted in October 1994. The RAA provided a preliminary screening of technologies for remediation of soil and groundwater where action levels have been exceeded. Site-wide remedial alternatives were developed and evaluated for conformance to the nine criteria identified in the National Contingency Plan (NCP).

In addition, as required by the AOC, a draft FS was prepared and submitted to the USEPA (Geraghty & Miller, Inc. 1995). The FS provided a more detailed screening and comparison of potential remedial alternatives, incorporated the findings of the final Baseline Risk Assessment, and included detailed cost estimates for alternatives. The FS evaluates remedial alternatives for conformance with the nine criteria from the NCP.



The remedial objectives for groundwater are the federal MCLs, or in their absence, PRGs calculated from the final Baseline Risk Assessment. However, the action levels for soils will be selected by the USEPA to be protective of groundwater quality through the migration pathway to groundwater. Soil cleanup goals are still being determined by the USEPA.



9.0 REFERENCES

- Arthur D. Little, Inc. 1994. Environmental Investigation Report, Tutu Area, St. Thomas, U.S. Virgin Islands, Revised February 16, 1994.
- Back, W. 1988. Region 26: West Indies, in Hydrogeology. Geological Society of America, Back W., Rosenshein, J.S., and Seaher, P.R., eds. The Geology of North America, Volume 0-2, Boulder, Colorado.
- Belgodere and Associates. 1988. Soil Vapor Screening at Tutu Esso in April 1988. May 1988.
- Bentley Architects and Engineers, Inc. 1992. Preconstruction Diagram and Grading Plan, Sheet 7 of 15, Figure C7. April 24, 1992.
- Blasland, Bouck & Lee, Inc. 1993a. Subsurface Investigation and Pipe Tracing Survey, Esso Tutu, St. Thomas, U.S. Virgin Islands, May 1993.
- Blasland, Bouck & Lee, Inc. 1993b. Hydrogeologic Assessment/Source Identification, Upper Tutu Aquifer Basin, Tutu, St. Thomas, U.S. Virgin Islands, October 1993.
- Blasland, Bouck & Lee, Inc. 1993c. Letter to R. Lehman, Esq., Archer and Greiner. Re: Esso Virgin Islands, Tutu Wellfields Storm Sewer Preliminary Report, November 1, 1993.
- Blasland, Bouck & Lee, Inc. 1994a. Preliminary Sample Analyses. Tutu Wells Contamination Investigation, October through December 1993. January 1994.
- Blasland, Bouck & Lee, Inc. 1994b. Tutu Groundwater Sampling Results, April 1994.
- Blasland, Bouck & Lee, Inc. 1994c. Analytical Results from Water and Sediment Samples Collected within the Tutu Storm Sewer System, November and December 1993. January 1994.
- Bouwer, E.J., B.E. Rittmann, and P.L. McCarthy. 1981. Anaerobic Degradation of Halogenated 1- and 2-Carbon Organic Compounds. Environmental Scientific Technologies, Volume 15, pp. 596-599.
- Budavari, S., (ed.), 1989. The Merck Index. An Encyclopedia of Chemicals, Drugs, and Biologicals, Eleventh Ed. Merck & Co., Inc., Rahway, New Jersey. 1606 pp.
- Camp, Dresser & McKee Federal Programs Corporation (CDM). 1988a. Field notes, Tutu Wellfield, September 6-15, 1988 and June 5-10, 1989 Sampling Events.
- Camp, Dresser & McKee Federal Programs Corporation (CDM). 1988b. Letter to C. Kwan, U.S. Environmental Protection Agency. Re: Overview of the Tutu Texaco Service Station Tank Excavation, October 31, 1988.



- Camp, Dresser & McKee Federal Programs Corporation (CDM). 1989a. Letter to C. Kwan, U.S. Environmental Protection Agency. Re: CLP Sample Analysis Data Summary of the 104(e). Letter Response Sampling, Tutu Wellfield Area, Work Assignment 648, March 31, 1989.
- Camp, Dresser & McKee Federal Programs Corporation (CDM). 1989b. Letter to C. Kwan, U.S. Environmental Protection Agency. Re: CLP Sample Analysis Data Summary of the Tutu Texaco Service Station Tank Excavation, Tutu Wellfield Area, St. Thomas, U.S. Virgin Islands, March 31, 1989.
- Camp, Dresser & McKee Federal Programs Corporation (CDM). 1990a. Letter to C. Kwan, U.S. Environmental Protection Agency. Re: Work Assignment C02048. CLP Sample Analysis Data Summary of Oils from the Tutu Texaco Stations, Tutu Esso Station, Ramsay Motor Center, and Consolidated Auto Parts, Tutu Wellfield Area, St. Thomas, U.S. Virgin Islands, February 2, 1990.
- Camp, Dresser & McKee Federal Programs Corporation (CDM). 1990b. Letter to C. Kwan, U.S. Environmental Protection Agency. Re: Preliminary (unvalidated) CLP Sample Analysis Data Summary of Soils and Waters from the Tutu Texaco Soil Pile, Tutu Esso Tank Excavation Pit and Soil Pile, and Second Round 104(e). Letter Response Sampling, Tutu Wellfield and Supercat Areas, St. Thomas, U.S. Virgin Islands, April 27, 1990.
- Camp, Dresser & McKee Federal Programs Corporation (CDM). 1990c. Letter to C. Kwan, U.S. Environmental Protection Agency. Re: Sampling Locations 104(e). Letter Response Sites Second Round of Sampling, 1989, Tutu Wellfield and Supercat Areas, St. Thomas, U.S. Virgin Islands, May 2, 1990.
- Camp, Dresser & McKee Federal Programs Corporation (CDM). 1990d. Letter to C. Kwan, U.S. Environmental Protection Agency. Re: Final CLP Sample Analysis Data Summary of Soils and Waters Sampled in 1989 from the Tutu Texaco Soil Pile, Tutu Esso Excavation Pit and Soil Pile, and 104(e) Letter Response Sites (Second Round) Tutu Well Field, St. Thomas, U.S. Virgin Islands, May 31, 1990.
- Camp, Dresser & McKee Federal Programs Corporation (CDM). 1992. Letter to C. Kwan, U.S. Environmental Protection Agency. Re: Technical Memorandum I, April 24, 1992.
- Camp, Dresser & McKee Federal Programs Corporation (CDM). 1995. Final Endangerment Assessment, Tutu Wells Site, St. Thomas, U.S. Virgin Islands. 3 Volumes. EPA Work Assignment No. 073-2P1D, Contract No. 68-W9-0024. January 12, 1995.
- Caribbean Hydro-Tech, Inc. 1993. Letter Report to J. Dema, Esq. Re: Four Winds Water Quality Results. May 12, 1993.



- Caribbean Hydro-Tech, Inc. 1994a. Letter Report to C. Crooke, Env. Specialist III, Division of Environmental Protection, Department of Planning and Natural Resources (DPNR). Re: Ramp Tank Remediation Plan, November 22, 1993. January 6, 1994.
- Caribbean Hydro-Tech, Inc. 1994b. Letter to J. Dema, Esq. Re: Summary of Aqueous and Non-Aqueous Phase Sample Analysis from Storm Sewer Investigation. December 30, 1993.
- Caribbean Hydro-Tech, Inc. 1994c. Additional Sampling Activities at Four Winds Plaza. March 9, 1994.
- Cooper Environmental, Inc. (CEI). 1993. Investigation of Ramsay Motors Site, Tutu St. Thomas, U.S. Virgin Islands, CEI File No. 92115, November 8, 1993.
- Cooper Environmental, Inc. (CEI). 1994. Letter to T. Danahy, Geraghty & Miller, Inc. Re: Summary of Split Samples from MW-15 and MW-17, August 29, 1994.
- Cooper, H.H., Jr. and C.E. Jacob. 1946. A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well Field History. Transactions, American Geophysical Union, Volume 27, No. 4.
- Donnelly, T.W. 1959. Geology of St. Thomas and St. John, Virgin Islands. Unpublished Ph.D. Dissertation, Princeton University, 179 pp.
- Donnelly, T.W. 1966. Geology of St. Thomas and St. John, Virgin Islands. Caribbean Geologic Investigations. H.H. Hess, ed. Geologic Society of America Memoir 98, pp. 15-121.
- Driscoll, Fletcher G. 1986. Groundwater and Wells, Second Edition. Johnson Division, St. Paul, Minnesota Library of Congress Card No. 85-63577. 1986
- ENSR Consulting & Engineering, Inc. 1993. Analytical Data Packages with Results of Water and Sludge Samples Collected at Western Auto, Tutu Wells Site, St. Thomas, U.S. Virgin Islands, May 27, 1993.
- ENSR Consulting & Engineering, Inc. 1994a. Closure Report for Underground Storage Tanks, June 1994.
- ENSR Consulting & Engineering, Inc. 1994b. Letter to T. Danahy, Geraghty & Miller, Inc. Re: Transmittal of Gore-Sorber Screening Survey Performed Field 14 and 15, 1994 at Western Auto. Report Dated August 11, 1994. August 19, 1994.
- ENSR Consulting & Engineering, Inc. 1994c. Results of Gore-Sorber Soil Gas Study at Four Winds Plaza, January 1994.



- ENSR Consulting & Engineering, Inc. 1994d. Memorandum to Coon, Sanford & Amerling, P.C. Re: Results of the December 1993 Split Sampling at Four Winds and Texaco. March 17, 1994.
- Fetter, Jr., C.W. 1980. Applied Hydrogeology. Bell and Howell Company. Columbus, Ohio. 1980.
- Four Winds Plaza Partnership. 1993. Supplemental Response to Request for Information. Assorted letter reports from Caribbean Hydro-Tech, Inc. to C. Crooke of DPNR, re: Western Auto Investigation dated November 28, 1992; December 4, 1992; December 12, 1992; and March 29, 1993. Assorted depositions taken by A.T. Colasanti.
- Garrett, P., M. Moreau, and J.R. Lowry. 1986. Methyl Tertiary Butyl Ether as a Groundwater Contaminant. Proceedings of the 1986 Conference on Petroleum and Organic Chemicals in Groundwater, National Water Well Association and American Petroleum Institute, Houston, Texas, pp. 227-238.
- Geo Caribe, Inc. and Pedro Panzardi & Associates. 1990. Remedial Investigation Work Plan for O'Henry Laundry, St. Thomas, U.S. Virgin Islands, March 1990.
- Geoscience Consultants, Ltd. (GCL). 1987. Final Report on Results of Soil Gas Survey, Tutu, St. Thomas, U.S. Virgin Islands. Prepared for Texaco Caribbean, Inc., December 18, 1987.
- Geoscience Consultants, Ltd. (GCL). 1988. Final Report on Results of Soil Gas Survey at Tutu Esso and Tillett, Tutu St. Thomas, U.S. Virgin Islands. Proposed for Texaco Caribbean, Inc. December 18, 1987, Revised 1988.
- Geoscience Consultants, Ltd. (GCL). 1994a. Phase I Remedial Investigation Report, St. Thomas, U.S. Virgin Islands, Revised June 10, 1994.
- Geoscience Consultants, Ltd. (GCL), 1994b. Letter to T. Danahy, Geraghty & Miller, Inc. and P. Ryan, Texaco, Inc. Re: Data from GCL Four Winds Investigation. December 1993/January 1994 conducted for Addison Meyers, Esq., O'Connor, Meyers & Lemos, P.A. September 26, 1994.
- Geraghty & Miller, Inc. 1983. Report on Current Groundwater Conditions in the U.S. Virgin Islands. Prepared for the U.S. Virgin Islands Department of Conservation and Cultural Affairs, April 1983.
- Geraghty & Miller, Inc. 1990. Sampling Analysis and Monitoring Plan (SAMP) for Wells, Tutu Wells Site, St. Thomas, U.S. Virgin Islands, September 1990.



- Geraghty & Miller, Inc. 1991. Revised Sampling Analysis and Monitoring Plan (SAMP) for Wells, Tutu Wells Site, St. Thomas, U.S. Virgin Islands, September 27, 1991.
- Geraghty & Miller, Inc. 1992a. Tutu Service Station Investigation Work Plan, St. Thomas, U.S. Virgin Islands, March 1992.
- Geraghty & Miller, Inc. 1992b. Technical Memorandum I, Tutu Wells Site, St. Thomas, U.S. Virgin Islands, April 1992.
- Geraghty & Miller, Inc. 1992c. Addendum to Technical Memorandum I, Tutu Service Station Investigation, St. Thomas, U.S. Virgin Islands, May 19, 1992.
- Geraghty & Miller, Inc. 1992d. Quality Assurance Project Plan (QAPP), Tutu Service Station Investigation, St. Thomas, U.S. Virgin Islands, March 20, 1992.
- Geraghty & Miller, Inc. 1993a. Technical Memorandum II, Results of the Field Program, Tutu Service Station Investigation, St. Thomas, U.S. Virgin Islands, May 28, 1992.
- Geraghty & Miller, Inc. 1993b. Phase II Remedial Investigation Work Plan, Tutu Wells Site, St. Thomas, U.S. Virgin Islands. December 20, 1993.
- Geraghty & Miller, Inc. 1993c. Eighth Sampling Report, March/April 1993, Tutu Wells Site, St. Thomas, U.S. Virgin Islands, July 13, 1993.
- Geraghty & Miller, Inc. 1994. Draft Phase II Remedial Investigation Report, Tutu Wells Site, St. Thomas, U.S. Virgin Islands. October 12, 1994.
- Geraghty & Miller, Inc. 1995. Draft Feasibility Study, Tutu Wells Site, St. Thomas, U.S. Virgin Islands. March 10, 1995.
- Graves, R.P., and R. González. 1988. Potentiometric Surface of the Turpentine Run Aquifer in the Tutu Area, Eastern St. Thomas, U.S. Virgin Islands, September 11, 1987. U.S. Geological Survey, Water Resources Investigation Report 88-4131.
- Hamlin Consulting Engineers, Inc. (Hamlin). 1985. Investigation and Report on Water Demand and Capability of the Tillett Well. July 1985.
- Hassett, J.J. and W.L. Banwart. 1989. The Sorption of Nonpolar Organics by Soils and Sediments. In: Reactions and Movement of Organic Chemicals in Soils. Sawhney, B.L., and K. Brown (eds). Soil Science Society of America. Madison, Wisconsin. Special Publication Number 22.



- Howard, P.H. 1989. Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume I, Large Production and Priority Contaminants. Lewis Publishers, Inc., Chelsea, Michigan. 574 pp.
- Howard, P.H. 1990. Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume II, Solvents. Lewis Publishers, Inc., Chelsea, Michigan. 546 pp.
- Howard, P.H. 1991. Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume III, Pesticides, Lewis Publishers, Inc., Chelsea, Michigan. 684pp.
- Howard, P.H. 1993. Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume IV, Solvents 2. Lewis Publishers, Inc., Chelsea, Michigan. 578 pp.
- Howard, P.H., R.S. Boethling, W.F. Jarvis, W.M. Meylan, and E.M. Michalenko. 1991. Handbook of Environmental Degradation Rates. Lewis Publishers, Inc., Chelsea, Michigan. 725 pp.
- Hydrologic Associates U.S.A., Inc. 1993a. Geohydrologic Analysis and Water Quality Data for the Upper Tutu Aquifer, St. Thomas, U.S. Virgin Islands, Volumes I and II; October 1993.
- Hydrologic Associates U.S.A., Inc. 1993b. Sources and Migratory Routes of Organic Constituents in the Tutu Aquifer, St. Thomas, U.S. Virgin Islands, October 1993.
- IT Corporation. 1990. Analytical Data for Samples Collected during 1990, August 1990.
- IT Corporation 1993. Investigation Report, O'Henry Laundry, Tutu, St. Thomas, IT Project No. 409440, March 1993.
- IT Corporation. 1994. Letter to T. Danahy, Geraghty & Miller, Inc. Re: Complete Set of Boring Logs for O'Henry Monitoring Wells at O'Henry Dry Cleaners. September 20, 1994.
- Jordan, D.G., and D.W. Fisher. 1977. Relation of Bulk Precipitation and Evaporation to Water Quality and Water Resources, St. Thomas, U.S. Virgin Islands. U.S. Geological Survey Water-Supply Paper 1663-I.
- Jordan, D.G., and O.J. Cosner. 1973. A Survey of the Water Resources of St. Thomas, U.S. Virgin Islands, U.S. Geological Survey Open-File Report, 55 pp.
- Kobayashi, H., and B.E. Rittman. 1982. Microbial Removal of Hazardous Organic Compounds. Environmental Scientific Technologies, Volume 16, pp. 170a-183A.



- Lugg, G.A. 1968. Diffusion Coefficients of Some Organic and Other Vapors in Air. Analytical Chemistry, Volume 40(7), pp. 1072-1077.
- Lyman, W.J., W.F. Reehl, and D.H. Rosenblatt. 1990. Handbook of Chemical Property Estimation Methods. American Chemical Society, Washington, D.C.
- Mabey, W.R., J.H. Smith, R.T. Podell, H.L. Johnson, T. Mill, Chou, J. Gates, I.W. Patridge, H. Jaber, and D. Vandenberg. 1982. Aquatic Fate Process Data for Organic Priority Pollutants. Office of Water Regulations and Standards, Washington, D.C.
- Mackay, D., W.Y. Shiu, J. Billington, and G.L. Huang, 1983. Physical Chemical Properties of Polychlorinated Biphenyls. In: Physical Behavior of PCBs in the Great Lakes. Ann Arbor Science, Ann Arbor, Michigan.
- Montgomery, J.H., and L.M. Welkom. 1990. Groundwater Chemicals Desk Reference. Lewis Publishers, Inc., Chelsea, Michigan. 640 pp.
- National Oceanic and Atmospheric Administration (NOAA) 1974. Climatological Data. Puerto Rico and Virgin Islands. Volume 20. Environmental Data and Information Service. National Climatic Data Center, Asheville, North Carolina.
- National Oceanic and Atmospheric Administration (NOAA) 1992. Climatological Data. Puerto Rico and Virgin Islands. Volume 38, No. 13. Environmental Data and Information Service. National Climatic Data Center. Asheville, North Carolina.
- National Oceanic and Atmospheric Administration (NOAA) 1993. Climatological Data. Puerto Rico and Virgin Islands. Volume 39. Environmental Data and Information Service. National Climatic Data Center. Asheville, North Carolina.
- National Oceanic and Atmospheric Administration (NOAA) 1994. Climatological Data. Puerto Rico and Virgin Islands. Volume 40. Environmental Data and Information Service. National Climatic Data Center. Asheville, North Carolina.
- New Jersey Department of Environmental Protection (NJDEP). 1994. Guidance Document for the Remediation of Contaminated Soils. June 1994.
- New York State Department of Environmental Conservation (NYSDEC). 1994. New York State Technical and Administrative Guidance Memorandum (NYS TAGM). Division of Hazardous Waste Remediation, HWR-94-4046. Revised January 24, 1994.
- Ney, R.E. 1990. Where Did That Chemical Go?. Van Nostrand Reinhold, New York, New York.



- NUS Corporation, Region 2 FIT. 1989a. Preliminary Assessment Report for Laga Building, Virgin Islands of Education, St. Thomas, U.S. Virgin Islands, TDD No. 02-8902-44, March 24, 1989.
- NUS Corporation, Region 2 FIT. 1989b. Preliminary Assessment Report for Ramsay Motors, St. Thomas, U.S. Virgin Islands, TDD No. 02-8902-42, March 24, 1989.
- NUS Corporation. 1989c. Final Draft, Preliminary Assessment, Gassett Motors, St. Thomas, U.S. Virgin Islands, March 24, 1989.
- NUS Corporation, Region 2 FIT. 1989d. Preliminary Assessment Report for Gassett Motors, St. Thomas, U.S. Virgin Islands, TDD No. 02-8902-41, March 24, 1989.
- NUS Corporation, Regional FIT. 1989e. Preliminary Assessment Report for Texaco Tutu, St. Thomas, U.S. Virgin Islands, TDD No. 02-8902-40, March 24, Revised March 26, 1989.
- NUS Corporation, Region 2 FIT. 1989f. Preliminary Assessment Report for Esso Tutu, St. Thomas, U.S. Virgin Islands, TDD No. 02-8902-43, March 24, 1989.
- Park, K.S., R.C. Sims, R.R. Dupont, W.J. Doucette, and J.E. Matthews. 1990. Fate of PAH Compounds in Two Soil Types. In: Influence of Volatilization, Abiotic Loss and Biological Activity. Environmental Toxicology Chemical, Volume 9, pp. 187-195.
- Parsons, F., P.R. Wood, and J. DeMarco. 1984. Transformations of Tetrachloroethene and Trichloroethene. In: Microcosms and Groundwater. Journal American Water Works Association, Volume 76, pp. 56-59.
- Pedro Panzardi & Associates. 1989. Preliminary Site Assessment Report for L'Henri, Inc., St. Thomas, U.S. Virgin Islands, October 1989.
- R. Lopez De Azua & Associates. 1992. Topographic and Planimetric Survey of Approximately 100 Acres Located at the New Tutu Section, St. Thomas, U.S. Virgin Islands, November 2, 1992.
- R. Lopez De Azua & Associates. 1993. Topographic and Planimetric Survey of Approximately 140 Acres Located at New Tutu, St. Thomas, U.S. Virgin Islands, November 1993.
- Schlumberger. 1987. Log Interpretation Principles and Applications, Houston: Schlumberger Educational Services.
- Shen, T.J. 1982. Air Quality Assurance for Land Disposal of Industrial Waste. Environmental Management, Volume 6, pp. 297-305.



- Shottroff, A. U.S. Virgin Islands of Department of Planning and Natural Resources. 1995. Personal communication with Thomas Danahy, Geraghty & Miller, Inc. Re: Sampling at the Curriculum Center on December 7, 1994. March 16, 1995.
- Smedley, David. 1961. Climate of Puerto Rico and U.S. Virgin Islands, *Climates of the States, Climatography of the United States*, No. 60-52.
- Soil Tech Corp. 1990. Final Report on Laboratory Analysis of Soil for Tank Replacement Work at Esso Tutu Service Station, Tutu, St. Thomas, U.S. Virgin Islands. Job No. 88364. January 11, 1990, Revised September 19, 1990.
- Stevens, K.E., F. Gómez-Gómez, and J. Alicia. 1981. Water Wells in the U.S. Virgin Islands, Part. 1, St. Thomas,. U.S. Geological Survey Open-File Report 82-82.
- Streng, D.L., and S.R. Peterson. 1989. Chemical Data Bases for the Multimedia Environmental Pollutant Assessment System (MEPAS): Version 1. Prepared for the U.S. Department of Energy, Assistant Secretary, Office of Environmental Audit. Pacific Northwest Laboratory, Richland, Washington.
- Subsurface Detections, Inc. (SDII). 1992. Results of Ground Penetrating Radar Survey at Esso Service Station, Tutu, St. Thomas, U.S. Virgin Islands, May 1992.
- Target Environmental Services, Inc. 1992a. Soil Gas Survey, UST Areas, Four Winds Shopping Center and Environs, Tutu Area, Anna's Retreat, U.S. Virgin Islands, February 1992.
- Target Environmental Services, Inc. 1992b. Soil Gas Survey, UST Areas, Four Winds Shopping Center and Environs, Tutu Area, Anna's Retreat, U.S. Virgin Islands, September 1992.
- Terra Vac, Inc. 1990. Final Report of Findings Ex-Fuel Home Petroleum Fort Mylner Service Station, Tutu, St. Thomas, U.S. Virgin Islands. Terra Vac Project No. 89-142. May 2, 1990.
- Theis, C.V. 1935. The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Groundwater Storage, *Transactions, American Geophysical Union*, Volume 16, pp. 519-524.
- Thomas, J.M., G.L. Clark, M.B. Tomson, P.B. Bedient, H.S. Rifai, and C.H. Ward. 1988. Final Report: Environmental Fate and Attenuation of Gasoline Components in the Subsurface. American Petroleum Institute, Washington, D.C.
- U.S. Census Bureau. 1990. Population Data for the Tutu Subdistrict of St. Thomas, U.S. Virgin Islands.



- U.S. Department of Agriculture (USDA) Soil Conservation Service. 1970. Soil Survey, Virgin Islands of the United States, August 1970.
- U.S. Environmental Protection Agency (USEPA). 1979. Water Related Environmental Fate of 129 Priority Pollutants, Volumes I and II. Office of Water Planning and Standards, Washington, D.C. USEPA 440/4-79-029a and b.
- U.S. Environmental Protection Agency (USEPA). 1988. Letter from C. Kwan to Mr. K.W. Etheridge of Texaco. Re: Review and Approval Pending QA/QC Section Submittal of Tank Removal Action Plan, Dated May 20, 1988. June 29, 1988.
- U.S. Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response, Washington, D.C.
- U.S. Environmental Protection Agency (USEPA). 1990a. Administrative Order No. II-CERCLA-00401 and RCRA-90-UST-9003-0401, March 22, 1990.
- U.S. Environmental Protection Agency (USEPA). 1990b. USEPA Contract Laboratory Program, Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration, Document Number OLM 01.0, Revised December 1990 and February 1991. USEPA Contract Laboratory Program, Washington, D.C.
- U.S. Environmental Protection Agency (USEPA). 1990c. Statement of Work for Inorganics Analysis (Multi-media, Multi-concentration), Document Number ILMO1.1, March 1990.
- U.S. Environmental Protection Agency (USEPA). 1990d. Resource Conservation and Recovery Act (RCRA). Soil Guidance Values. Federal Register. July 27, 1990.
- U.S. Environmental Protection Agency (USEPA). 1991. Hazardous Ranking System (HRS) Documentation Record, Tutu Wellfield, August 1991.
- U.S. Environmental Protection Agency (USEPA). 1992a. Administrative Order on Consent No. II-RCRA-7003 and 9003-92-0401, February 19, 1992.
- U.S. Environmental Protection Agency (USEPA). 1992b. Estimating Potential Occurrence of DNAPL at Superfund Sites.
- U.S. Environmental Protection Agency (USEPA). 1994a. Letter to A.G. Ramos, TEIC Designated Coordinator. Re: Approval of Phase II Work Plan. March 17, 1994.
- U.S. Environmental Protection Agency (USEPA). 1994b. Letter to J. McBurney and G. Seibel, TEIC Designated Coordinator. Re: Comments of the Draft Phase II Remedial Investigation and Development and Screening of Remedial Alternatives Report. December 28, 1994.



- U.S. Environmental Protection Agency (USEPA). 1994c. USEPA Region III Memorandum on Risk-Based Concentration, Fourth Quarter. Prepared by R. L. Smith, Ph.D., Senior Toxicologist. November 8, 1994.
- U.S. Geological Survey. 1954. Topographic Map for the Eastern St. Thomas Quadrangle, 1:24,000 scale. Photo revised 1982.
- U.S. Geological Survey. 1979. Preliminary Photolineament Map of St. Thomas, U.S. Virgin Islands. Prepared by J. M'Gonigle and J. Weaver. U.S. Geological Survey Open File Report 79-967.
- U.S. Geological Survey. 1993. Water Wells on St. Thomas, U.S. Virgin Islands. Open File Data Report 91-504.
- Veith, G.D., and P. Kosian. 1982. Estimating Bioconcentration Potential from Octanol/Water Partition Coefficients. In: Physical Behavior of PCBs in the Great Lakes. Mackay, Paterson, Eisenreich, and Simmons (Eds.), Ann Arbor Science, Ann Arbor, Michigan.
- Verschueren, K. 1983. Handbook of Environmental Data on Organic Chemicals, Second Ed. Van Nostrand Reinhold Co., New York, New York. 1,310 pp.
- Vogel, T., C.S. Criddle, and P.L. McCarty. 1987. Transformations of Halogenated Aliphatic Compounds. Environmental Scientific Technology, Volume 21, pp. 722-736.
- Western Atlas International Core Laboratories. 1992. Petrographic study (detailed thin section petrography analysis) of MW-4D, MW-6D, MW-11D, and MW-13D, St. Thomas, U.S. Virgin Islands. File 192187. October 7, 1992.
- Weston Major Programs Division. 1995. Sampling Trip Report - Tutu Wells Site, St. Thomas, U.S. Virgin Islands, December 7, 1994. February 1995.
- Weston/Spill Prevention and Emergency Response (SPER) Division II TAT. 1987. Memorandum to P. Cammarata, Response and Prevention Branch, USEPA. Re: Data Evaluation for Rhymer Highway Samples Collected July 22, 1987. August 3, 1987.
- Weston/Spill Prevention and Emergency Response (SPER) Division II TAT. 1988a. Memorandum from A. Martinez, TAT II PM and D. Henne, TAT II-QC to C. O'Neill, USEPA Caribbean Field Office. Re: St. Thomas, Tutu HSL + 40 Sampling Results TAT-02-F-04398, January 27, 1988.
- Weston/Spill Prevention and Emergency Response (SPER) Division II TAT. 1988b. Letter prepared for C. O'Neill & B. Sprague, Response and Prevention Branch, USEPA Region II, Edison, NJ. Summary of Laboratory Results for Oil and Water Samples Collected from



Tanks, Storm Drains, and Sumps at Gasoline Stations and Auto Body Shops in Tutu, St. Thomas, U.S. Virgin Islands on August 17, 1987, February 23, 1988.

Weston/Spill Prevention and Emergency Response (SPER) Division II TAT. 1988c. Memorandum to P. Cammarata, Response and Prevention Branch USEPA. Re: Tutu Wells Data, September 1987 to January 1988. February 11, 1988.

Weston/Spill Prevention and Emergency Response (SPER) Division II TAT. 1989a. Memorandum to L. E. Santos, OSC, EPA Caribbean Field Office. Re: Results of the August 1989 Photovac Sampling of the Tutu Wells Site, September 13, 1989.

Weston/Spill Prevention and Emergency Response (SPER) Division II TAT. 1989b. Letter to L. E. Santos, OSC, EPA Caribbean Field Office. Re: Final Results of the November 1988 TCL Sampling and Comparison to TCL Sampling Conducted October 1987, May 1, 1989.

g:\aproject\tutu\pr0013.034\reports\tuturi.rpt



Table 3-1. Soil Sampling Details, Phase II Remedial Investigation, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Monitoring Well	Date Sampled	Date Analyzed	Interval Sampled (feet bls)	Analytical Parameters
MW-13	3/29/94	4/16/94	2.0 - 3.5	VOCs, BNAs, metals, cyanide, TPHs
MW-15	3/28/94	4/16/94	0 - 2.0 4.0-6.0	VOCs BNAs, metals, cyanide, TPHs
MW-16	4/4/94	4/14/94	0 - 2.0 0 - 3.0	VOCs BNAs, TPHs, metals, cyanide
MW-17	3/28/94	4/16/94	6.0 - 8.0	VOCs, BNAs, metals, cyanide, TPHs
MW-18	3/28/94	4/16/94	12.0 - 14.0	VOCs, BNAs, metals, cyanide, TPHs
MW-19	4/6/94	4/16/94	4.0 - 6.0 4.0 - 8.0	VOCs VOCs, BNAs, metals, cyanide, TPHs
MW-24				
MW-16 FR	4/4/94	4/14/94	0 - 2.0 0 - 3.0	VOCs BNAs, TPHs, metals, cyanide
VOCs	Volatile organic compounds.			
BNAs	Base neutral and acid extractable compounds.			
metals	Includes metals specified in the Target Analyte List.			
TPHs	Total petroleum hydrocarbons.			
feet bls	Feet below land surface.			

TUT 005 0622

Table 3-2. Monitoring Well Construction Details, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well Identification	Date Installed	Top of Casing Elevation (ft msl)	Total Borehole Depth (ft bls)	Borehole Diameter (in.)	Well Casing Depth (ft bls)	Diameter (in.) and Casing Material	Screened Interval/ Open Borehole (ft bls)	Screen Slot Size (in.)	Top of Sand (ft bls)	Top of Bentonite (ft bls)	Depth to Top of Bedrock (ft bls)
<u>Esso Tutu Service Station</u>											
SW-1	12/93	166.36	---	8	5.0	4 PVC	5.0-35.0	0.010	3.0	---	11.0
SW-2	12/93	166.52	---	8	5.0	4 PVC	5.0-35.0	0.010	3.0	---	8.0
SW-3	12/93	166.68	---	8	5.0	4 PVC	5.0-40.0	0.010	3.0	---	10.0
SW-4	12/93	152.96	---	8	5.0	4 PVC	5.0-35.0	0.010	3.0	---	12.0
SW-5	12/93	142.21	---	8	6.0	4 PVC	6.0-31.0	0.010	4.0	---	9.0
SW-6	12/93	147.60	---	8	5.0	4 PVC	5.0-35.0	0.010	3.0	---	9.0
SW-7	12/93	167.02	---	8	7.0	4 PVC	7.0-22.0	0.010	3.0	---	---
DW-1	12/93	167.16	80.0	5.25	65.0	6 ST	65.0-80.0	Open	NA	NA	8.0
DW-2	12/93	147.73	80.0	5.25	65.0	6 ST	65.0-80.0	Open	NA	NA	8.0
<u>Four Winds Plaza</u>											
CHT-1 (MW-1)	2/92	167.70	28.5	8	18.5	2 PVC	18.5-28.5	0.010	16.5	14.5	17
CHT-2 (MW-2)	2/92	161.86	36	8	31.0	2 PVC	31-36	0.010	25	22	29
CHT-3 (MW-3)	2/92	161.86	34	8	23.0	2 PVC	23-33	0.010	22	21	32
CHT-4 (MW-4)	2/92	166.95	29	8	19.0	2 PVC	19-29	0.010	17	14	29
CHT-5 (MW-5)	2/92	---	48	8	27.0	2 PVC	27-37	0.010	32	30	21
WO Well	1992	---	6	4	5.0	4 PVC	5-6	---	---	---	---
CHT-6D (DTW-2)	5/92	174.20	144	9	20.0	6 PVC	20-144	Open	---	---	10
CHT-7D (DTW-1)	5/92	158.29	124	8	20.0	6 PVC	20-124	Open	---	---	20
<u>Geraghty & Miller, Inc. Sitewide Shallow</u>											
MW-1	6/30/92	195.08	46.0	8	43.6	4 SS	23.6-43.6	0.020	21.1	19.1	1.8
MW-2	8/25/92	178.15	28.0	10	27.0	4 SS	7.0-27.0	0.020	5.0	3.0	3.1
MW-3	6/11/92	181.84	34.0	6	30.4	4 SS	10.4-30.4	0.020	8.4	6.4	2.4
MW-4	6/17/92	175.66	28.0	6	27.0	4 SS	7.0-27.0	0.020	5.0	3.0	8.7
MW-5	8/25/92	187.09	40.8	10	39.0	4 SS	19.0-39.0	0.020	17.0	15.0	4.8
MW-6R	9/2/92	171.17	23.7	10	22.7	4 SS	2.7-22.7	0.020	1.6	0.8	4.92
MW-7	7/29/92	180.13	39.6	10	35.4	4 SS	15.4-35.4	0.020	12.8	11.0	15.0
MW-8	7/23/92	167.54	26.0	10	25.5	4 SS	5.5-25.5	0.020	3.0	1.5	8.3

See last page for notes.

Table 3-2. Monitoring Well Construction Details, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well Identification	Date Installed	Top of Casing Elevation (ft msl)	Total Borehole Depth (ft bls)	Borehole Diameter (in.)	Well Casing Depth (ft bls)	Diameter (in.) and Casing Material	Screened Interval/ Open Borehole (ft bls)	Screen Slot Size (in.)	Top of Sand (ft bls)	Top of Bentonite (ft bls)	Depth to Top of Bedrock (ft bls)
<u>Geraghty & Miller, Inc. Sitewide (continued)</u>											
MW-9	7/30/92	162.26	34.3	10	34.1	4 SS	14.1-34.1	0.020	11.8	10.0	5.0
MW-9S	9/14/92	162.37	21.0	6	18.7	4 SS	8.7-18.7	0.020	6.7	5.7	5.0
MW-10	8/20/92	161.50	36.7	10	35.6	4 SS	15.6-35.6	0.020	13.0	11.0	2.9
MW-13	4/28/94	236.31	80.5	6	60.3	6 SS	60.3-80.5	Open	NA	NA	3.5
MW-14*	7/2/92	196.12	48.0	8	45.2	4 SS	25.2-45.2	0.020	22.4	19.8	3.0
MW-15	3/31/94	178.95	36.2	6	15.0	6 SS	15.0-36.2	Open	NA	NA	7.5
MW-16	5/2/94	202.33	44.6	6	24.6	6 SS	24.6-44.6	Open	NA	NA	3.0
MW-17	3/30/94	177.18	15.0	8	8.5	4 SS	8.5-13.5	0.020	7.0	6.0	9.5
MW-18	4/7/94	159.26	20.5	8	15.5	4 SS	15.5-20.5	0.020	13.0	12.0	14.5
MW-19	4/17/94	148.78	17.4	8	12.0	4 SS	12.0-17.0	0.020	10.0	8.0	11.5
MW-20	5/11/94	174.92	29.0	6	12.6	6 SS	12.6-29.0	Open	NA	NA	12.0
MW-22D	4/18/94	167.57	128.0	6	108.0	6 SS	108.0-128.0	Open	NA	NA	6.0
MW-24	5/12/94	167.75	38.5	6	18.0	6 SS	18.0-38.5	Open	NA	NA	11.0
MW-25	4/7/94	166.34	45.0	6	25.0	6 SS	25.0-45.0	Open	NA	NA	21.0
<u>Deep</u>											
MW-1D	7/8/92	195.14	90.0	6	70.0	6 SS	70.0-90.0	Open	NA	NA	2.8
MW-4D	6/17/92	176.02	71.0	6	47.7	6 SS	47.7-71.0	Open	NA	NA	10.7
MW-6D	8/10/92	171.01	65.0	6	45.0	6 SS	45.0-65.0	Open	NA	NA	4.92
MW-10D	8/19/92	161.38	75.1	6	55.1	6 SS	55.1-75.1	Open	NA	NA	1.7
MW-11D	7/20/92	153.22	74.3	6	53.0	6 SS	53.0-74.3	Open	NA	NA	10.2
MW-12D	7/23/92	161.81	88.0	10	80.5	4 SS	60.5-80.5	0.020	56.4	54.0	5.9
MW-13D	7/15/92	236.60	120.0	6	100.0	6 SS	100.0-120.0	Open	NA	NA	5.0
MW-20D	5/9/94	174.71	68.0	6	48.0	6 SS	48.0-68.0	Open	NA	NA	12.0
MW-21D	4/11/94	123.48	96.0	6	76.0	6 SS	76.0-96.0	Open	NA	NA	20.0
<u>Kentucky Fried Chicken Corp.</u>											
KFMW-2 (KFC-1)	6/7/90	121.81	19.8	7	9	4 PVC	9.0-19.0	0.020	6.0	5.0	19.7
KFMW-3 (KFC-2)	6/7/90	122.02	20.5	7	7.3	4 PVC	7.3-17.3	0.020	2.5	1.5	20.0

See last page for notes.

Table 3-2. Monitoring Well Construction Details, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well Identification	Date Installed	Top of Casing Elevation (ft msl)	Total Borehole Depth (ft bls)	Borehole Diameter (in.)	Well Casing Depth (ft bls)	Diameter (in.) and Casing Material	Screened Interval/ Open Borehole (ft bls)	Screen Slot Size (in.)	Top of Sand (ft bls)	Top of Bentonite (ft bls)	Depth to Top of Bedrock (ft bls)
<u>O'Henry Cleaners</u>											
OHMW-1	7/18/90	137.84	42.0	6	22.5	2 SS	22.5-37.5	0.020	18.5	15.5	14.0
OHMW-2	7/18/90	138.82	42.0	6	22.0	2 SS	22.0-37.0	0.020	14.0	11.0	24.0
OHMW-3	7/18/90	145.95	35.5	6	15.5	2 SS	15.5-35.5	0.020	8.3	9.3	10.0
OHMW-4	7/18/90	148.64	52.0	6	27.0	2 SS	27.0-52.0	0.020	25.0	22.0	10.0
<u>Texaco Tutu Service Station</u>											
TT-1	12/10/93	179.03	36.3	8	10.0	4 PVC	10.0-30.0	0.010	9.0	6.0	15.0
TT-2	12/10/93	179.69	37.0	8	9.0	4 PVC	9.0-29.0	0.010	8.0	6.0	5.0
TT-4	12/3/93	180.51	36.0	8	8.5	4 PVC	8.5-28.5	0.020	10.5	8.0	9.0
TT-5	12/3/93	182.34	38.0	8	10.0	4 PVC	10.0-30.0	0.020	8.5	7.1	7.5
TT-6	12/11/93	169.18	33.0	8	3.5	4 PVC	3.5-13.5	0.010	3.2	2.0	1.5
TT-1D	12/10/93	179.45	53.0	6	45.3	2 PVC	45.3-50.3	0.020	42.5	37.9	16.5
TT-3D	12/10/93	181.75	55.0	6	43.0	2 PVC	43.0-53.0	0.020	30.0	23.3	2.5

NA Not applicable.
 ft msl Feet above mean sea level.
 ft bls Feet below land surface.
 MW-6R Replacement well for MW-6.
 MW-9S Additional shallow well at MW-9 location.
 --- Not available.
 PVC Polyvinyl chloride.
 SS Stainless steel.
 ST Black steel.
 in. Inches.
 * Well destroyed.

Wells with the prefix "SW-" or "DW-" were installed by Blasland, Bouck & Lee, Inc.

Wells with the prefix "CHT-" were installed by Caribbean Hydro-Tech, Inc.

Wells with the prefix "KFMW-" were installed by Terra Vac, Inc.

Wells with the prefix "OHMW-" were installed by Geo Caribe, Inc..

Wells with the prefix "TT-" were installed by GCL.

Wells with the prefix "MW-" were installed by Geraghty & Miller, Inc.

Table 3-3. Groundwater Sampling Details for the Comprehensive Sampling Event, May Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well ID	Date Sampled	Analytical Parameters
<u>Geraghty & Miller Monitoring Wells</u>		
MW-1	6/8/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-1D	6/8/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-2	6/17/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-3	6/14/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-4	6/13/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-4D	6/13/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-5	6/22/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-6R	6/6/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-6D	6/7/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-7	6/6/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-8	6/3/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-9S	5/31/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-10	5/31/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-10D	5/31/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-11D	5/27/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-12D	5/20/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-13	6/15/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-13D	6/15/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-14		Well destroyed
MW-15	06/7/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-16	06/10/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-17	06/7/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-18	06/24/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-19	06/20/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-20	06/15/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-20D	6/15/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-21D	6/14/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-22D	6/22/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-24	6/3/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
MW-25	6/2/94	TCL VOC, TCL BNA, TAL metals, water quality parameters

Notes on last page.



Table 3-3. Groundwater Sampling Details for the Comprehensive Sampling Event, May Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well ID	Date Sampled	Analytical Parameters
<u>Other Monitoring Wells</u>		
CHT-3	6/1/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
CHT-5		Not sampled
CHT-6D	6/1/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
CHT-7D	6/2/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
DW-1	6/3/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
DW-2	5/27/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
SW-2	6/22/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
SW-3	6/23/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
SW-4	6/16/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
SW-5	5/25/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
SW-6	5/26/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
SW-7	6/23/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
OHMW-1	5/24/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
OHMW-2	5/24/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
OHMW-3	5/24/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
OHMW-4	5/24/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
TT-1	6/9/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
TT-1D	6/9/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
TT-2	6/9/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
TT-3D	6/14/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
TT-4	6/10/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
TT-5	6/9/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
KFMW-2 (KFC-1)	6/22/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
<u>Supply Wells</u>		
Delegarde	5/26/94	VOC (524.2), TCL BNA, TAL metals, water quality parameters
	7/27/94	VOCs
Eglin I	5/19/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
Eglin II		Not sampled

Notes on last page.



Table 3-3. Groundwater Sampling Details for the Comprehensive Sampling Event, May Through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well ID	Date Sampled	Analytical Parameters
<u>Supply Wells (Continued)</u>		
Eglin III	5/18/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
Four Winds I	7/22/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
Four Winds II	7/21/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
Harvey	7/27/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
Harthman (Wilfred)		Well pump not working; not accessible for sampling.
Harthman (Racetrack)	5/17/94	VOC (524.2), TCL BNA, TAL metals, water quality parameters
LaPlace	5/19/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
Matthias	5/24/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
Gassett (New)	5/17/94	VOC (524.2), TCL BNA, TAL metals, water quality parameters
Ottley		Well not found; not in use by current owner.
Ramsay	5/26/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
Rodriguez		Well pump not working; not accessible for sampling.
Smith	5/20/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
Steele	5/18/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
Tillett	5/25/94	TCL VOC, TCL BNA, TAL metals, water quality parameters
VIHA I	7/19/94	VOC (524.2), TCL BNA, TAL metals, water quality parameters
VIHA III		Well pump not working; not accessible for sampling.
TCL VOC Target compound list volatile organic compounds plus methyl tertiary butyl ether, n-propylbenzene, and 1,2-dibromomethane.		
TCL BNA Target compound list base/ neutral and acid extractable organic compounds.		
TAL metals Target analyte list metals.		

Water quality parameters include total dissolved solids, total suspended solids, sulfate, sulfide, nitrate, nitrite, phosphorous, alkalinity, cyanide, organo-metallic lead, chloride, manganese, chemical oxygen demand, and hardness.



Table 3-4. Supply Well Construction Details and Estimated Pumping Rates, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well	Year Drilled	Approximate Total Depth of Well (ft bls)	Depth of Casing (ft bls)	Approximate Elevation of Measuring Point (ft mal)	Diameter (in.) and Type of Casing	Possible Water-Bearing Zone (ft bls)	Estimated Pumping Rates*	Hours Operating Per Day
C. Adkins #1	1972-1973	100	20	—	6 PVC	—	—	—
C. Adkins #2	1972-1973	80	—	—	—	—	—	—
C. Adkins #3	1972-1973	120	—	—	—	—	—	—
Baptist Mission	1977	55	30	—	6 PVC	—	—	—
Bertha C. Boschulte School	—	—	—	—	—	—	—	—
Bryan I	1978	140	—	215	6 PVC	60, 70, 89	—	—
Bryan II	1978	140	48	220	6 PVC	—	80,000	6
Bryan III	1978	140	30	218	6 PVC	50-60	Max. (10 gpm)	Intermittent
Church (God of Holiness)	1981	265	—	+ 182.14	6 Steel	—	—	—
Creger Motors No. 1	—	—	—	135	—	—	—	—
Creger Motors No. 2	—	—	—	135	—	—	—	—
Creger Motors No. 3	—	—	—	137	—	—	—	—
Creger Motors No. 4	—	—	—	148	—	—	—	—
Controlled Concrete Products	—	—	80	—	6 PVC	—	—	—
Delegarde	1965	70	—	70	6 —	—	—	—
Demitri	—	300	—	231	6 PVC	—	—	—
Dench	—	140	—	—	6 PVC	—	15,000	—
Dept. of Agriculture Animal Shelter	—	—	—	9	—	—	—	—
Dept. of Education (Gomez School)	1980-1981	—	—	—	—	—	52,800	—
Dept. of Education (James Madison School)	—	—	—	—	—	—	—	—

See last page for footnotes.

Table 3-4. Supply Well Construction Details and Estimated Pumping Rates, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well	Year Drilled	Approximate Total Depth of Well (ft bla)	Depth of Casing (ft bla)	Approximate Elevation of Measuring Point (ft msl)	Diameter (in.) and Type of Casing	Possible Water-Bearing Zone (ft bla)	Estimated Pumping Rates*	Hours Operating Per Day
Devcon (Poly Carib) I	1981(deepened 1984)	260	—	—	6 PVC	150-170, 190-220	—	—
Devcon (Poly Carib) II	1980	250	—	—	6 Steel	—	—	—
Devcon (Poly Carib) III	1982	250	—	—	8 PVC	—	—	—
Devcon (Poly Carib) IV	—	—	—	35	—	—	—	—
Didi Well/Public Well	—	—	—	27	6	—	—	—
E & A Corp. Well No. 1	—	—	—	123	—	—	—	—
E & A Corp. Well No. 2	—	—	—	126	—	—	—	—
E & A Corp. Well No. 3	—	—	—	126	—	—	—	—
E & A Corp. Well No. 4	—	—	—	—	—	—	—	—
Eglin I (G. Eglin Well I)	1965	225	—	+ 146.65	6 Steel	—	25,000	—
Eglin II (G. Eglin Well II)	—	225	—	+ 151.98	6 Steel	—	25,000	—
Eglin III (G. Eglin Well III)	—	325	40	+ 155.17	6 Steel	—	(46 - 40 gpm)	24
Farrington Well	—	—	—	43	—	—	—	—
Fort Mylner	1938	18	—	120	133	—	—	—
Four Winds I	1981	305	30	166	6 PVC	160-164	500 (12 gpm)	16
Four Winds II	1981	285	40	165	6 PVC	90-120 170-190	500 (5 - 10 gpm)	16
Four Winds III	—	—	—	—	—	—	—	—
"New" Gassett (Gassett Motors II)	—	128	—	135	6 —	—	—	—
"Old" Gassett (Gassett Motors I)	—	—	—	135	—	—	—	—
Harthman Bakery	1978	325	36	130	6 PVC	—	—	—
Harthman Baptiste	—	97	—	—	6 Steel	—	—	—
Harthman Cow Pen	—	97	—	—	—	—	—	—
Harthman Crusher (Destroyed)	1978	210	65	140	6 PVC	—	10,000	24
Harthman Estate	1965	210	100	196	6 —	—	30 gpm	—
Harthman Mango Garden	1978	325	20	—	6 PVC	—	—	—
Harthman No. 69	Deepened 1978	125	40	—	6 PVC	69, 125	—	—
Harthman Racetrack	—	180	—	—	6 Steel	—	—	—
Harthman Wilfred	—	60	—	—	6 Steel	—	—	—
Harthman Zero Filter	—	120	—	—	6 PVC	—	—	—

See last page for footnotes.

GERAGHTY & MILLER, INC.

TUT 005 0630

Table 3-4. Supply Well Construction Details and Estimated Pumping Rates, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well	Year Drilled	Approximate Total Depth of Well (ft bls)	Depth of Casing (ft bls)	Approximate Elevation of Measuring Point (ft mal)	Diameter (in.) and Type of Casing	Possible Water-Bearing Zone (ft bls)	Estimated Pumping Rates*	Hours Operating Per Day
Stevens	1980	100	80	—	6 PVC	68-80	—	—
Tillett	1963	100	15	186	6 Steel	—	40,000 (60 gpm)	24
Versailles Assoc. (DEVCON)	1965	40	—	120	6 —	—	—	—
VIHA I	1977	175	41	+ 234.16	6 Steel	—	500 (48 gpm)	24
VIHA II	1977	150	37	+ 235.99	6 Steel	—	500 (47 gpm)	—
VIHA III	1978	142	73	239	6 Steel	70-72, 78, 87, 105, 125, 138	44 (44 gpm)	—
VIHA IV	1978	176	69	278	6 Steel	—	500 (46 gpm)	—
Villanueva	—	—	—	—	—	—	—	—
Virgin Islands (V.I.) Government (near God of Holiness Church)	—	27	—	145	108	—	—	—
V. I. Government (Old Tutu Water Treatment Plant)	1925	34	—	175	84 —	—	—	—

ft bls Feet below land surface.

ft mal Feet above mean sea level.

in. Inches.

* Estimated pumping rates are in gallons per day, unless otherwise noted.

+ Surveyed measuring point elevation.

PVC Polyvinyl chloride.

— Not available.

VIHA Virgin Islands Housing Authority.

gpm Gallons per minute.

Sources: Graves and Gonzalez (1988).

Hydrologic Associates, U.S.A., Inc. (1993a).

U.S. Geological Survey (1993).

Table 3-5. Schedule of Data Collection Intervals Used with the Data Logger During the May 1994 Eglin III Pumpage Impact Test, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Elapsed Time	Frequency of Water-Level Measurements
0-20 Seconds	0.5 Second
20-60 Seconds	1 Second
1-10 Minutes	12 Seconds
10-100 Minutes	2 Minutes
Greater than 100 Minutes	10 Minutes



Table 4-1. Precipitation Data from Estate Fort Mylner, 1961 Through 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Month	1961 to 1990 Monthly Precipitation Normals (inches)	1990 Monthly Precipitation Totals (inches)	1991 Monthly Precipitation Totals (inches)	1992 Monthly Precipitation Totals (inches)	1993 Monthly Precipitation Totals (inches)	1994 Monthly Precipitation Totals (inches)
January	2.63	5.26	3.38	9.08	NA	3.04
February	1.94	1.73	3.76	1.71	NA	2.76
March	2.32	2.97	2.66	1.23	NA	2.99
April	3.27	2.68	0.55	2.15	NA	2.14
May	5.06	1.79	1.91	6.89	NA	1.01
June	3.04	2.29	1.90	1.36	M 4.04	1.09
July	3.13	3.52	3.25	2.21	1.73	0.76
August	4.72	4.24	3.16	3.46	0.70	0.39
September	5.15	3.45	7.63	5.27	M 3.93	2.19
October	6.51	13.53	2.47	5.31	M 5.03	1.39
November	6.33	3.18	5.94	10.74	M 8.25	NA
December	3.37	4.70	2.19	NA	NA	NA
Annual	47.47	49.34	38.80	NA	NA	NA

Source: National Oceanic and Atmospheric Administration (NOAA 1994).

NA Data not available.

M Insufficient or partial data. M is appended to average and/or total values computed with one to nine daily values missing.



Table 4-2. Temperature Data from Cyril E. King Airport, 1961 Through 1993, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Month	1990 Average Temperatures	1991 Average Temperatures	1992 Average Temperatures	1993 Average Temperatures	1961-1990 Temperature Normals
January	M	79.1	78.8	NA	78.4
February	M 77.6	M 79.3	79.7	NA	78.5
March	M 78.7	80.1	M 79.9	NA	79.1
April	M 79.2	81.1	82.1	NA	80.0
May	M 81.5	81.9	81.9	NA	80.9
June	82.9	84.1	84.3	84.5	82.5
July	84.8	84.0	85.8	86.2	83.3
August	85.6	M 84.9	M 85.6	87.2	83.3
September	83.7	84.6	85.7	86.3	82.7
October	M 82.9	82.6	85.2	85.5	82.1
November	83.2	81.3	82.4	62.8	80.8
December	M 79.8	79.0	NA	NA	79.1
Annual	M	M 81.8	NA	NA	80.9

Source: National Oceanic and Atmospheric Administration (NOAA 1993).
All temperatures in degrees Fahrenheit.

NA Data not available.

M Insufficient or partial data. M is appended to average and/or total values computed with one to nine daily values missing. M appears alone if ten or more daily values are missing.



Table 4-3. Soil Properties and Classification, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Soil Type Name	Depth from surface (in inches)	USDA Texture	Unified Soil Classification	Percentage Passing Sieve				Permeability (cm/sec)
				No. 4	No. 10	No. 40	No. 200	
Cramer/ Cramer Isaac	0-9	Gravelly clay loam	GM/ML	65-75	60-70	55-65	45-55	0.0014-0.0045
	9-19	Clay and gravelly clay	CL	90-100	80-90	65-75	55-65	0.0004-0.0014
	19	Volcanic mudstone	--	--	--	--	--	--
Descalabrado	0-10	Clay loam	MH/CH	85-95	85-90	80-90	70-80	0.0001-0.0004
	10-19	Silty clay loam	ML/CL	100	100	90-95	65-75	0.0004-0.0014
	19	Volcanic rock	--	--	--	--	--	--
Dorothea	0-12	Clay loam	MH/CH	100	100	90-100	65-75	0.0004-0.0014
	12-30	Clay	MH/CH	100	100	90-100	70-80	0.0001-0.0004
	30-59	Clay loam	MH/CH	100	100	90-100	65-75	0.0004-0.0014
Glynn	0-6	Clay loam	CL	96	90-100	80-90	65-75	0.0001-0.0004
	6-19	Clay, clay loam	CH	99	99	95-100	85-95	0.0001-0.0004
	19-36	Clay loam, sandy loam and clay	CH	99	95-100	90-100	80-90	0.0004-0.0014
Lavallee	0-18	Gravelly clay loam	CL/ML	75-85	70-80	65-75	70-80	0.0001-0.0004
	18-48	Very gravelly loam	GC	55-65	45-55	45-55	30-40	0.0004-0.0014
San Anton	0-9	Clay loam	MH	85-95	85-95	80-90	70-80	0.0004-0.0014
	9-32	Gravelly clay loam	CL/ML	75-85	70-90	65-75	70-80	0.0004-0.0014
	32-50	Clay loam	MH	100	100	90-100	70-80	0.0004-0.0014

USDA United States Department of Agriculture.
 -- Not applicable.
 cm/sec Centimeters per second.
 Soil sampling, analysis, and classification performed by the USDA (1970).

g:\project\tutu\pr0013.034\data\soilprop.wk3

TUT 005 0636



Table 4-4. Depths of Fracture Zones Identified by Downhole Geophysical Testing, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Monitoring Well Boring	Primary Fracture Zone (ft bls)	Secondary Fracture Zone (ft bls)
MW-1D	32 to 37 49 to 52	NI
MW-4D	31 to 37 53 to 57	NI
MW-6D	8 to 15 31 to 35 44 to 50 52 to 55	NI
MW-10D	26 to 39 42 to 45 53 to 57	NI
MW-11D	20 to 32 39 to 43 50 to 60	NI
MW-12D	NI	32 to 38 42 to 47 51 to 55
MW-13D	8 to 34	56 to 59 76 to 80 88 to 90 93 to 95 101 to 102

ft bls Feet below land surface.
NI Not identified.



Table 4-5. Groundwater Elevations, September 10, 1992 Through July 20, 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

		September 10, 1992		November 16, 1992		May 10, 1994		May 23 to 24, 1994		July 20, 1994	
	Measuring Point	Depth to	Water-Level	Depth to	Water-Level	Depth to	Water-Level	Depth to	Water-Level	Depth to	Water-Level
Well	Elevation	Water	Elevation	Water	Elevation	Water	Elevation	Water	Elevation	Water	Elevation
Identification	(ft msl)	(ft bmp)	(ft msl)	(ft bmp)	(ft msl)	(ft bmp)	(ft msl)	(ft bmp)	(ft msl)	(ft bmp)	(ft msl)
<u>Shallow Wells</u>											
<u>Eso Tutu Service Station</u>											
SW-1	166.36	—	—	—	—	9.10	157.26	20.50	145.86	—	—
SW-2	166.52	—	—	—	—	18.45	148.07	17.43	149.09	—	—
SW-3	166.68	—	—	—	—	18.96	147.72	17.62	149.06	—	—
SW-4	152.96	—	—	—	—	10.28	142.68	10.54	142.42	—	—
SW-5	142.21	—	—	—	—	20.74	121.47	20.75	121.46	—	—
SW-6	147.60	—	—	—	—	10.52	137.08	11.45	136.15	—	—
SW-7	167.02	—	—	—	—	10.08	156.94	10.77	156.25	—	—
 <u>Four Winds Plaza</u>											
CHT-1 (MW-1)	167.70	—	—	—	—	—	—	13.76	153.94	—	—
CHT-2 (MW-2)	161.86	—	—	—	—	—	—	15.05	146.81	—	—
CHT-3 (MW-3)	161.86	—	—	—	—	—	—	17.58	144.28	—	—
CHT-4 (MW-4)	166.95	—	—	—	—	—	—	12.11	154.84	—	—
CHT-5 (MW-5)	(not surveyed)	—	—	—	—	—	—	—	—	—	—
 <u>Geraghty & Miller, Inc. Sitewide</u>											
MW-1	195.08	30.08	165.00	24.89	170.19	—	—	30.28	164.80	31.56	163.52
MW-2	178.15	13.60	164.55	10.18	167.97	—	—	13.38	164.77	—	—
MW-3	181.84	17.40	164.44	13.49	168.35	17.35	164.49	17.29	164.55	—	—
MW-4	175.66	11.64	164.02	8.09	167.57	11.46	164.20	11.40	164.26	12.42	163.24
MW-5	187.09	—	—	19.93	167.16	23.58	163.51	23.49	163.60	—	—
MW-6R	171.17	8.22	162.95	5.51	165.66	8.12	163.05	8.08	163.09	—	—
MW-7	180.13	17.58	162.55	15.46	164.67	17.49	162.64	17.48	162.65	—	—
MW-8	167.54	17.96	149.58	12.20	155.34	13.70	153.84	13.64	153.90	—	—
MW-9	162.26	—	—	10.95	151.31	11.76	150.50	11.75	150.51	—	—
MW-9S	162.37	—	—	10.47	151.90	11.54	150.83	11.56	150.81	—	—
MW-10	161.50	20.66	140.84	16.72	144.78	17.58	143.92	17.65	143.85	—	—
MW-13	236.31	—	—	—	—	65.08	171.23	64.99	171.32	67.90	168.41
MW-14	196.12	28.08	168.04	24.24	171.88	—	—	—	—	—	—
MW-15	178.95	—	—	—	178.95	11.04	167.91	10.80	168.15	—	—
MW-16	202.33	—	—	—	202.33	31.54	170.79	31.33	171.00	33.62	168.71
MW-17	177.18	—	—	—	177.18	9.82	167.36	9.63	167.55	—	—

See footnotes on Page 3.



Table 4-5. Groundwater Elevations, September 10, 1992 Through July 20, 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

		<u>September 10, 1992</u>		<u>November 16, 1992</u>		<u>May 10, 1994</u>		<u>May 23 to 24, 1994</u>		<u>July 20, 1994</u>	
	Measuring	Depth	Water-	Depth	Water-	Depth	Water-	Depth	Water-	Depth	Water-
	Point	to	Level	to	Level	to	Level	to	Level	to	Level
Well	Elevation	Water	Elevation	Water	Elevation	Water	Elevation	Water	Elevation	Water	Elevation
Identification	(ft msl)	(ft bmp)	(ft msl)	(ft bmp)	(ft msl)	(ft bmp)	(ft msl)	(ft bmp)	(ft msl)	(ft bmp)	(ft msl)
<u>Shallow Wells (continued)</u>											
<u>Geraghty & Miller, Inc. Sitewide (continued)</u>											
MW-18	159.26	--	--	--	--	--	--	14.90	144.36	--	--
MW-19	148.78	--	--	--	--	10.79	137.99	11.63	137.15	--	--
MW-20	174.92	--	--	--	--	--	--	24.74	150.18	--	--
MW-22D	167.57	--	--	--	--	106.37 (2)	61.20 (1)	93.62	73.95	--	--
MW-24	167.75	--	--	--	--	--	--	7.70	160.05	--	--
MW-25	166.34	--	--	--	--	--	--	12.17	154.17	--	--
<u>O'Henry Cleaners</u>											
OHMW-1	137.84	--	--	--	--	21.47	116.37	21.65	116.19	--	--
OHMW-2	138.82	--	--	--	--	17.42	121.40	17.39	121.43	--	--
OHMW-3	145.95	--	--	--	--	9.06	136.89	9.65	136.30	--	--
OHMW-4	148.64	--	--	--	--	32.29	116.35	32.42	116.22	--	--
<u>Texaco Tutu Service Station</u>											
TT-1	179.03	--	--	--	--	15.36	163.67	15.30	163.73	--	--
TT-2	179.69	--	--	--	--	15.16	164.53	15.11	164.58	--	--
TT-4	180.51	--	--	--	--	16.70	163.81	16.67	163.84	--	--
TT-5	182.34	--	--	--	--	18.54	163.80	18.48	163.86	--	--
TT-6	169.18	--	--	--	--	--	--	6.77	162.41	--	--
<u>Kentucky Fried Chicken</u>											
KFMW-2 (KFC-1)	121.81	--	--	--	--	--	--	9.45	112.36 (3)	--	--
KFMW-3 (KFC-2)	122.02	--	--	--	--	--	--	9.22	112.80 (3)	--	--
<u>Deep Wells</u>											
<u>Esso Tutu Service Station</u>											
DW-1	167.16	--	--	--	--	13.68	153.48	13.63	153.53	--	--
DW-2	147.73	--	--	--	--	10.99	136.74	12.07	135.66	--	--
<u>Four Winds Plaza</u>											
CHT-6D (DTW-2)	174.20	--	--	--	--	--	--	10.60	163.60	--	--
CHT-7D (DTW-1)	158.29	--	--	--	--	--	--	16.29	142.00	--	--

See footnotes on Page 3.



Table 4-5. Groundwater Elevations, September 10, 1992 Through July 20, 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

		<u>September 10, 1992</u>		<u>November 16, 1992</u>		<u>May 10, 1994</u>		<u>May 23 to 24, 1994</u>		<u>July 20, 1994</u>	
	Measuring Point	Depth to	Water-Level	Depth to	Water-Level	Depth to	Water-Level	Depth to	Water-Level	Depth to	Water-Level
Well	Elevation	Water	Elevation	Water	Elevation	Water	Elevation	Water	Elevation	Water	Elevation
Identification	(ft mal)	(ft bmp)	(ft mal)	(ft bmp)	(ft mal)	(ft bmp)	(ft mal)	(ft bmp)	(ft mal)	(ft bmp)	(ft mal)
<u>Deep Wells (continued)</u>											
<u>Geraghty & Miller, Inc. Sitewide</u>											
MW-1D	195.14	31.48	163.66	44.75	150.39	29.78	165.36	—	—	42.48	152.66
MW-4D	176.02	12.32	163.70	8.78	167.24	12.15	163.87	12.08	163.94	13.04	162.98
MW-6D	171.01	8.02	162.99	5.32	165.69	7.95	163.06	7.91	163.10	—	—
MW-10D	161.38	20.96	140.42	17.26	144.12	17.76	143.62	18.09	143.29	—	—
MW-11D	153.22	20.40	132.82	15.43	137.79	15.66	137.56	16.60	136.62	—	—
MW-12D	161.81	28.94	132.87	23.69	138.12	23.85	137.96	24.82	136.99	—	—
MW-13D	236.60	97.32	139.28	90.86	145.74	62.80	173.80	62.84	173.76	89.30	147.30
MW-20D	174.71	—	—	—	—	—	—	60.94	113.77	—	—
MW-21D	123.48	—	—	—	—	31.07	92.41	34.86	88.62	—	—
 <u>Texaco Tutu Service Station</u>											
TT-1D	179.45	—	—	—	—	15.79	163.66	15.72	163.73	—	—
TT-3D	181.75	—	—	—	—	17.02	164.73	16.94	164.81	—	—
 <u>Supply Wells</u>											
Church	• 182.5	—	—	—	—	42.16	140.34 (2)	—	—	—	—
Eglin II	151.98	—	—	—	—	18.26	133.72	—	—	—	—
Eglin III	155.17	—	—	—	—	25.56	129.61	—	—	—	—
Harvey	• 143.5	—	—	—	—	25.78	117.72 (2)	—	—	—	—
Steele	• 180	—	—	—	—	66.80	113.20 (2)	—	—	—	—

ft mal Feet above mean sea level.
ft bmp Feet below measuring point.
— Not measured.

All data were collected by Geraghty & Miller, Inc.

* Measuring point elevation is approximate.

(1) Data collected on May 13, 1994.

(2) Data collected on May 11, 1994.

(3) Data collected on June 22, 1994.

Wells with the prefix "SW-" or "DW-" were installed by Blasland, Bouck & Lee, Inc.

Wells with the prefix "CHT-" were installed by Carribean Hydro-Tech, Inc.

Wells with the prefix "MW-" were installed by Geraghty & Miller, Inc.

Wells with the prefix "OHMW-" were installed by Geo Caribe, Inc.

Wells with the prefix "TT-" were installed by GCL.

Wells with the prefix "KFMW-" were installed by Terra Vac, Inc.



Table 4-6. Comparison of Groundwater Elevations for Monitoring Well Clusters, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well ID	Date of Development	<u>Measurement Dates and Groundwater Elevations (feet above mean sea level)</u>								
		9/10/92	9/17/92	9/28/92	10/28/92	11/9/92	11/16/92	3/23/94	5/10/94	5/13/94
MW-1	8/29/92	165.00	165.20	167.48	167.98	169.97	170.19	165.46	+	191.59
MW-1D	8/28/92	163.66	164.14	165.16	144.24	+	150.39	165.38	+	165.36
MW-4	8/24/92	164.02	164.04	164.82	166.86	167.30	167.57	164.64	164.20	164.18
MW-4D	8/24/92	163.70	163.70	164.58	166.52	166.52	167.24	164.30	163.87	163.86
MW-6R	9/9/92	162.95	162.97	163.65	165.19	165.49	165.66	163.38	163.05	163.05
MW-6D	9/9/92	162.99	162.97	163.67	165.23	165.49	165.69	163.40	163.06	163.05
MW-8	8/31/92	+	+	+	+	+	+	154.15	153.84	+
DW-1		--	--	--	--	--	--	153.76	153.48	+
MW-10	9/2/92	140.84	140.80	140.98	143.89	144.08	144.78	143.63	143.92	144.26
MW-10D	9/2/92	140.32	140.32	140.40	143.54	144.50	144.12	143.40	143.62	143.85
MW-13	5/3/94	--	--	--	--	--	--	--	171.23	171.08
MW-13D	9/3/92	+	+	+	+	+	+	+	173.80	173.83
MW-20	5/17/94	--	--	--	--	--	--	--	+	+
MW-20D	5/17/94	--	--	--	--	--	--	--	+	+
SW-6	--	--	--	--	--	--	--	--	137.08	137.29
DW-2	--	--	--	--	--	--	--	--	136.74	136.83
TT-1	--	--	--	--	--	--	--	--	163.67	+
TT-1D	--	--	--	--	--	--	--	--	163.66	+

TUT 005 0641

Table 4-6. Comparison of Groundwater Elevations for Monitoring Well Clusters, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well ID	Date of Development	<u>Measurement Dates and Groundwater Elevations (feet above mean sea level)</u>								
		5/24/94	5/26/94	5/31/94	6/3/94	6/8/94	6/9/94	6/13/94	6/15/94	7/20/94 ¹
MW-1	8/29/92	164.80	+	+	+	164.08 *	+	+	+	163.52
MW-1D	8/28/92	+	+	+	+	165.50 *	+	+	+	152.66
MW-4	8/24/92	164.26	+	+	+	+	+	163.61 *	+	163.26
MW-4D	8/24/92	163.94	+	+	+	+	+	163.35 *	+	162.98
MW-6R	9/9/92	163.09	+	+	+	+	+	+	+	+
MW-6D	9/9/92	163.10	+	+	+	+	+	+	+	+
MW--8	8/31/92	158.90	+	+	153.70 *	+	+	+	+	+
DW-1		153.53	+	+	153.28 *	+	+	+	+	+
MW-10	9/2/92	143.85	+	143.64 *	+	+	+	+	+	+
MW-10D	9/2/92	143.29	+	143.10 *	+	+	+	+	+	+
MW-13	5/3/94	171.32	+	+	+	+	+	+	169.85 *	168.41
MW-13D	9/3/92	173.76	+	+	+	+	+	+	173.46 *	147.30
MW-20	5/17/94	150.18	+	+	+	+	+	+	150.14 *	+
MW-20D	5/17/94	113.77 ²	+	+	+	+	+	+	131.36 *	+
SW-6	--	136.15	136.52*	+	+	+	+	+	+	+
DW-2	--	135.66	136.13*	+	+	+	+	+	+	+
TT-1	--	163.73	+	+	+	+	163.23	+	+	+
TT-1D	--	163.73	+	+	+	+	163.25	+	+	+

ID

Identification

--

Monitoring well not installed.

*

Groundwater elevations obtained during groundwater sampling.

+

Water-level measurement not taken.

¹

Water-level measurement taken 24 hours after of VIHA I was purged for groundwater sampling.

²

Water-level may still represent recovery from well development.

TUT 005 0642

Table 4-7. Vertical Gradients of Groundwater Flow, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well Pair	Vertical Distance Between Center Point of Screen/Open Interval (feet)	Minimum Groundwater Elevation Difference (feet)	Maximum Groundwater Elevation Difference (feet)	Vertical Gradient (feet/feet)		Vertical Gradient Direction
				Minimum	Maximum	
MW-1 MW-1D	43.2	-1.42	26.23	- 0.0329	0.6072	Predominantly downward
MW-4 MW-4D	40.1	0.24	0.78	0.0060	0.0195	Slightly downward
MW-6R MW-6D	39.4	-0.04	0	- 0.0010	0.0000	Essentially horizontal
MW-8 DW-1	53.0	0.36	5.37	0.0068	0.1013	Slightly downward
MW-10 MW-10D	38.5	-0.42	0.66	-0.0109	0.0171	Predominantly downward
MW-13 MW-13D	37.3	-2.75	21.11	-0.0737	0.5660	Moderately upward; affected by pumping of VIHA supply wells
MW-20 MW-20D	31.0	18.78	36.41	0.6058	1.2555	Strongly downward
SW-6 DW-2	50.0	0.34	0.52	0.0068	0.0104	Slightly downward
TT-1 TT-1D	25.3	-0.02	0.02	-0.0008	0.0008	Essentially horizontal

Negative values indicate an upward gradient.

Table 4-8. Calculated Transmissivity, Hydraulic Conductivity, and Storage Values for Bedrock Aquifer, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well	Pumping Well	Solution Method	Transmissivity (T) Values (ft ² /min)	Transmissivity Values (gpd/ft)	Assumed Aquifer Thickness (b) (feet)	Calculated Hydraulic Conductivity (K) (gpd/ft ²)	Storage Values (S) (Dimensionless)
MW-6R	MW-6R	Cooper-Jacob	8.39	90,500	300	302	NA
CHT-6D	MW-6D	Cooper-Jacob	8.14	87,500	300	292	0.0007
MW-6D	MW-6D	Cooper-Jacob	5.225	56,100	300	187	NA
Eglin II	Eglin III	Cooper-Jacob	0.2052	2,210	300	7.37	0.00007
Eglin II	Eglin III	Theis	0.2112	2,275	300	7.61	0.00007
Eglin II	Eglin III	Theis Recovery	0.177	1,906	300	6.37	NA

Aquifer test conducted by Geraghty & Miller, Inc.

ft²/min Square feet per minute.
gpd/ft Gallons per day per foot.
gpd/ft² Gallons per day per square feet.
NA Not applicable.

TUT 005 0644

Table 4-9. Supply Wells Known to be in Use During the Remedial Investigation, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well Identification	Estimated Daily Pumpage in Gallons Per Day	Type of Usage
Ramsay	500*	Car wash, etc. (non-potable use)
Four Winds II	500*	Splash & Dash Car Wash, etc. (non-potable use)
Eglin III	25,000*	Laundromat (non-potable use)
Harthman Mango Garden	800-900	Residential
Steele	400-450	Residential
La Place	400-450	Residential
Smith	400-450	Residential
Matthias	400-450	Residential
Delegarde	400-450	Residential

* Source: Geraghty & Miller, Inc. (1993b).

Wells are listed generally in order from upgradient (Ramsay) to downgradient (Delegarde).



Table 5-1. Concentrations of Volatile Organic Compounds in Soil Samples Collected in March and April 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID:	MW-13 (2.0-3.5')	MW-15 (4.0-6.0')	MW-16 (0-2.0')	MW-16 FR (0-2.0')	MW-17 (6.0-8.0')	MW-18 (12.0- 14.0')	MW-19 (4.0-6.0')	MW-24 (4.5-6.5')	MW-25 (12.0- 14.0')
	Date:	29-Mar-94	28-Mar-94	4-Apr-94	4-Apr-94	28-Mar-94	26-Mar-94	6-Apr-94	31-Mar-94	31-Mar-94
Chloromethane		11 U	12 U	11 UJ	11 UJ	11 U	12 UJ	11 UJ	11 U	12 U
Bromomethane		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
Vinyl chloride		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
Chloroethane		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
Methylene chloride		11 U	12 U	11 U	1 J	11 U	12 UJ	11 U	2 J	3 J
Acetone		11 UJ	4 J	11 UJ	11 UJ	3 J	50 BJ	21 UJ	5 J	33 J
Carbon disulfide		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
1,1-Dichloroethene		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
1,1-Dichloroethane		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
1,2-Dichloroethene (cis/trans)		11 U	12 U	11 U	11 U	2 J	12 UJ	11 U	11 U	12 U
Chloroform		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
1,2-Dichloroethane		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
2-Butanone		11 U	12 U	11 UJ	11 UJ	11 U	13 BJ	11 UJ	11 U	12 U
1,1,1-Trichloroethane		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
Carbon tetrachloride		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
Bromodichloromethane		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
1,2-Dichloropropane		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
cis-1,3-Dichloropropene		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
Trichloroethene		11 U	12 U	1 J	11 U	11 U	12 UJ	11 U	11 U	12 U
Dibromochloromethane		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
1,1,2-Trichloroethane		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
Benzene		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
trans-1,3-Dichloropropene		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
Bromoform		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
4-Methyl-2-pentanone		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
2-Hexanone		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
1,1,2,2-Tetrachloroethane		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
Tetrachloroethene		11 U	12 U	72 J	35 J	1 J	12 UJ	11 U	11 U	12 U
Toluene		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
Chlorobenzene		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
Ethylbenzene		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
Styrene		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
Xylenes (total)		11 U	12 U	11 U	11 U	11 U	12 UJ	11 U	11 U	12 U
tert-Butyl Methyl ether		55 U	20 J	55 U	55 U	55 U	60 UJ	56 U	55 U	60 U
n-Propylbenzene		R	R	R	R	R	R	R	R	R
Dibromomethane		R	R	R	R	R	R	R	R	R

Analyte concentrations in micrograms per kilogram (parts per billion [ppb]).

Analyses were performed by Ensco-East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

Table 5-2. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Soil Samples Collected in March and April 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID:	MW-13 (2.0-3.5')	MW-15 (4.0-6.0')	MW-16 (0-3.0')	MW-16 FR (0-3.0')	MW-17 (6.0-8.0')	MW-18 (12.0-14.0')	MW-19 (4.0-8.0')	MW-24 (6.5-8.5')	MW-25 (12.0-14.0')
	Date:	29-Mar-94	28-Mar-94	4-Apr-94	4-Apr-94	28-Mar-94	26-Mar-94	6-Apr-94	31-Mar-94	31-Mar-94
Acenaphthene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Acenaphthylene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Anthracene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Carbazole		370 U	410 U	360 UJ	340 U	370 U	750 U	360 UJ	360 U	390 U
Benzo(a)anthracene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Benzo(a)pyrene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Benzo(b)fluoranthene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Benzo(g,h,i)perylene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Benzo(k)fluoranthene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
4-Bromophenyl phenyl ether		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Butyl benzyl phthalate		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
4-Chloroaniline		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
bis(2-Chloroethoxy)methane		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
bis(2-Chloroethyl)ether		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
bis(2-Chloroisopropyl)ether		370 U	410 U	360 U	340 U	NA	750 U	360 U	360 U	390 U
4-Chloro-3-methylphenol		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
2-Chloronaphthalene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
2-Chlorophenol		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
4-Chlorophenyl phenyl ether		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Chrysene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Di-n-butyl phthalate		370 U	410 U	52 J	340 U	370 U	750 U	360 U	360 U	390 U
Dibenz(a,h)anthracene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Dibenzofuran		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
1,2-Dichlorobenzene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
1,3-Dichlorobenzene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
1,4-Dichlorobenzene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
3,3'-Dichlorobenzidine		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
2,4-Dichlorophenol		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Diethyl phthalate		370 U	410 U	360 UJ	340 U	370 U	750 U	360 UJ	360 U	390 U
2,4-Dimethylphenol		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Dimethyl phthalate		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
4,6-Dinitro-2-methylphenol		890 U	980 UJ	880 U	810 UJ	900 U	1800 U	880 U	880 U	930 U
2,4-Dinitrophenol		890 UJ	R	880 UJ	810 UJ	900 UJ	1800 UJ	880 UJ	880 UJ	930 UJ
2,4-Dinitrotoluene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
2,6-Dinitrotoluene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Di-n-octyl phthalate		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
bis(2-Ethylhexyl)phthalate		210 J	410 U	360 U	340 U	370 J	130 J	360 U	240 J	140 J
Fluoranthene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U

Analyte concentrations in micrograms per kilogram (parts per billion [ppb]).

Analyses were performed by Ensco-East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

NA Not analyzed

Table 5-2. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Soil Samples Collected in March and April 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID: MW-13 (2.0-3.5')	MW-15 (4.0-6.0')	MW-16 (0-3.0')	MW-16 FR (0-3.0')	MW-17 (6.0-8.0')	MW-18 (12.0-14.0')	MW-19 (4.0-8.0')	MW-24 (6.5-8.5')	MW-25 (12.0-14.0')	
Analyte	Date:	29-Mar-94	28-Mar-94	4-Apr-94	4-Apr-94	28-Mar-94	26-Mar-94	6-Apr-94	31-Mar-94	31-Mar-94
Fluorene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Hexachlorobenzene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Hexachlorobutadiene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Hexachlorocyclopentadiene		370 U	410 UJ	360 UJ	340 U	370 U	750 U	360 UJ	360 U	390 U
Hexachloroethane		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Indeno(1,2,3-cd)pyrene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Isophorone		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
2-Methylnaphthalene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
2-Methylphenol		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
4-Methylphenol		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Naphthalene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
2-Nitroaniline		890 U	980 U	880 U	810 U	900 U	1800 U	880 U	880 U	930 U
3-Nitroaniline		890 U	980 UJ	880 UJ	810 UJ	900 U	1800 U	880 UJ	880 U	930 U
4-Nitroaniline		890 U	980 U	880 UJ	810 U	900 U	1800 U	880 UJ	880 U	930 U
Nitrobenzene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
2-Nitrophenol		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
4-Nitrophenol		890 U	980 U	880 UJ	810 UJ	900 U	1800 U	880 UJ	880 U	930 U
N-Nitrosodiphenylamine		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
N-Nitroso-di-n-propylamine		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Pentachlorophenol		890 U	980 UJ	880 UJ	810 U	900 U	1800 U	880 UJ	880 U	930 U
Phenanthrene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Phenol		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
Pyrene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
1,2,4-Trichlorobenzene		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
2,4,5-Trichlorophenol		890 U	980 U	880 U	810 U	900 U	1800 U	880 U	880 U	930 U
2,4,6-Trichlorophenol		370 U	410 U	360 U	340 U	370 U	750 U	360 U	360 U	390 U
2,2'-oxybis(1-Chloropropane)		NA	NA	NA	NA	370 U	NA	NA	NA	NA

Analyte concentrations in micrograms per kilogram (parts per billion [ppb]).

Analyses were performed by Enseco-East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

NA Not analyzed

Table 5-3. Concentrations of Metals in Soil Samples Collected in March and April 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID:	MW-13 (2.0-3.5')	MW-15 (4.0-6.0')	MW-16 (0-3.0')	MW-16 FR (0-3.0')	MW-18 (12.0-14.0')	MW-19 (4.0-8.0')	MW-24 (6.5-8.5')	MW-25 (12.0-14.0')
	Date:	29-Mar-94	28-Mar-94	4-Apr-94	4-Apr-94	26-Mar-94	6-Apr-94	31-Mar-94	31-Mar-94
Aluminum		23000	21100	25700	29000	22200	27300	14100	17000
Antimony		5.2 UJ	6 UJ	5 UJ	5.2 UJ	5.5 UJ	5.4 UJ	5.2 UJ	5.6 UJ
Arsenic		0.71 B	0.82 B	2.1	0.77 B	1.3 B	1.3 B	3	0.94 B
Barium		40.5 B	81.1	41.3 B	26.5 B	37.9 B	38.4 B	41.9 B	114
Beryllium		0.22 B	0.34	0.28 B	0.25 B	0.28 B	0.33 B	0.22 U	0.35 B
Cadmium		0.86 U	1.1 B	0.84 U	0.97 B	0.91 U	1 B	1 B	0.95 B
Calcium		67400	5730	22800	54400	10800	30400	1140	2340
Chromium		23.8 J	33.2 J	39.1 J	45.3 J	27.5 J	30.1 J	2.1 BJ	13.5 J
Cobalt		17.1	21.3	27.4 J	23.7 J	20.1	22 J	9.3 B	18.4
Copper		77.9	94.9	135	82.4	62.6	71.1	30.3	56.5
Iron		29100	38600	35300	36900	34300	39800	30700	39300
Lead		33.6	4.9	3.2	3	8.5	2.4	6.9	11.7
Magnesium		18700	11100	22000	25100	15600	21600	5920	6280
Manganese		705	622	927	818	472	743 *	1350	1250
Mercury		0.05 U	0.08 B	0.05 U	0.05 U	0.06 U	0.06 U	0.05 U	0.06 U
Nickel		27.3	18.4	21.5	21.9	17	16.2	2.6 U	8.3 B
Potassium		492 B	773 B	151 U	175 B	1440	1800	217 B	1130 B
Selenium		0.43 UJ	0.5 U	0.42 U	0.43 U	0.46 U	0.45 U	0.44 U	1.1 B
Silver		0.64 U	0.75 U	0.63 U	0.65 U	0.68 U	0.83 B	0.8 B	0.82 B
Sodium		393 U	1550	384 U	396 U	511 B	413 U	993 B	430 U
Thallium		0.43 U	0.5 U	0.42 U	0.43 U	0.46 U	0.45 U	0.44 U	0.47 U
Vanadium		84.5	112	120	109	130	126	37.9	89.6
Zinc		585	51.4	51.7	52.3	65.2	57.1	57.2	87.2

Analyte concentrations in milligrams per kilogram (parts per million [ppm]).

Analyses were performed by Ensco-East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

* Duplicate analysis not within control limits.

B Concentration is between the instrument detection limit (IDL) and the contract required detection limit (CRDL).

J Estimated result.

U The analyte was analyzed for, but not detected at the corresponding reporting limits.

Table 5-4. Concentrations of Total Cyanide in Soil Samples Collected in March and April 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID:	MW-13 (2.0-3.5')	MW-15 (4.0-6.0')	MW-16 (0-3.0')	MW-16 FR (0-3.0')	MW-17 (6.0-8.0')	MW-18 (12.0- 14.0')	MW-19 (4.0-8.0')	MW-24 (6.5-8.5')	MW-25 (12.0- 14.0')
	Date:	29-Mar-94	28-Mar-94	4-Apr-94	4-Apr-94	28-Mar-94	26-Mar-94	6-Apr-94	31-Mar-94	31-Mar-94
Cyanide, Total		0.58 U	0.79 U	0.52 U	0.54 U	0.53 U	0.57 U	0.56 U	0.54 U	0.59 U

Analyte concentrations in milligrams per kilogram (parts per million [ppm]).

Analyses were performed by Enseco-East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

TUT 005 0650

Table 5-5. Concentrations of Total Petroleum Hydrocarbons in Soil Samples Collected in March and April 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID:	MW-13 (2.0-3.5')	MW-15 (4.0-6.0')	MW-16 (0-3.0')	MW-16 FR (0-3.0')	MW-17 (6.0-8.0')	MW-18 (12.0- 14.0')	MW-19 (4.0-8.0')	MW-24 (6.5-8.5')	MW-25 (12.0- 14.0')
	Date:	29-Mar-94	28-Mar-94	4-Apr-94	4-Apr-94	28-Mar-94	26-Mar-94	6-Apr-94	31-Mar-94	31-Mar-94
Total Petroleum Hydrocarbons		230	25 U	37 J	53 J	21 U	23 U	23 U	22 U	23 U

Analyte concentrations in milligrams per kilogram (parts per million [ppm]).

Analyses were performed by Enseco-East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

TUT 005 0651

Table 5-6. Currently Available Soil Screening Levels, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Contaminant	New York State TAGM Levels Groundwater Quality Protection Objectives (a)	New Jersey Impact to Groundwater Soil Criteria (b)	RCRA Soil Guidance (c)	New Jersey Non-Residential Direct Contact Criteria (b)	New Jersey Residential Direct Contact Criteria (b)	USEPA Region III Residential Soil Ingestion (d)	USEPA Drinking Water MCL
<u>BTEX VOCs</u>							
Benzene	60	1,000	NA	13,000	3,000	22,000	5
Toluene	1,500	500,000	20,000,000	1,000,000	1,000,000	16,000,000	1,000
Ethylbenzene	5,500	100,000	8,000,000	1,000,000	1,000,000	7,800,000	700
Xylenes	1,200	10,000	200,000,000	1,000,000	410,000	160,000,000	10,000
<u>Non-BTEX VOCs</u>							
Tetrachloroethene	1,400	1,000	10,000	6,000	4,000	12,000	5
cis-1,2-Dichloroethene	NA	1,000	8,000*	1,000,000	79,000	780,000	70
trans-1,2-Dichloroethene	300	50,000	8,000*	1,000,000	1,000,000	1,600,000	100
Trichloroethene	700	1,000	60,000	54,000	23,000	58,000	5
1,1,1-Trichloroethane	800	50,000	700,000	100,000	210,000	7,000,000	200
Vinyl chloride	120	10,000	NA	7,000	2,000	340	2
<u>BNAs</u>							
Naphthalene	13,000	100,000	NA	4,200,000	230,000	3,100,000	NA
2,6-Dinitrotoluene	1,000	10,000*	1,000*	4,000*	1,000*	78,000	NA
2-Methylnaphthalene	36,400	NA	NA	NA	NA	3,100,000**	NA
4-Methyl phenol	900	NA	NA	10,000,000	2,800,000	390,000	NA
<u>Metals</u>							
Arsenic	NA	NA	80,000	20,000	20,000	23,000	50
Antimony	NA	NA	8,000	340,000	14,000	31,000	6
Beryllium	NA	NA	20	1,000	1,000	150	4
Chromium VI	NA	NA	400,000	NA	NA	390,000	100
Nickel	NA	NA	2,000,000	2,400,000	250,000	1,600,000	100

All soil values are in micrograms per kilogram (ug/kg), equivalent to parts per billion (ppb).

MCL values are in micrograms per liter (ug/L), equivalent to ppb.

* Not distinct by isomer.

** USEPA Region III standard for 2-Methylnaphthalene not provided; use value for naphthalene (substitute surrogate).

NA Not available.

TAGM Technical and Administrative Guidance Memorandum.

RCRA Resource Conservation and Recovery Act.

BTEX Benzene, toluene, ethylbenzene, xylenes.

VOCs Volatile organic compounds.

MCL Maximum contaminant level.

BNAs Base neutral/acid extractable compounds.

(a) New York State (NYS) Technical and Administrative Guidance Memorandum, NYS Department of Environmental Conservation, Division of Hazardous Waste Remediation, HWR-94-4046, January 24, 1994 (revised).

(b) New Jersey Department of Environmental Protection (NJDEP) soil clean-up values published in Guidance Document for the Remediation of Contaminated Soils, NJDEP, June 1994.

(c) USEPA RCRA soil guidance values published in Federal Register, Friday, July 27, 1990.

(d) USEPA Region III Memorandum on Risk-Based Concentration, fourth quarter, by: Roy L. Smith, Ph.D., Senior Toxicologist, November 8, 1994.



Table 5-7. Volatile Organic Compounds Present in Soil Samples Exceeding New York State Technical and Administrative Guidance Memorandum Soil Cleanup Levels to Protect Groundwater Quality, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Constituents:	Acetone	Benzene	2-Butanone	1,1-Dichloro-ethane	1,2-Dichloro-ethene(trans) ^a	Ethylbenzene	Methylene Chloride	Tetra-chloroethene	1,1,1-Tri-chloroethane	Toluene	Xylenes (total)
Revised TAGM Soil Cleanup Objectives (ppb):	110	60	300	200	300	5,500	100	1,400	800	1,500	1,200
Property Name											
Sample Identification (depth in parentheses)											
Virgin Islands Housing Authority (VIHA)											
No constituents exceed TAGM soil cleanup levels											
Curriculum Center (former Laga facility)											
B-6 (4.0 - 8.0')	370	---	---	---	---	---	---	---	---	---	---
SS-12 (0.0 - 0.5')	---	6,300 J	---	---	---	12,000 J	---	---	---	270,000	77,000
TWS-03 (0.0 - 0.3')	---	2,700	---	---	---	47,000	---	---	1,800	500,000	420,000
Ramsay Motors											
HB-2 (4.5')	500 B	---	---	---	---	---	---	---	---	---	---
HB-3 (3.0')	1,000 B	---	---	---	---	---	---	---	---	---	---
HB-4 (2.5')	1,500 BD	---	1,900 D	---	---	---	---	---	---	---	---
HB-5 (2.3')	800 BJ	---	1,000 J	---	---	---	---	---	---	---	---
HB-7 (1.25')	370 BD	---	---	---	---	---	---	---	---	---	---
Antilles Auto Parts											
No constituents exceed TAGM soil cleanup levels											
Texaco Tutu Service Station											
MW-4 (2.7 - 4.7')	190 B	---	---	---	---	---	---	---	---	---	---
TT-1D (4.5 - 5.0')	120	66/170 ^b	---	---	---	---	---	---	---	---	---
TT-1D (4.5 - 5.0') FR	---	69	---	---	---	---	---	---	---	---	---

See last page for footnotes.



Table 5-7. Volatile Organic Compounds Present in Soil Samples Exceeding New York State Technical and Administrative Guidance Memorandum Soil Cleanup Levels to Protect Groundwater Quality, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Constituents:	Acetone	Benzene	2-Butanone	1,1-Dichloro-ethane	1,2-Dichloro-ethene(trans) ^a	Ethylbenzene	Methylene Chloride	Tetra-chloroethene	1,1,1-Tri-chloroethane	Toluene	Xylenes (total)
Revised TAGM Soil Cleanup Objectives (ppb):	110	60	300	200	300	5,500	100	1,400	800	1,500	1,200
Property Name											
Sample Identification (depth in parentheses)											
Texaco Tutu Service Station (continued)											
SB-6 (3.8')	180	---	---	---	---	---	---	---	---	---	---
Tillett Gardens											
No constituents exceed TAGM soil cleanup levels											
Four Winds Plaza											
MW-2 (0.0 - 2.0') FR	130 J	---	---	---	---	---	---	---	---	---	---
Western Auto											
SS-1 (2.0')	---	140	---	---	---	---	---	---	---	3,900	34,000
SS-6 (5.0 - 6.0')	---	---	---	---	---	---	---	---	---	---	2,700
T1-3 (4.0')	190	---	---	---	---	---	---	---	---	---	---
T2-AS (0.0 - 0.5')	810 J	---	1,800	---	---	---	---	---	---	---	5,800
T2-ASRE (0.0 - 0.5')	---	---	2,700	---	---	---	---	---	---	---	6,100
T2-1S (6.7')	120	---	---	---	---	---	---	---	---	---	---
T2-3S (6.7')	---	---	3,400	---	---	---	---	---	---	---	7,000
T2-4S (1.0 - 1.5')	230	---	---	---	---	---	---	---	---	---	---
Esso Tutu Service Station											
B-101 (10.0 - 12.0')	---	---	---	---	---	---	---	---	---	---	2,293
B-102 (10.0 - 12.0')	---	625	---	---	---	---	---	---	---	---	---

See last page for footnotes.



Table 5-7. Volatile Organic Compounds Present in Soil Samples Exceeding New York State Technical and Administrative Guidance Memorandum Soil Cleanup Levels to Protect Groundwater Quality, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Constituents:	Acetone	Benzene	2-Butanone	1,1-Dichloro-ethane	1,2-Dichloro-ethene(trans) ^a	Ethylbenzene	Methylene Chloride	Tetra-chloroethene	1,1,1-Tri-chloroethane	Toluene	Xylenes (total)
Revised TAGM Soil Cleanup Objectives (ppb):	110	60	300	200	300	5,500	100	1,400	800	1,500	1,200
Property Name											
Sample Identification (depth in parentheses)											
Esso Tutu Service Station (continued)											
SS-1 (9.0')	---	---	---	560	3,200	12,000	---	---	---	46,000	80,400
SS-3 (3.0')	---	880	---	---	---	11,000	---	---	---	53,000	77,400
SS-4 (3.0')	---	---	---	---	---	---	---	---	---	4,600	24,200
SS-5 (3.0')	---	---	---	---	---	---	---	---	---	6,500	29,000
SS-7 (5.0')	---	160	---	---	---	---	---	---	---	33,000	58,000
SS-8 (7.0')	---	270	---	---	---	11,000	---	1,500	---	51,000	78,000
SW-3 (0.0 - 2.0')	---	66	---	---	---	---	---	---	---	---	---
TP-2 (North Floor)	---	---	---	---	---	---	---	---	---	---	1,600 E
TP-3 (Northeast Floor)	---	230 J	400 BJ	---	---	---	---	---	---	5,200	31,000 E
TP-5 (Center Floor)	---	1,100	3,600 B	---	---	7,000	---	---	---	---	---
TP-6 (East Floor)	---	---	19,000 BJ	---	---	55,000	---	---	---	180,000	540,000
TP-8 (South)	---	93	---	---	---	---	---	---	---	---	---
O'Henry Dry Cleaners											
OHSS-1 (2.0')	310	---	---	---	---	---	---	5,400 D	---	---	---
OHSS-1 (5.0')	360 J	---	440 BJ	---	---	---	450 BJ	59,000 D	---	---	---
OHSS-1 FR (5.0')	---	---	---	---	---	---	3,000 BJ	22,000	---	---	4,700 BJ
OHSS-1 (8.0')	1,300	---	320 BJ	---	---	---	290 BJ	---	---	---	---
OHSS-1 (20.0')	---	---	---	---	---	---	1,300 B	---	---	---	---
e-01 (0.0')	---	---	---	---	---	---	---	440,000*	---	---	---
e02-02 (1.5 - 2.5')	---	---	---	---	---	---	---	180,000	---	---	---

See last page for footnotes.



Table 5-7. Volatile Organic Compounds Present in Soil Samples Exceeding New York State Technical and Administrative Guidance Memorandum Soil Cleanup Levels to Protect Groundwater Quality, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Constituents:	Acetone	Benzene	2-Butanone	1,1-Dichloroethane	1,2-Dichloroethene(trans) ^a	Ethylbenzene	Methylene Chloride	Tetra-chloroethene	1,1,1-Tri-chloroethane	Toluene	Xylenes (total)
Revised TAGM Soil Cleanup Objectives (ppb):	110	60	300	200	300	5,500	100	1,400	800	1,500	1,200

Property Name

Sample Identification (depth in parentheses)

Fire Station

No constituents exceed TAGM soil cleanup levels

Vitelco

No constituents exceed TAGM soil cleanup levels

God of Holiness Church

No constituents exceed TAGM soil cleanup levels

Lutheran Church

No constituents exceed TAGM soil cleanup levels

Assembly of God Church

No constituents exceed TAGM soil cleanup levels

TAGM Technical and Administrative Guidance Memorandum published January 1994 by the New York State Department of Environmental Conservation.

ppb Parts per billion, equivalent to micrograms per kilogram (ug/kg).

- Constituent is either not detected in associated sample or concentration is below TAGM impact-to-groundwater standard.

a Samples listed as exceeding TAGM standards for trans-1,2-dichloroethene were actually analyzed for combined cis- and trans- isomers.

b Split sample collected by Blasland, Bouck, and Lee, Inc..

* Reported by the U.S. Environmental Protection Agency as tetrachloroethane; this is believed to be a typographical error.

B Analyte also detected in blank sample.

D Analyte identified at a secondary dilution.

J Result was detected below reporting limit and/or is an estimated concentration.

FR Field replicate.

TUT 005 0656



Table 5-8. Base/Neutral and Acid Extractable Compounds Present in Soil Samples Exceeding New York State Technical and Administrative Guidance Memorandum Soil Cleanup Levels to Protect Groundwater Quality, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Constituents:	Benzo(a)anthracene	Benzo(b)fluoranthene	Chrysene	2,6-Dinitrotoluene	2-Methylnaphthalene	4-Methyl phenol	Naphthalene
Revised TAGM Soil Cleanup Objectives (ppb):	3,000	1,100	400	1,000	36,400	900	13,000
Property Name							
Sample Identification (depth in parentheses)							
Virgin Islands Housing Authority (VIHA)							
No constituents exceed TAGM soil cleanup levels							
Curriculum Center (former Laga facility)							
TWS-03 (0.0 - 0.3')	---	---	---	1,300 J	41,000	3,200 J	42,000 J
Ramsay Motors							
SB-3 (0.0')	---	---	790	---	---	---	---
Antilles Auto Parts							
No constituents exceed TAGM soil cleanup levels							
Texaco Tutu Service Station							
No constituents exceed TAGM soil cleanup levels							
Tillett Gardens							
No constituents exceed TAGM soil cleanup levels							
Four Winds Plaza							
No constituents exceed TAGM soil cleanup levels							

See last page for footnotes.



Table 5-8. Base/Neutral and Acid Extractable Compounds Present in Soil Samples Exceeding New York State Technical and Administrative Guidance Memorandum Soil Cleanup Levels to Protect Groundwater Quality, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Constituents:	Benzo(a)anthracene	Benzo(b)fluoranthene	Chrysene	2,6-Dinitrotoluene	2-Methylnaphthalene	4-Methyl phenol	Naphthalene
Revised TAGM Soil Cleanup Objectives (ppb):	3,000	1,100	400	1,000	36,400	900	13,000
Property Name							
Sample Identification (depth in parentheses)							
Western Auto							
SS-1 (2.0')	---	---	11,000	---	---	---	---
SS-2 (3.0')	---	---	1,800	---	---	---	---
SS-3 (3.0')	---	2,600	3,400	---	---	---	---
SS-4 (5.0 - 6.0')	---	2,400	3,200	---	---	---	---
SS-5 (5.0 - 6.0')	---	1,200	1,700	---	---	---	---
SS-6 (5.0 - 6.0')	---	4,900	5,400	---	---	---	---
SS-9 (5.0')	---	---	460	---	---	---	---
SS-11 (1.0')	---	5,700	18,000	---	---	---	---
T1-1 (4.0')	---	---	760 J	---	---	---	---
T1-2 (4.0')	---	---	1,400 J	---	---	---	---
T1-4 (4.0')	---	---	950 J	---	---	---	---
T2-1S (6.7')	---	1,500 J	4,100	---	---	---	---
T2-2S (6.7')	---	---	1,300	---	---	---	---
T2-3S (6.7')	---	2,700 J	5,700	---	---	---	---
T2-4S (1.0 - 1.5')	---	4,500 J	11,000	---	---	---	---
T2-AS (0.0 - 0.5')	---	3,600	9,900	---	---	---	14,000
T2-SN (1.0' - 1.5')	---	1,600 J	4,200	---	---	---	---
4-G (0.0 - 0.5')	---	1,600 J	4,200	---	---	---	---
Esso Tutu Service Station							
SS-3 (3.0')	5,800	6,100	5,100	---	---	---	29,000
SS-4 (3.0')	---	2,000	2,000	---	---	---	---
SS-5 (3.0')	4,300	3,800	3,600	---	---	---	22,000
SS-7 (5.0')	---	2,000	1,900	---	---	---	19,000
SS-8 (7.0')	---	2,500	2,400	---	---	---	23,000
TP-3 (Northeast)	---	---	---	---	45,000 E	---	32,000 J
TP-6 (East)	---	---	---	---	43,000 E	---	45,000 E

See last page for footnotes.



Table 5-8. Base/Neutral and Acid Extractable Compounds Present in Soil Samples Exceeding New York State Technical and Administrative Guidance Memorandum Soil Cleanup Levels to Protect Groundwater Quality, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Constituents:	Benzo(a)anthracene	Benzo(b)fluoranthene	Chrysene	2,6-Dinitrotoluene	2-Methylnaphthalene	4-Methyl phenol	Naphthalene
Revised TAGM Soil Cleanup Objectives (ppb):	3,000	1,100	400	1,000	36,400	900	13,000

Property Name

Sample Identification (depth in parentheses)

O'Henry Dry Cleaners

No constituents exceed TAGM soil cleanup levels

Fire Station

No constituents exceed TAGM soil cleanup levels

Vitelco

No constituents exceed TAGM soil cleanup levels

God of Holiness Church

No constituents exceed TAGM soil cleanup levels

Lutheran Church

No constituents exceed TAGM soil cleanup levels

Assembly of God Church

No constituents exceed TAGM soil cleanup levels

TAGM	Revised Technical and Administrative Guidance Memorandum published January 1994 by the New York State Department of Environmental Conservation.
--	Constituent is either not detected in associated sample or concentration is below TAGM impact-to-groundwater standard.
ppb	Parts per billion, equivalent to micrograms per kilogram (ug/kg).
E	Estimated concentration, exceeded calibration range of instrument.
J	Result was detected below reporting limit and/or is an estimated concentration.



Table 5-9. Comparison of Average Background Metal Concentrations with Maximum Background Concentrations, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Metal	Background Samples				Average Background Concentration	Twice Average Background Concentration	Maximum Background Concentration
	SS-1 (0.16' - 0.5')	SS-2 (0.16' - 0.5')	SS-8 (0.16' - 0.5')	B-7 (2.0' - 4.0')			
Aluminum	23600	16100	21500	28400	22400	44800	28400
Antimony	6.1	4.2	14.7	5.9	7.725	15.45	14.7
Arsenic	0.44	0.42	0.99	1	0.7125	1.425	1
Barium	41.9	30.1	29.3	36.9	34.55	69.1	41.9
Calcium	75100	9630	144000	51600	70082.5	140165	144000
Chromium	23.4	25.8	16.2	28.6	23.5	47	28.6
Cobalt	25.7	18	16.9	23.4	21	42	25.7
Copper	55.3	40.3	43.1	73.1	52.95	105.9	73.1
Cyanide, total	1.2	0.52	1.1	0.52	0.835	1.67	1.2
Iron	31300	22600	25400	35400	28675	57350	35400
Lead	2.1	1.7	2.5	19.8	6.525	13.05	19.8
Magnesium	20500	13200	21400	21500	19150	38300	21500
Manganese	763	535	888	828	753.5	1507	888
Nickel	18.9	15.5	12.9	17.8	16.275	32.55	18.9
Potassium	412	568	325	460	441.25	882.5	568
Silver	0.98	0.99	1.7U	0.83	0.7	1.4	0.99
Sodium	557	157	187	561	365.5	731	561
Vanadium	109	74.9	82.1	94.8	90.2	180.4	109
Zinc	50.6	40.1	43.8	62.4	49.225	98.45	62.4

All values in parts per million (ppm), equivalent to milligrams per kilogram.



Table 5-10. Concentrations of Volatile Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: CHT-3 Date:	CHT-6D 1-Jun-94	CHT-7D 2-Jun-94	Delegarde 26-May-94	Delegarde ** 27-Jul-94	DW-1 3-Jun-94	DW-2 27-May-94	Eglin I ** 19-May-94	Eglin III ** 18-May-94	Four Winds I ** 22-Jul-94	Four-Winds II ** 21-Jul-94	Four-Winds II FR ** 21-Jul-94	Gassett ** 17-May-94
tert-Butyl methyl ether	13000 DJ	76 J	28 J	0.5 U	7 J	16 J	19 J	3.6 J	23 J	32 J	9.4 J	9.5 J	NA
EDB (1,2-Dibromoethane)	100 UJ	10 UJ	10 UJ	NA	NA	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	NA
n-Propylbenzene	1100 J	10 UJ	10 UJ	NA	NA	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	NA
Chloromethane	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
Bromomethane	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
Vinyl chloride	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	1 J	1 J	0.5 U
Chloroethane	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
Methylene chloride	100 U	10 U	10 U	0.5 U	0.18 BJ	10 UJ	10 U	1 J	1 J	3.2 JB	1 J	2 J	0.5 U
Acetone	100 U	10 U	10 U	R	2 U	10 UJ	10 U	10 U	10 U	3.9 JB	10 U	10 U	2 U
Carbon disulfide	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
1,1-Dichloroethene	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
1,1-Dichloroethane	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
1,2-Dichloroethene (cis/trans)	100 U	42	91	7.4 J	8.5	92 J	43	2 J	31	64	60	59	0.5 U
Chloroform	100 U	1 J	2 J	0.5 U	0.16 J	3 J	1 J	10 U	10 U	1.4 J	1 J	1 J	0.5 U
1,2-Dichloroethane	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
2-Butanone	100 U	10 U	10 U	2 U	2 U	10 UJ	10 U	10 U	10 U	5.5 J	10 U	5 J	2 U
1,1,1-Trichloroethane	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
Carbon tetrachloride	100 U	10 U	10 U	R	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
Bromodichloromethane	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
1,2-Dichloropropane	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
trans-1,3-Dichloropropene	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
Trichloroethene	100 U	3 J	10	3.9 J	4.3	10 J	5 J	3 J	12	6.2 J	5 J	5 J	0.5 U
Dibromochloromethane	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
1,1,2-Trichloroethane	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
Benzene	1700	10 U	10 U	0.5 U	0.17 JB	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
cis-1,3-Dichloropropene	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
Bromoform	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
4-Methyl-2-pentanone	100 U	10 U	10 U	2 U	2 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	2 U
2-Hexanone	100 U	10 U	10 U	2 U	2 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	2 U
1,1,2,2-Tetrachloroethane	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
Tetrachloroethene	100 U	12	36	15 J	16	42 J	18	10	31	25	23	23	0.5 U
Toluene	180	10 U	10 U	0.5 U	0.15 JB	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
Chlorobenzene	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
Ethylbenzene	1800 D	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
Styrene	100 U	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U
Xylenes (total)	2000	10 U	10 U	0.5 U	0.5 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	0.5 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-10. Concentrations of Volatile Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID:	Harthman Race Track	Harvey **	KFC-1	La Place **	Mathias **	MW-1	MW-1D	MW-2	MW-3	MW-4	MW-4D	MW-5	MW-6D
Analyte	Date:	17-May-94	27-Jul-94	22-Jun-94	19-May-94	25-May-94	8-Jun-94	8-Jun-94	17-Jun-94	14-Jun-94	13-Jun-94	13-Jun-94	22-Jun-94	7-Jun-94
tert-Butyl methyl ether	NA		2.6 J	230 DJ	83	50 U	50 UJ	200 UJ	50 UJ	5 J	21 J	1.9 J	50 UJ	170 J
EDB (1,2-Dibromoethane)	NA		10 U	10 UJ	10 U	10 U	10 UJ	40 UJ	10 UJ	40 UJ	10 UJ	10 UJ	10 UJ	10 UJ
n-Propylbenzene	NA		10 U	8 J	10 U	10 U	10 UJ	40 UJ	10 UJ	40 UJ	10 UJ	10 UJ	150 J	10 UJ
Chloromethane	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
Bromomethane	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
Vinyl chloride	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	48	10 UJ	10 UJ	10 UJ	10 U
Chloroethane	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
Methylene chloride	0.5 U		3 BJ	10 UJ	1 J	1 J	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
Acetone	2 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	14 J	10 UJ	10 UJ	10 UJ	10 U
Carbon disulfide	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
1,1-Dichloroethene	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
1,1-Dichloroethane	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
1,2-Dichloroethene (cis/trans)	0.5 U		21	10 UJ	95	15	950 D	500	9 UJ	440 D	76 J	64 J	19 J	100
Chloroform	0.5 U		10 U	10 UJ	4 J	10 U	5 J	10 J	2 UJ	25 U	1 J	2 J	10 UJ	4 J
1,2-Dichloroethane	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
2-Butanone	2 U		6 J	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
1,1,1-Trichloroethane	0.5 U		3 J	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
Carbon tetrachloride	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
Bromodichloromethane	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
1,2-Dichloropropane	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
trans-1,3-Dichloropropene	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
Trichloroethene	0.5 U		13	10 UJ	15	6 J	78	71	1 UJ	17 J	6 J	4 J	10 UJ	11
Dibromochloromethane	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
1,1,2-Trichloroethane	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
Benzene	0.5 U		10 U	110 J	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	460 DJ	10 U
cis-1,3-Dichloropropene	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
Bromoform	R		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
4-Methyl-2-pentanone	2 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
2-Hexanone	2 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
1,1,2,2-Tetrachloroethane	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
Tetrachloroethene	0.15 J		100	10 UJ	58	30	330 D	360	8 UJ	56	20 J	17 J	4 J	31
Toluene	0.5 U		10 U	2 J	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	20 J	10 U
Chlorobenzene	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
Ethylbenzene	0.5 U		10 U	31 J	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	760 DJ	10 U
Styrene	0.5 U		10 U	10 UJ	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	10 UJ	10 U
Xylenes (total)	0.5 U		10 U	5 J	10 U	10 U	10 U	40 U	10 UJ	25 U	10 UJ	10 UJ	370 DJ	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Ensco-East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-10. Concentrations of Volatile Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Date:	Sample ID: MW-6R	MW-7	MW-8	MW-9S	MW-10	MW-10D	MW-11D	MW-11D FR	MW-12D	MW-13	MW-13D	MW-15	MW-16
		6-Jun-94	6-Jun-94	3-Jun-94	31-May-94	31-May-94	31-May-94	27-May-94	27-May-94	20-May-94	15-Jun-94	15-Jun-94	7-Jun-94	10-Jun-94
tert-Butyl methyl ether		50 UJ	420 DJ	17 J	240 J	340 J	170 J	50 UJ	50 UJ	360 DJ	50 UJ	50 UJ	50 UJ	1000 UJ
EDB (1,2-Dibromoethane)		10 UJ	10 UJ	10 UJ	20 UJ	25 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	200 UJ
n-Propylbenzene		10 UJ	10 UJ	10 UJ	4.2 J	25 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	200 UJ
Chloromethane		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
Bromomethane		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
Vinyl chloride		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	260 D	1300
Chloroethane		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
Methylene chloride		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 UJ	200 U
Acetone		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	57 J	10 U	200 U
Carbon disulfide		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
1,1-Dichloroethene		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
1,1-Dichloroethane		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
1,2-Dichloroethene (cis/trans)		22	180	88 J	6 J	76 J	110 J	2 J	2 J	67 J	10 UJ	10 UJ	1500 D	2100
Chloroform		1 J	8 J	3 J	20 UJ	25 UJ	4 J	5 J	5 J	2 J	10 UJ	10 UJ	2 J	200 U
1,2-Dichloroethane		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
2-Butanone		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 J	10 U	200 U
1,1,1-Trichloroethane		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
Carbon tetrachloride		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
Bromodichloromethane		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
1,2-Dichloropropane		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
trans-1,3-Dichloropropene		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
Trichloroethene		2 J	27	10 J	20 UJ	18 J	14 J	10 U	10 U	9 J	10 UJ	2 J	23	72 J
Dibromochloromethane		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
1,1,2-Trichloroethane		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
Benzene		10 U	21	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
cis-1,3-Dichloropropene		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
Bromoform		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	4 J	5 J	10 UJ	10 UJ	10 UJ	10 U	200 U
4-Methyl-2-pentanone		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
2-Hexanone		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
1,1,2,2-Tetrachloroethane		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
Tetrachloroethene		10	130	38 J	20 UJ	34 J	48 J	1 J	1 J	33 J	4 J	28 J	120	71 J
Toluene		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
Chlorobenzene		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
Ethylbenzene		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
Styrene		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U
Xylenes (total)		10 U	10 U	10 UJ	20 UJ	25 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	200 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-10. Concentrations of Volatile Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Page 4 of 9

Analyte	Date:	7-Jun-94	29-Jun-94	20-Jun-94	15-Jun-94	15-Jun-94	14-Jun-94	21-Jun-94	3-Jun-94	2-Jun-94	24-May-94	24-May-94	24-May-94	24-May-94
Sample ID:		MW-17	MW-18R	MW-19	MW-20	MW-20D	MW-21D	MW-22D	MW-24	MW-25	OHMW-1	OHMW-2	OHMW-3	OHMW-4
tert-Butyl methyl ether		50 UJ	6 J	30 J	50 UJ	50 UJ	R	50 UJ	50 UJ	50 U	4.8 J	1.3 J	50 UJ	50 UJ
EDB (1,2-Dibromoethane)		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ
n-Propylbenzene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ
Chloromethane		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Bromomethane		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Vinyl chloride		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Chloroethane		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Methylene chloride		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Acetone		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	9 J	10 UJ	10 U	10 U	10 U	10 U	10 U
Carbon disulfide		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethane		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethene (cis/trans)		53	13 J	13 J	10 UJ	35 J	11 J	4 J	10 UJ	27	12	9 J	8 J	23
Chloroform		1 J	10 UJ	10 UJ	10 UJ	7 J	R	10 UJ	10 UJ	1 J	10 U	10 U	10 U	10 U
1,2-Dichloroethane		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
2-Butanone		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	6 J	10 UJ	10 U	10 U	10 U	10 U	10 U
1,1,1-Trichloroethane		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	2 J
Carbon tetrachloride		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Bromodichloromethane		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
1,2-Dichloropropane		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
trans-1,3-Dichloropropene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Trichloroethene		9 J	3 J	2 J	10 UJ	5 J	14 J	2 J	10 UJ	2 J	4 J	5 J	3 J	16
Dibromochloromethane		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloroethane		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Benzene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
cis-1,3-Dichloropropene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Bromoform		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
4-Methyl-2-pentanone		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
2-Hexanone		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
1,1,2,2-Tetrachloroethane		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Tetrachloroethene		37	10 UJ	2 J	10 UJ	22 J	45 J	4 J	1 J	11	10	26	6 J	140
Toluene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Chlorobenzene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Ethylbenzene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Styrene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Xylenes (total)		10 U	10 UJ	10 UJ	10 UJ	10 UJ	R	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-10. Concentrations of Volatile Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID:	Ramsay	Smith	Steele **	SW-2	SW-3	SW-4	SW-5	SW-6	SW-7	SW-7 FR	Tillett	TT-1	TT-1D
Analyte	Date:	26-May-94	20-May-94	18-May-94	21-Jun-94	23-Jun-94	16-Jun-94	25-May-94	26-May-94	23-Jun-94	23-Jun-94	25-May-94	9-Jun-94	9-Jun-94
tert-Butyl methyl ether		3.7 J	12 J	4.8 J	35000 DJ	89000 DJ	6.3 J	50 UJ	50 UJ	1500 J	1500 J	250 DJ	28000 DJ	1900 DJ
EDB (1,2-Dibromoethane)		10 UJ	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 UJ	10 UJ	100 UJ	200 UJ	10 UJ	100 UJ	10 UJ
n-Propylbenzene		10 UJ	10 UJ	10 U	1000 UJ	3800 J	10 UJ	10 UJ	10 UJ	100 UJ	200 UJ	10 UJ	450 J	14 J
Chloromethane		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
Bromomethane		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
Vinyl chloride		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
Chloroethane		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
Methylene chloride		10 U	10 UJ	1 J	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
Acetone		10 U	10 UJ	10 U	1000 UJ	2700 J	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
Carbon disulfide		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	3 J	10 U	100 UJ	200 UJ	10 U	100 U	10 U
1,1-Dichloroethene		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
1,1-Dichloroethane		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
1,2-Dichloroethene (cis/trans)		10 U	39 J	100	1000 UJ	1000 UJ	38 J	4 J	10 U	100 UJ	200 UJ	360 D	12 J	10
Chloroform		1 J	10 UJ	10 U	1000 UJ	150 J	1 J	10 U	10 U	100 UJ	200 UJ	7 J	100 U	10 U
1,2-Dichloroethane		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	290	10 U
2-Butanone		10 U	10 UJ	10 U	620 J	420 J	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
1,1,1-Trichloroethane		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
Carbon tetrachloride		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
Bromodichloromethane		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
1,2-Dichloropropane		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
trans-1,3-Dichloropropene		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
Trichloroethene		10 U	19 J	33	1000 UJ	1000 UJ	4 J	2 J	10 U	100 UJ	200 UJ	45	100 U	10 U
Dibromochloromethane		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
1,1,2-Trichloroethane		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
Benzene		10 U	10 UJ	10 U	550 J	10000 J	10 UJ	10 U	10 U	99 J	110 J	10 U	21000 D	1700 D
cis-1,3-Dichloropropene		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
Bromoform		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
4-Methyl-2-pentanone		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
2-Hexanone		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
1,1,2,2-Tetrachloroethane		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
Tetrachloroethene		11	110 J	40	1000 UJ	1000 UJ	15 J	4 J	10 U	100 UJ	200 UJ	180	100 U	10 U
Toluene		10 U	10 UJ	10 U	360 J	3200 J	10 UJ	10 U	10 U	100 UJ	200 UJ	2 J	16000 D	48
Chlorobenzene		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
Ethylbenzene		10 U	10 UJ	10 U	1000 UJ	4100 J	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	3700 D	63
Styrene		10 U	10 UJ	10 U	1000 UJ	1000 UJ	10 UJ	10 U	10 U	100 UJ	200 UJ	10 U	100 U	10 U
Xylenes (total)		10 U	10 UJ	10 U	1800 J	22000 J	10 UJ	10 U	10 U	82 J	78 J	2 J	18000 D	62

Analyte concentrations in micrograms per liter (parts per billion (ppb)).

Analyses were performed by Enseco- East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-10. Concentrations of Volatile Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: TT-2 Date:	TT-2 FR 9-Jun-94	TT-3D 14-Jun-94	TT-4 10-Jun-94	TT-5 9-Jun-94	VIHA I ** 19-Jul-94	WTS-1 (Port 3) 18-May-94	WTS-2 (Port 3) ** 16-Jun-94	WTS-3 (Port 3) 29-Jun-94	WTS-4 (PORT 3) 28-Jul-94	Field Blank 17-May-94	Field Blank 6-Jun-94	Field Blank 16-Jun-94
tert-Butyl methyl ether	120 UJ	120 UJ	100 UJ	56000 J	50 UJ	NA	NA	NA	50 UJ	NA	NA	50 UJ	50 UJ
EDB (1,2-Dibromoethane)	25 UJ	25 UJ	20 UJ	5000 UJ	10 UJ	NA	NA	NA	10 UJ	NA	NA	10 UJ	10 UJ
n-Propylbenzene	25 UJ	25 UJ	20 UJ	5000 UJ	7.9 J	NA	NA	NA	10 UJ	NA	NA	10 UJ	10 UJ
Chloromethane	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Bromomethane	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Vinyl chloride	25 U	25 U	9 J	5000 U	42	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Chloroethane	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Methylene chloride	25 U	25 U	20 U	5000 U	10 UJ	0.19 JB	0.5 U	1.2 B	10 UJ	0.22 JB	0.44 J	10 U	2 JB
Acetone	25 U	25 U	20 U	5000 U	41 U	2 U	2.8 U	2 U	10 UJ	2 U	R	10 U	10 UJ
Carbon disulfide	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	3.9 J	10 U	10 UJ
1,1-Dichloroethene	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
1,1-Dichloroethane	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
1,2-Dichloroethene (cis/trans)	330	330	280	5000 U	180	0.15 J	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Chloroform	2 J	3 J	3 J	5000 U	1 J	7.4	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
1,2-Dichloroethane	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
2-Butanone	25 U	25 U	20 U	5000 U	10 U	2 U	2 U	2 U	10 UJ	2 U	R	10 U	10 UJ
1,1,1-Trichloroethane	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Carbon tetrachloride	25 U	25 U	20 U	5000 U	10 U	0.5 U	R	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Bromodichloromethane	25 U	25 U	20 U	5000 U	10 U	0.36 J	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
1,2-Dichloropropane	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
trans-1,3-Dichloropropene	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Trichloroethene	20 J	20 J	15 J	5000 U	32	0.1 J	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Dibromochloromethane	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
1,1,2-Trichloroethane	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Benzene	25 U	25 U	20 U	21000	1 J	0.16 JB	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
cis-1,3-Dichloropropene	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Bromoform	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
4-Methyl-2-pentanone	25 U	25 U	20 U	5000 U	10 U	2 U	2 U	2 U	10 UJ	2 U	R	10 U	10 UJ
2-Hexanone	25 U	25 U	20 U	5000 U	10 U	2 U	2 U	2 U	10 UJ	2 U	R	10 U	10 UJ
1,1,2,2-Tetrachloroethane	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Tetrachloroethene	90	91	23	5000 U	3 J	1.9	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Toluene	25 U	25 U	20 U	17000	10 U	0.14 JB	0.5 U	0.06 J	10 UJ	0.12 JB	R	10 U	10 UJ
Chlorobenzene	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Ethylbenzene	25 U	25 U	20 U	3300 J	3 J	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Styrene	25 U	25 U	20 U	5000 U	10 U	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ
Xylenes (total)	25 U	25 U	20 U	17000	1 J	0.5 U	0.5 U	0.5 U	10 UJ	0.5 U	R	10 U	10 UJ

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-10. Concentrations of Volatile Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: Field Blank **	Trip Blank	Trip Blank 1	Trip Blank 2	Trip Blank **	Trip Blank	Trip Blank	Trip Blank 1	Trip Blank 2	Trip Blank	Trip Blank	Trip Blank	Trip Blank
Date:	27-Jul-94	17-May-94	18-May-94	18-May-94	19-May-94	20-May-94	24-May-94	26-May-94	26-May-94	27-May-94	31-May-94	1-Jun-94	2-Jun-94
tert-Butyl methyl ether	50 U	NA	NA	50 UJ	50 U	R	R	NA	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ
EDB (1,2-Dibromoethane)	10 U	NA	NA	10 UJ	10 U	R	R	NA	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
n-Propylbenzene	10 U	NA	NA	10 UJ	10 U	R	R	NA	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Chloromethane	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Bromomethane	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Vinyl chloride	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Chloroethane	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Methylene chloride	3 BJ	R	0.5 U	10 U	1 J	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Acetone	9 BJ	R	5.2 J	10 U	10 U	R	R	R	5 J	7 J	10 UJ	10 U	10 U
Carbon disulfide	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
1,1-Dichloroethene	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
1,1-Dichloroethane	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
1,2-Dichloroethene (cis/trans)	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Chloroform	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
1,2-Dichloroethane	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
2-Butanone	10 U	R	2 U	10 U	10 U	R	R	2 U	10 U	10 U	10 UJ	10 U	10 U
1,1,1-Trichloroethane	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Carbon tetrachloride	10 U	R	R	10 UJ	10 U	R	R	R	10 U	10 U	10 UJ	10 U	10 U
Bromodichloromethane	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
1,2-Dichloropropane	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
trans-1,3-Dichloropropene	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Trichloroethene	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Dibromochloromethane	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
1,1,2-Trichloroethane	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Benzene	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
cis-1,3-Dichloropropene	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Bromoform	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
4-Methyl-2-pentanone	10 U	R	2 U	10 U	10 U	R	R	2 U	10 U	10 U	10 UJ	10 U	10 U
2-Hexanone	10 U	R	2 U	10 U	10 U	R	R	2 U	10 U	10 U	10 UJ	10 U	10 U
1,1,2,2-Tetrachloroethane	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Tetrachloroethene	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Toluene	10 U	0.085 J	0.5 U	10 U	10 U	R	R	0.32 J	10 U	10 U	10 UJ	10 U	10 U
Chlorobenzene	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Ethylbenzene	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Styrene	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U
Xylenes (total)	10 U	R	0.5 U	10 U	10 U	R	R	0.5 U	10 U	10 U	10 UJ	10 U	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-10. Concentrations of Volatile Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Date:	Sample ID: Trip Blank	Trip Blank	Trip Blank	Trip Blank	Trip Blank	Trip Blank	Trip Blank	Trip Blank	Trip Blank	Trip Blank	Trip Blank	Trip Blank	Trip Blank
		3-Jun-94	6-Jun-94	7-Jun-94	9-Jun-94	10-Jun-94	13-Jun-94	14-Jun-94	15-Jun-94	16-Jun-94	17-Jun-94	20-Jun-94	21-Jun-94	22-Jun-94
tert-Butyl methyl ether		50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	50 UJ	NA
EDB (1,2-Dibromoethane)		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	NA
n-Propylbenzene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	NA
Chloromethane		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Bromomethane		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Vinyl chloride		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Chloroethane		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Methylene chloride		10 UJ	10 U	10 U	1 J	10 U	10 BJ	10 U	10 UJ	2 BJ	10 UJ	10 UJ	10 UJ	5 UJ
Acetone		10 UJ	10 U	10 U	10 U	10 U	15 J	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Carbon disulfide		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
1,1-Dichloroethene		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
1,1,1-Trichloroethane		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
1,2-Dichloroethene (cis/trans)		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
Chloroform		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	1 J	10 UJ	5 UJ
1,2-Dichloroethane		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
2-Butanone		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
1,1,1-Trichloroethane		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
Carbon tetrachloride		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
Bromodichloromethane		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
1,2-Dichloropropane		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
trans-1,3-Dichloropropene		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
Trichloroethene		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
Dibromochloromethane		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
1,1,2-Trichloroethane		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
Benzene		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
cis-1,3-Dichloropropene		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
Bromoform		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
4-Methyl-2-pentanone		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
2-Hexanone		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
1,1,2,2-Tetrachloroethane		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
Tetrachloroethene		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
Toluene		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
Chlorobenzene		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
Ethylbenzene		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
Styrene		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ
Xylenes (total)		10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	5 UJ

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-10. Concentrations of Volatile Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Date:	23-Jun-94	29-Jun-94	19-Jul-94	21-Jul-94	22-Jul-94	27-Jul-94	28-Jul-94
		Sample ID: Trip Blank	Trip Blank	Trip Blank **	Trip Blank **	Trip Blank **	Trip Blank **	Trip Blank **
tert-Butyl methyl ether		50 UJ	50 UJ	NA	50 U	50 U	50 U	NA
EDB (1,2-Dibromoethane)		10 UJ	10 UJ	NA	10 U	10 U	10 U	NA
n-Propylbenzene		10 UJ	10 UJ	NA	10 U	10 U	10 U	NA
Chloromethane		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Bromomethane		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Vinyl chloride		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Chloroethane		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Methylene chloride		1 J	10 UJ	0.5 U	2 J	3.1 JB	3 BJ	0.5 U
Acetone		10 UJ	10 UJ	4.8	7 J	7.4 JB	9 BJ	3.5 B
Carbon disulfide		10 UJ	10 UJ	0.51	10 U	1.3 J	10 U	0.5 U
1,1-Dichloroethene		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
1,1-Dichloroethane		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
1,2-Dichloroethene (cis/trans)		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Chloroform		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
1,2-Dichloroethane		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
2-Butanone		10 UJ	10 UJ	2 U	10 U	4.8 J	5 J	2 U
1,1,1-Trichloroethane		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Carbon tetrachloride		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Bromodichloromethane		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
1,2-Dichloropropane		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
trans-1,3-Dichloropropene		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Trichloroethene		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Dibromochloromethane		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
1,1,2-Trichloroethane		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Benzene		10 UJ	10 UJ	0.14 JB	10 U	10 U	10 U	0.5 U
cis-1,3-Dichloropropene		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Bromoform		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
4-Methyl-2-pentanone		10 UJ	10 UJ	2 U	10 U	10 U	10 U	2 U
2-Hexanone		10 UJ	10 UJ	2 U	10 U	10 U	10 U	2 U
1,1,2,2-Tetrachloroethane		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Tetrachloroethene		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Toluene		10 UJ	10 UJ	0.12 JB	10 U	10 U	10 U	0.14 JB
Chlorobenzene		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Ethylbenzene		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Styrene		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U
Xylenes (total)		10 UJ	10 UJ	0.5 U	10 U	10 U	10 U	0.5 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-11. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: CHT-3 Date:	CHT-6D 1-Jun-94	CHT-7D 2-Jun-94	Delegarde 26-May-94	DW-1 3-Jun-94	DW-2 27-May-94	Eglin I 19-May-94	Eglin III 18-May-94	Four Winds I ** 22-Jul-94	Four-Winds II ** 21-Jul-94	Four-Winds II FR ** 21-Jul-94	Gassett ** 17-May-94	Harthman Race Track 17-May-94
2,2'oxybis(1-Chloropropane)	10 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	NA	10 U	10 U	10 U	10 U
Acenaphthene	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthylene	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Anthracene	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbazole	20 U	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)anthracene	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(b)fluoranthene	20 U	10 U	10 UJ	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(k)fluoranthene	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(g,h,i)perylene	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)pyrene	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Bromophenyl phenyl ether	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Butylbenzylphthalate	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloroaniline	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Chloroethoxy)methane	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Chloroethyl)ether	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Chloroisopropyl)ether	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloro-3-methylphenol	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Chloronaphthalene	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Chlorophenol	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chlorophenyl phenyl ether	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chrysene	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibenz(a,h)anthracene	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibenzofuran	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butylphthalate	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichlorobenzene	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
3,3'-Dichlorobenzidine	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dichlorophenol	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Diethyl phthalate	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dimethylphenol	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dimethylphthalate	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4,6-Dinitro-2-methylphenol	50 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 U	25 U	25 U	25 U	25 U	25 UJ
2,4-Dinitrophenol	50 UJ	25 UJ	25 UJ	R	25 UJ	R	25 U	25 U	25 U	25 U	25 U	25 U	25 UJ
2,4-Dinitrotoluene	20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-11. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: CHT-3 CHT-6D CHT-7D Delegarde DW-1 DW-2 Eglin I Eglin III Four Winds I ** Four-Winds II ** Four-Winds II FR ** Gassett ** Harthman Race Track													
	Date:	1-Jun-94	1-Jun-94	2-Jun-94	26-May-94	3-Jun-94	27-May-94	19-May-94	18-May-94	22-Jul-94	21-Jul-94	21-Jul-94	17-May-94	17-May-94
2,6-Dinitrotoluene		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-octylphthalate		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Ethylhexyl)phthalate		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	2 J	2 J	4 BJ	4 BJ	49	10 U
Fluoranthene		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluorene		6 J	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobenzene		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobutadiene		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorocyclopentadiene		20 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Hexachloroethane		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Indeno(1,2,3-cd)pyrene		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isophorone		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylnaphthalene		110	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylphenol		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Methylphenol		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene		310 D	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitroaniline		50 UJ	25 U	25 U	25 U	25 UJ	25 UJ	25 U	25 U	25 U	25 U	25 U	25 U	25 U
3-Nitroaniline		50 U	25 U	25 U	25 U	25 UJ	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 UJ
4-Nitroaniline		50 U	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Nitrobenzene		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitrophenol		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Nitrophenol		50 UJ	25 UJ	25 U	25 UJ	25 UJ	25 UJ	25 U	25 U	25 U	25 U	25 U	25 U	25 U
N-Nitrosodiphenylamine		20 UJ	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitroso-di-n-propylamine		20 UJ	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachlorophenol		50 U	25 U	25 U	25 U	25 UJ	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Phenanthrene		4 J	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenol		11 J	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pyrene		20 U	10 U	10 UJ	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4,5-Trichlorophenol		50 U	25 U	25 U	25 U	25 UJ	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
2,4,6-Trichlorophenol		20 U	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-11. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: Harvey Date: 27-Jul-94	KFC-1 22-Jun-94	La Place 19-May-94	Mathias 25-May-94	MW-1 8-Jun-94	MW-1D 9-Jun-94	MW-2 17-Jun-94	MW-3 14-Jun-94	MW-4 13-Jun-94	MW-4D 13-Jun-94	MW-5 22-Jun-94	MW-6D 7-Jun-94	MW-6R 6-Jun-94
2,2'-oxybis(1-Chloropropane)	NA	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Acenaphthene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Acenaphthylene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Anthracene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Carbazole	10 U	10 UJ	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Benzo(a)anthracene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Benzo(b)fluoranthene	10 U	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Benzo(k)fluoranthene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Benzo(g,h,i)perylene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Benzo(a)pyrene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
4-Bromophenyl phenyl ether	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Butylbenzylphthalate	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ
4-Chloroaniline	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
bis(2-Chloroethoxy)methane	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
bis(2-Chloroethyl)ether	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
bis(2-Chloroisopropyl)ether	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
4-Chloro-3-methylphenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
2-Chloronaphthalene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
2-Chlorophenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
4-Chlorophenyl phenyl ether	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Chrysene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Dibenz(a,h)anthracene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Dibenzofuran	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Di-n-butylphthalate	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
1,2-Dichlorobenzene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	1 J	10 UJ	10 UJ	10 UJ	10 U	10 U
1,3-Dichlorobenzene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
1,4-Dichlorobenzene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
3,3'-Dichlorobenzidine	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U
2,4-Dichlorophenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Diethyl phthalate	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
2,4-Dimethylphenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Dimethylphthalate	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
4,6-Dinitro-2-methylphenol	25 U	25 UJ	25 U	25 U	25 UJ	25 UJ	25 UJ	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ
2,4-Dinitrophenol	25 U	R	25 U	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	R	25 UJ	25 UJ
2,4-Dinitrotoluene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-11. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: Harvey **	KFC-1	La Place **	Mathias **	MW-1	MW-1D	MW-2	MW-3	MW-4	MW-4D	MW-5	MW-6D	MW-6R
Date:	27-Jul-94	22-Jun-94	19-May-94	25-May-94	8-Jun-94	9-Jun-94	17-Jun-94	14-Jun-94	13-Jun-94	13-Jun-94	22-Jun-94	7-Jun-94	6-Jun-94
2,6-Dinitrotoluene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Di-n-octylphthalate	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
bis(2-Ethylhexyl)phthalate	5 J	10 UJ	1 J	10 U	10 U	50 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Fluoranthene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Fluorene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Hexachlorobenzene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Hexachlorobutadiene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Hexachlorocyclopentadiene	10 U	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U
Hexachloroethane	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Indeno(1,2,3-cd)pyrene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Isophorone	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
2-Methylnaphthalene	10 U	1 J	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	75 J	10 U	10 U
2-Methylphenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
4-Methylphenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Naphthalene	10 U	6 J	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	120 DJ	10 U	10 U
2-Nitroaniline	25 U	25 UJ	25 U	25 U	25 U	25 U	25 UJ	25 U	25 UJ	25 UJ	25 UJ	25 U	25 U
3-Nitroaniline	25 U	25 UJ	25 U	25 U	25 U	25 U	25 UJ	25 U	25 UJ	25 UJ	25 UJ	25 U	25 U
4-Nitroaniline	25 U	25 UJ	25 U	25 U	25 UJ	25 U	25 UJ	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ
Nitrobenzene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
2-Nitrophenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
4-Nitrophenol	25 U	25 UJ	25 U	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ
N-Nitrosodiphenylamine	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
N-Nitroso-di-n-propylamine	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Pentachlorophenol	25 U	25 UJ	25 U	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 U
Phenanthrene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Phenol	10 U	12 J	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Pyrene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
1,2,4-Trichlorobenzene	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
2,4,5-Trichlorophenol	25 U	25 UJ	25 U	25 U	25 U	25 U	25 UJ	25 U	25 UJ	25 UJ	25 UJ	25 U	25 U
2,4,6-Trichlorophenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-11. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID: MW-7	MW-8	MW-9S	MW-10	MW-10D	MW-11D	MW-11D FR	MW-12D	MW-13	MW-13D	MW-15	MW-16	MW-17	
Analyte	Date:	6-Jun-94	3-Jun-94	31-May-94	31-May-94	31-May-94	27-May-94	27-May-94	20-May-94	15-Jun-94	16-Jun-94	7-Jun-94	10-Jun-94	7-Jun-94
2,2'oxybis(1-Chloropropane)		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Acenaphthene		10 U	10 UJ	1 J	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Acenaphthylene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Anthracene		10 U	10 UJ	1 J	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Carbazole		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Benzo(a)anthracene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Benzo(b)fluoranthene		10 U	10 UJ	1 J	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Benzo(k)fluoranthene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Benzo(g,h,i)perylene		10 U	10 UJ	1 J	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Benzo(a)pyrene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
4-Bromophenyl phenyl ether		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Butylbenzylphthalate		10 UJ	10 UJ	1 J	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
4-Chloroaniline		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
bis(2-Chloroethoxy)methane		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
bis(2-Chloroethyl)ether		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
bis(2-Chloroisopropyl)ether		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
4-Chloro-3-methylphenol		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
2-Chloronaphthalene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
2-Chlorophenol		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
4-Chlorophenyl phenyl ether		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Chrysene		10 U	10 UJ	4 J	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Dibenz(a,h)anthracene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Dibenzofuran		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Di-n-butylphthalate		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
1,2-Dichlorobenzene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
1,3-Dichlorobenzene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
1,4-Dichlorobenzene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	2 J	10 U
3,3'-Dichlorobenzidine		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
2,4-Dichlorophenol		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Diethyl phthalate		10 U	10 UJ	10 UJ	10 UJ	60 J	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
2,4-Dimethylphenol		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Dimethylphthalate		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
4,6-Dinitro-2-methylphenol		25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ
2,4-Dinitrophenol		25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	R	R	R	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ
2,4-Dinitrotoluene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-11. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID: MW-7	MW-8	MW-9S	MW-10	MW-10D	MW-11D	MW-11D FR	MW-12D	MW-13	MW-13D	MW-15	MW-16	MW-17	
Analyte	Date:	6-Jun-94	3-Jun-94	31-May-94	31-May-94	31-May-94	27-May-94	27-May-94	20-May-94	15-Jun-94	16-Jun-94	7-Jun-94	10-Jun-94	7-Jun-94
2,6-Dinitrotoluene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Di-n-octylphthalate		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
bis(2-Ethylhexyl)phthalate		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	11 U	10 UJ	10 UJ	10 U	10 U	11 U
Fluoranthene		10 U	10 UJ	1 J	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Fluorene		10 U	10 UJ	8 J	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Hexachlorobenzene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Hexachlorobutadiene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Hexachlorocyclopentadiene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Hexachloroethane		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Indeno(1,2,3-cd)pyrene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Isophorone		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
2-Methylnaphthalene		10 U	10 UJ	4 J	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
2-Methylphenol		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
4-Methylphenol		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Naphthalene		10 U	10 UJ	3 J	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
2-Nitroaniline		25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 UJ	25 UJ	25 U	25 U	25 U
3-Nitroaniline		25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 U	25 UJ	25 UJ	25 UJ	25 U	25 U	25 U
4-Nitroaniline		25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ
Nitrobenzene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
2-Nitrophenol		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	3 J	10 U	10 U	10 U
4-Nitrophenol		25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ
N-Nitrosodiphenylamine		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
N-Nitroso-di-n-propylamine		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Pentachlorophenol		25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ
Phenanthrene		10 U	10 UJ	2 J	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Phenol		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
Pyrene		10 U	10 UJ	3 J	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U
1,2,4-Trichlorobenzene		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	3 J	10 U
2,4,5-Trichlorophenol		25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 U	25 U	25 UJ	25 UJ	25 U	25 U	25 U
2,4,6-Trichlorophenol		10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-11. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID: MW-18	MW-19	MW-20	MW-20D	MW-21D	MW-22D	MW-24	MW-25	OHMW-1	OHMW-2	OHMW-3	OHMW-4	Ramsey
Analyte	Date: 24-Jun-94	20-Jun-94	16-Jun-94	15-Jun-94	14-Jun-94	21-Jun-94	3-Jun-94	2-Jun-94	24-May-94	24-May-94	24-May-94	24-May-94	26-May-94
2,2'-oxybis(1-Chloropropane)	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthylene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Anthracene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Carbazole	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Benzo(a)anthracene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(b)fluoranthene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Benzo(k)fluoranthene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(g,h,i)perylene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)pyrene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
4-Bromophenyl phenyl ether	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Butylbenzylphthalate	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloroaniline	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Chloroethoxy)methane	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Chloroethyl)ether	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Chloroisopropyl)ether	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloro-3-methylphenol	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2-Chloronaphthalene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2-Chlorophenol	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
4-Chlorophenyl phenyl ether	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Chrysene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Dibenz(a,h)anthracene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Dibenzofuran	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butylphthalate	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichlorobenzene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
3,3'-Dichlorobenzidine	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dichlorophenol	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Diethyl phthalate	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dimethylphenol	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Dimethylphthalate	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
4,6-Dinitro-2-methylphenol	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ
2,4-Dinitrophenol	R	R	25 UJ	25 UJ	25 UJ	R	25 UJ	25 UJ	R	R	R	R	R
2,4-Dinitrotoluene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Ensco-East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-11. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: MW-18 MW-19 MW-20 MW-20D MW-21D MW-22D MW-24 MW-25 OHMW-1 OHMW-2 OHMW-3 OHMW-4 Ramsay													
	Date:	24-Jun-94	20-Jun-94	16-Jun-94	15-Jun-94	14-Jun-94	21-Jun-94	3-Jun-94	2-Jun-94	24-May-94	24-May-94	24-May-94	24-May-94	26-May-94
2,6-Dinitrotoluene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-octylphthalate		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Ethylhexyl)phthalate		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Fluoranthene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Fluorene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobenzene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobutadiene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorocyclopentadiene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Hexachloroethane		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Indeno(1,2,3-cd)pyrene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Isophorone		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylnaphthalene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylphenol		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
4-Methylphenol		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitroaniline		25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 U	25 U	25 U	25 U	25 U
3-Nitroaniline		25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 U	25 U	25 U	25 U	25 U
4-Nitroaniline		25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ
Nitrobenzene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitrophenol		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
4-Nitrophenol		25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ
N-Nitrosodiphenylamine		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitroso-di-n-propylamine		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Pentachlorophenol		25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 U	25 U	25 U	25 U	25 U
Phenanthrene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Phenol		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Pyrene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2,4,5-Trichlorophenol		25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 U	25 U	25 U	25 U	25 U
2,4,6-Trichlorophenol		10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.
 B The compound was also detected in the associated method blank.
 D Compound concentration was determined at a secondary dilution factor.
 J Estimated result.
 U The compound was analyzed for, but not detected at the corresponding reporting limits.
 R Result rejected.
 ** Sample results were not validated.
 NA Not analyzed.

Table 5-11. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID: Smith	Steele **	SW-2	SW-3	SW-4	SW-5	SW-6	SW-7	SW-7 FR	Tillett	TT-1	TT-1D	TT-2	
Analyte	Date:	20-May-94	18-May-94	22-Jun-94	23-Jun-94	16-Jun-94	25-May-94	26-May-94	23-Jun-94	23-Jun-94	25-May-94	9-Jun-94	9-Jun-94	9-Jun-94
2,2'oxybis(1-Chloropropane)		10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U
Acenaphthene		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	1 J	2 J	10 U	10 U	10 U	10 U
Acenaphthylene		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	1 J	1 J	10 U	10 U	10 U	10 U
Anthracene		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	1 J	10 U	10 U	10 U	10 U
Carbazole		10 U	10 U	10 UJ	50 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U
Benzo(a)anthracene		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	1 J	10 U	10 U	10 U	10 U
Benzo(b)fluoranthene		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ
Benzo(k)fluoranthene		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
Benzo(g,h,i)perylene		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	1 J	10 U	10 U	10 U	10 U
Benzo(a)pyrene		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
4-Bromophenyl phenyl ether		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
Butylbenzylphthalate		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	2 J	10 U	10 U	10 U
4-Chloroaniline		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
bis(2-Chloroethoxy)methane		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
bis(2-Chloroethyl)ether		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
bis(2-Chloroisopropyl)ether		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
4-Chloro-3-methylphenol		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	100 U	10 U	10 U
2-Chloronaphthalene		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
2-Chlorophenol		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	100 U	10 U	10 U
4-Chlorophenyl phenyl ether		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
Chrysene		10 U	10 U	10 UJ	9 J	10 UJ	10 U	10 U	10 UJ	1 J	10 U	10 U	10 U	10 U
Dibenz(a,h)anthracene		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
Dibenzofuran		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
Di-n-butylphthalate		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
1,2-Dichlorobenzene		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	7 J	6 J	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
3,3'-Dichlorobenzidine		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
2,4-Dichlorophenol		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	100 U	10 U	10 U
Diethyl phthalate		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
2,4-Dimethylphenol		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	60 J	10 U	100 U	10 U	10 U
Dimethylphthalate		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U
4,6-Dinitro-2-methylphenol		25 UJ	25 U	25 UJ	120 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	250 U	25 UJ	25 UJ
2,4-Dinitrophenol		R	25 U	R	380 UJ	25 UJ	R	R	50 UJ	25 UJ	R	250 U	25 UJ	25 UJ
2,4-Dinitrotoluene		10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-11. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID: Smith	Steele **	SW-2	SW-3	SW-4	SW-5	SW-6	SW-7	SW-7 FR	Tillett	TT-1	TT-1D	TT-2	
Analyte	Date:	20-May-94	18-May-94	22-Jun-94	23-Jun-94	16-Jun-94	25-May-94	26-May-94	23-Jun-94	23-Jun-94	25-May-94	9-Jun-94	9-Jun-94	9-Jun-94
2,6-Dinitrotoluene	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Di-n-octylphthalate	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
bis(2-Ethylhexyl)phthalate	10 U	1 J	10 UJ	130 BJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	22 U	26 U	10 U	10 U
Fluoranthene	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	1 J	10 U	10 U	10 U	10 U	10 U
Fluorene	10 U	10 U	10 UJ	40 J	10 UJ	10 U	10 U	4 J	6 J	10 U	2 J	10 U	10 U	10 U
Hexachlorobenzene	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Hexachlorobutadiene	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Hexachlorocyclopentadiene	10 UJ	10 U	10 UJ	50 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Hexachloroethane	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Indeno(1,2,3-cd)pyrene	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Isophorone	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
2-Methylnaphthalene	10 U	10 U	10 UJ	450 DJ	10 UJ	10 U	10 U	40 J	40 J	10 U	270 D	1 J	10 U	10 U
2-Methylphenol	10 U	10 U	4 J	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	27 J	10 U	10 U	10 U
4-Methylphenol	10 U	10 U	3 J	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	72 J	10 U	10 U	10 U
Naphthalene	10 U	10 U	10 UJ	1000 DJ	10 UJ	10 U	10 U	96 DJ	69 J	10 U	760 D	16	10 U	10 U
2-Nitroaniline	25 U	25 U	25 UJ	120 UJ	25 UJ	25 U	25 U	25 UJ	25 UJ	25 U	25 U	25 U	25 U	25 U
3-Nitroaniline	25 UJ	25 U	25 UJ	120 UJ	25 UJ	25 U	25 U	25 UJ	25 UJ	25 U	25 U	25 U	25 U	25 U
4-Nitroaniline	25 U	25 U	25 UJ	120 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 U	25 U	25 U
Nitrobenzene	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
2-Nitrophenol	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	100 U	10 U	10 U	10 U
4-Nitrophenol	25 UJ	25 U	25 UJ	120 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	250 U	25 UJ	25 UJ	25 UJ
N-Nitrosodiphenylamine	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
N-Nitroso-di-n-propylamine	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
Pentachlorophenol	25 UJ	25 U	25 UJ	120 UJ	25 UJ	25 U	25 U	25 UJ	25 UJ	25 U	250 U	25 UJ	25 UJ	25 UJ
Phenanthrene	10 U	10 U	10 UJ	32 J	10 UJ	10 U	10 U	3 J	4 J	10 U	2 J	10 U	10 U	10 U
Phenol	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	15 J	10 UJ	10 U	67 J	10 U	10 U	10 U
Pyrene	10 U	10 U	10 UJ	8 J	10 UJ	10 U	10 U	2 J	3 J	10 U	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U
2,4,5-Trichlorophenol	25 U	25 U	25 UJ	120 UJ	25 UJ	25 U	25 U	25 UJ	25 UJ	25 U	250 U	25 U	25 U	25 U
2,4,6-Trichlorophenol	10 U	10 U	10 UJ	50 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ	10 U	100 U	10 U	10 U	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-11. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: TT-2 FR TT-3D TT-4 TT-5 VIHA I **										
	Date:	9-Jun-94	14-Jun-94	10-Jun-94	9-Jun-94	19-Jul-94	17-May-94	6-Jun-94	16-Jun-94	24-Jun-94	27-Jul-94
2,2'-oxybis(1-Chloropropane)		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	NA
Acenaphthene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Acenaphthylene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Anthracene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Carbazole		10 U	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U
Benzo(a)anthracene		10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Benzo(b)fluoranthene		10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Benzo(k)fluoranthene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Benzo(g,h,i)perylene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Benzo(a)pyrene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
4-Bromophenyl phenyl ether		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Butylbenzylphthalate		10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U
4-Chloroaniline		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
bis(2-Chloroethoxy)methane		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
bis(2-Chloroethyl)ether		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
bis(2-Chloroisopropyl)ether		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
4-Chloro-3-methylphenol		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
2-Chloronaphthalene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
2-Chlorophenol		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
4-Chlorophenyl phenyl ether		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Chrysene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Dibenz(a,h)anthracene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Dibenzofuran		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Di-n-butylphthalate		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
1,2-Dichlorobenzene		10 U	10 U	10 U	1 J	10 U	10 U	10 U	10 UJ	10 UJ	10 U
1,3-Dichlorobenzene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
1,4-Dichlorobenzene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
3,3'-Dichlorobenzidine		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
2,4-Dichlorophenol		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Diethyl phthalate		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
2,4-Dimethylphenol		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Dimethylphthalate		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
4,6-Dinitro-2-methylphenol		25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 U
2,4-Dinitrophenol		25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 UJ	25 UJ	25 UJ	R	25 U
2,4-Dinitrotoluene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-11. Concentrations of Base Neutral and Acid Extractable Organic Compounds in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: TT-2 FR TT-3D TT-4 TT-5 VIHA I **										
	Date:	9-Jun-94	14-Jun-94	10-Jun-94	9-Jun-94	19-Jul-94	17-May-94	6-Jun-94	16-Jun-94	24-Jun-94	27-Jul-94
2,6-Dinitrotoluene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Di-n-octylphthalate		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
bis(2-Ethylhexyl)phthalate		10 U	10 U	10 U	31 U	10 U	10 U	1 J	10 UJ	2 BJ	3 J
Fluoranthene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Fluorene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Hexachlorobenzene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Hexachlorobutadiene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Hexachlorocyclopentadiene		10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 U	10 UJ	10 UJ	10 U
Hexachloroethane		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Indeno(1,2,3-cd)pyrene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Isophorone		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
2-Methylnaphthalene		10 U	10 U	100 D	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
2-Methylphenol		10 U	10 U	16	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
4-Methylphenol		10 U	10 U	58	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Naphthalene		10 U	10 U	510 D	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
2-Nitroaniline		25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 UJ	25 UJ	25 U
3-Nitroaniline		25 U	25 UJ	25 U	25 U	25 U	25 UJ	25 U	25 UJ	25 UJ	25 U
4-Nitroaniline		25 U	25 UJ	25 UJ	25 U	25 U	25 U	25 UJ	25 UJ	25 UJ	25 U
Nitrobenzene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
2-Nitrophenol		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
4-Nitrophenol		25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 U	25 UJ	25 UJ	25 UJ	25 U
N-Nitrosodiphenylamine		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
N-Nitroso-di-n-propylamine		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Pentachlorophenol		25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 U	25 U	25 UJ	25 UJ	25 U
Phenanthrene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Phenol		10 U	10 U	59	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
Pyrene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
1,2,4-Trichlorobenzene		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U
2,4,5-Trichlorophenol		25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 UJ	25 UJ	25 U
2,4,6-Trichlorophenol		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Ensco-East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B The compound was also detected in the associated method blank.

D Compound concentration was determined at a secondary dilution factor.

J Estimated result.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

NA Not analyzed.

Table 5-12. Concentrations of Total Metals in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID: CHT-3	CHT-6D	CHT-7D	Delegarde	DW-1	DW-2	Eglin I **	Eglin III **	Four Winds I **	Four-Winds II **	Four-Winds II FR **	Gassett **	Harthman Race Track	
Analyte	Date:	1-Jun-94	1-Jun-94	2-Jun-94	26-May-94	3-Jun-94	27-May-94	19-May-94	18-May-94	22-Jul-94	21-Jul-94	21-Jul-94	17-May-94	17-May-94
Aluminum	R		60 U	118 B	1890 B	300	1490	60 U	60 U	60 U	60 U	63.1 B	154 B	60 U
Antimony	15 U		15 U	15 U	300 U	15 U	75 U	15 U	15 U	15 U	22 B	15 U	15 U	15 UJ
Arsenic	4.7 B		2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Barium	R		7.2 B	15.2 B	153 B	3.9 B	64.6 B	28.7 B	43.6 B	3.6 B	7.2 B	5.3 B	32.6 B	3.6 B
Beryllium	1 U		1 U	1 UJ	20 U	1 UJ	5 U	1 U	1 U	1 B	1 U	1 U	1 U	1 U
Cadmium	3 U		3 U	3 U	60 U	3 U	15 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Calcium	R		40300	44000	823000	45000	242000	49800	58700	48800	47200	44200	41300	51000 J
Chromium	R		3.3 B	3 U	60 U	17.1	628	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Cobalt	R		3 U	3 U	60 U	3 U	15 U	3 U	3.3 B	3 U	3 U	3 U	3 U	3 U
Copper	R		4.3 B	4.9 B	167 B	3 B	28.3 B	4 B	4.9 B	5.1 B	10 B	8.4 B	41.9	4.8 B
Iron	R		125	177	4120 J	1150	3100	27.6 B	42.7 B	19.3 B	72.6 B	69.1 B	300	43.9 BJ
Lead	R		13.2	9.9 J	2 U	4.4 J	5	2 U	2 U	2 U	2 U	2 U	167	2 U
Magnesium	R		35100	31800	858000	32000	183000	40800	44200	34400	34500	32300	22000	37000 J
Manganese	R		10.3 B	282	163 B	24.3	620	2.2 B	7.9 B	14.9 B	125	119	30	1.1 B
Mercury	R		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Nickel	R		10 U	10 U	200 U	10 U	374	10 U	10 U	10 U	10 U	10 U	12.4 B	10 U
Potassium	R		1200 B	4070 B	23400 B	5470	7500 B	1690 B	1850 B	7440	1500 B	1340 B	2150 B	1650 B
Selenium	10 UJ		2 UJ	2 UJ	2 U	2 UJ	2 U	2 U	2 U	2.1 B	2 U	2 U	2 U	2 U
Silver	3 U		3 U	3 U	60 U	3 U	15 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Sodium	276000		231000	216000	9870000	203000 J	1230000	324000	361000	219000	229000	214000	156000	268000 J
Thallium	2 U		2 UJ	2 U	2 UJ	2.4 B	2 UJ	2 U	2 U	2 U	2 U	2 U	2 U	2 UJ
Vanadium	R		46.2 B	52	234 B	64.6	241 B	27.8 B	15.9 B	55.1	48.2 B	45.3 B	6.1 B	110 J
Zinc	R		227	14.6 B	1830	13.5 B	154	15.3 B	9.4 B	6.7 B	39.9	35.9	43.8	10.5 B

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B Concentration is between the instrument detection limit (IDL) and the contract required detection limit (CRDL).

J Estimated result.

U The analyte was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

TUT 005 0682

Table 5-12. Concentrations of Total Metals in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID: Harvey **	KFC-1	La Place **	Mathias **	MW-1	MW-1D	MW-2	MW-3	MW-4	MW-4D	MW-5	MW-6D	MW-6R
Analyte	Date: 27-Jul-94	22-Jun-94	19-May-94	25-May-94	8-Jun-94	9-Jun-94	17-Jun-94	14-Jun-94	13-Jun-94	13-Jun-94	22-Jun-94	7-Jun-94	6-Jun-94
Aluminum	111 B	R	60 U	60 U	18600 J	9420 UJ	R	R	R	R	R	60 U	46400
Antimony	15 U	18.6 BJ	15 U	15 U	17.6 B	15 U	15 B	17 B	20.1 B	15 U	20.1 B	25.3 B	15 U
Arsenic	2 U	2 UJ	2 U	2 U	2 U	2 U	3.3 B	2 U	2 U	2 U	3.8 B	2 U	2 U
Barium	55.6 B	246 J	7.6 B	12.2 B	26.7 B	14 B	25 B	51.3 BJ	47.4 B	3.3 B	53.3 B	3.7 B	36.1 BJ
Beryllium	1 U	1 UJ	1 U	1 U	1 UJ	1 UJ	1 U	1 U	1 U	1 U	1 U	1 UJ	1 UJ
Cadmium	3 U	3 UJ	3 U	3 U	3 U	3 U	3 U	3 UJ	3 U	3 U	3 U	3 U	3 U
Calcium	71200	64200 J	36700	37600	86400	60400	58900	67300	42000	35100 J	49900	37700	75700
Chromium	3 U	14.3 J	3 U	3 U	453	23.7	619	12.6 J	32.7	45.8	12.9	31.9	203
Cobalt	3 U	43.8 BJ	3 U	3 U	22.3 B	5.2 B	34.2 B	4.1 B	7.5 B	3 U	5.8 B	3 U	30.2 B
Copper	7 B	347 J	3.2 B	3 U	45.5	19.5 B	44	9.5 B	15 B	10.5 B	18.6 B	4.8 B	121
Iron	2500	80000 J	37.7 B	53.2 B	25600	10500	19900	3830	7590	1440	5730	124	56900
Lead	14.9	13.5 J	2 U	2 U	27.1 J	6.8 J	2.8 B	2 U	2.4 B	12.1	10.9 J	6.5 J	6.4
Magnesium	54900	55500 J	30600	35400	41400	19100	43500	34700	32000	35000	38300	29800	61100
Manganese	267	1030 J	2 B	1.4 B	570	338	366	2540	1290	55.1	1080	4.5 B	736
Mercury	0.1 U	0.1 UJ	0.24	0.1 U	0.1 U	0.1 U	0.1 U	0.11 B	0.1 U	0.1 U	0.1 U	0.1 U	0.19 B
Nickel	10 U	12.1 BJ	10 U	10 U	124	14.2 B	266	10 U	66.7	460	10 U	31.9 B	127
Potassium	1700 B	4890 BJ	1230 B	1190 B	1070 B	6910	2020 B	892 B	2150 B	1520 B	2710 B	4470 B	2390 B
Selenium	6.5	2 UJ	2 U	5.9	2 UJ	2.5 B	2 U	2 UJ	2 UJ	2 U	2 U	2 U	2 UJ
Silver	3 U	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Sodium	279000	344000 J	257000	409000	237000	263000	230000	213000	253000	227000	227000	207000	229000
Thallium	2 U	2 UJ	2 U	2 U	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 U
Vanadium	23.7 B	313 J	33.2 B	11.6 B	166	52.6	218	28.7 B	52.8	40.7 B	11.5 B	63.1	235
Zinc	310	191 J	5.6 B	15.2 B	37.7	54.4	21.2 J	19.6 B	18.6 B	23	35.8 J	343	144

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Ensco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B Concentration is between the instrument detection limit (IDL) and the contract required detection limit (CRDL).

J Estimated result.

U The analyte was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

Table 5-12. Concentrations of Total Metals in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID:	MW-7	MW-8	MW-9S	MW-10	MW-10D	MW-11D	MW-11D FR	MW-12D	MW-13	MW-13D	MW-15	MW-16	MW-17
	Date:	6-Jun-94	3-Jun-94	31-May-94	31-May-94	31-May-94	27-May-94	27-May-94	20-May-94	15-Jun-94	16-Jun-94	7-Jun-94	10-Jun-94	7-Jun-94
Aluminum		10300	28700	2050	956	160 B	132 B	147 B	93.9 B	R	R	3730 J	R	33000 J
Antimony		21.3 B	15 U	15 U	15 U	15 U	15 U	15 U	15 U	15 U	424 B	15 U	15 U	15 U
Arsenic		9.2 B	2.4 B	6.5 B	3 B	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Barium		16.7 BJ	202	440	258	8.4 B	4.4 B	6.2 B	18 BJ	10.7 B	4400 B	19.4 B	46.3 B	114 B
Beryllium		1 UJ	1 UJ	1 U	1 U	1 U	1 U	1 U	1 U	1 U	40.8 B	1 UJ	1 U	1 UJ
Cadmium		3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 UJ	75 U	3 U	3 U	3 U
Calcium		54200	60800	57600	31200	38600	10100	10800	30600	85300	11600000	45700	53700 J	75300
Chromium		1050	210	7.2 B	6.1 B	15.3	148	150	90.4	10.2	4300	7.6 B	3 U	238
Cobalt		34.4 B	19.4 B	3 U	3.2 B	3 U	3 U	3 U	3 U	4.2 B	362 B	3.3 B	3 U	27.7 B
Copper		62.1	93.6	9 B	11.5 B	5.3 B	8.4 B	7 B	11.7 B	8.1 B	1730 J	14.8 B	3 U	111
Iron		44800	49700	3760	1410	607	323	312	334	3670	378000	5360	92 B	43500
Lead		4.8	10.8 J	53.7	2.1 B	2.2 B	7.5	7.7	9.9	2.7 B	2 U	5.7 J	2 U	8.8 J
Magnesium		32200	42800	30400	25200	28400	5070	5490	21500	41800	297000	33900	30900 J	55800
Manganese		453	2350	2560	597	216	7.5 B	7.6 B	114	110	20400	149	532	1550
Mercury		1	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 B	0.31	0.1 U	0.1 B	0.1 U
Nickel		445	109	10 U	10 U	10.7 B	10 U	10 U	10 U	10 U	2050	10 U	11.4 B	140
Potassium		14200 J	13700	1930 B	5830	8840	6950	7020	12400 J	783 B	46700 BJ	967 B	648 B	2350 B
Selenium		2 UJ	2 UJ	2 UJ	2 UJ	2 U	2 UJ	2 U	2 UJ	2 U	2 U	2 U	2.4 BJ	2 UJ
Silver		3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	75 U	3 U	3 U	3 U
Sodium		191000	217000	223000	257000	204000	44900	48200	165000	134000	292000 J	244000	251000 J	211000
Thallium		2 U	2 U	2 UJ	2 UJ	2 U	2 UJ	2 UJ	2 UJ	2 UJ	20 UJ	2 UJ	2 UJ	2 UJ
Vanadium		627	85.7	12.4 B	31.8 B	71.3	9.7 B	12.6 B	41.2 BJ	60	252 B	65.1	47.6 B	164
Zinc		30	131	37.1	19.1 B	6.7 B	22.3	27.1	23.4	13 B	2490 J	26.3	6.3 B	173

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Ensco-East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B Concentration is between the instrument detection limit (IDL) and the contract required detection limit (CRDL).

J Estimated result.

U The analyte was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

Table 5-12. Concentrations of Total Metals in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID:	MW-18	MW-19	MW-20	MW-20D	MW-21D	MW-22D	MW-24	MW-25	OHW-1	OHW-2	OHW-3	OHW-4	Ramsay
	Date:	24-Jun-94	20-Jun-94	16-Jun-94	15-Jun-94	14-Jun-94	21-Jun-94	3-Jun-94	2-Jun-94	24-May-94	24-May-94	24-May-94	24-May-94	26-May-94
Aluminum	R		R	R	R	R	R	4160	15800	245000	8970	60000	356000	120 U
Antimony	20.6 BJ		15 UJ	15 U	15 U	19.6 B	22.3 BJ	15 U	15 U	16.1 B	15 U	50.7 B	15 U	30 U
Arsenic	3.4 BJ		2 UJ	2 U	2 U	2 U	2.2 BJ	2 U	2 U	3 B	80.8 J	18.2	2 U	2 U
Barium	266 J		29.1 BJ	31.2 B	43.9 B	137 B	19.1 BJ	18.4 B	67.8 B	773	139 B	599	4320	10.3 B
Beryllium	1 UJ		1 UJ	1 U	1 U	1 U	1 UJ	1 UJ	1 UJ	3.5 B	1 U	1 U	2.1 B	2 U
Cadmium	3 UJ		3 UJ	3 U	3 U	3 UJ	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U	60 U
Calcium	118000 J		43300 J	67200	70100	108000	17600 UJ	62800	66200	126000	67000	85700	161000	95900
Chromium	50.5 J		17.3 J	14.8	94.2	47.9	25.6 UJ	11.8	10.7	2200	10.8	4610	397	60 U
Cobalt	28.6 BJ		3 UJ	16.5 B	9.5 B	11.3 B	3.4 BJ	3 U	9.2 B	128	7.8 B	158	308	60 U
Copper	154 J		20.3 BJ	97.9 J	35.2	24.2 B	20.8 BJ	9.2 B	61.1	446	43.7	441	1370	60 U
Iron	68500 J		3420 J	23900	37800	19400	3000 UJ	6890	30500	338000	15700	154000	572000	29.5 B
Lead	27.4 J		2 UJ	16	20	4.3	43.4 UJ	2.9 BJ	5.4 J	48.3	201	17.3	71.8	2 U
Magnesium	49400 J		37500 J	34700	30600	75900	27900 UJ	37300	40800	218000	52800	83400	262000	72200
Manganese	3740 J		72.6 J	997	1140	402	71.6 UJ	215	982	5870	275	3180	13500	2 U
Mercury	0.26 J		0.1 UJ	0.13 B	0.12 B	0.11 B	1.6 UJ	0.1 U	0.1 U	3.1	0.1 U	0.1 U	0.77	0.1 U
Nickel	136 J		23.9 BJ	23.5 B	48.2	21.6 B	10 UJ	10 U	13.2 B	1120 J	14.6 B	1840 J	603 J	20 U
Potassium	4980 BJ		1690 BJ	5000 J	6760	5610	33300 UJ	2290 B	1870 B	21400	4300 B	13000	119000	2820 B
Selenium	2 UJ		2 UJ	2 U	2 U	2 UJ	2 UJ	2 UJ	2 UJ	10 UJ	2 UJ	2.3 BJ	10 UJ	2.4 BJ
Silver	3 UJ		3 UJ	3 U	3 U	3 U	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U	60 U
Sodium	201000 J		308000 J	74400	198000	579000	662000 UJ	233000	244000	342000	329000	372000	243000	471000
Thallium	2 UJ		2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2.1 B	2 U	2 U	2 UJ	2 U	2 U	2 UJ
Vanadium	166 J		32.6 BJ	56	86	50.9	13.7 BJ	68.6	138	498	85.4	624	1000	119
Zinc	294 J		18.6 BJ	93.4 J	169	83.8	80.7 UJ	24.7	80.3	1800	50.2	317	2510	11.7 B

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

- FR Field replicate of previous sample.
 B Concentration is between the instrument detection limit (IDL) and the contract required detection limit (CRDL).
 J Estimated result.
 U The analyte was analyzed for, but not detected at the corresponding reporting limits.
 R Result rejected.
 ** Sample results were not validated.

Table 5-12. Concentrations of Total Metals in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: Smith		Steele ♦♦	SW-2	SW-3	SW-4	SW-5	SW-6	SW-7	SW-7 FR	Tillen	TT-1	TT-1D	TT-2
	Date:	20-May-94	18-May-94	22-Jun-94	23-Jun-94	16-Jun-94	25-May-94	26-May-94	23-Jun-94	23-Jun-94	25-May-94	9-Jun-94	9-Jun-94	9-Jun-94
Aluminum		60.9 B	60 U	R	R	R	12100	14500	R	R	60 U	6130 J	153 B	1090 J
Antimony		15 U	15 U	15.4 BJ	16.4 BJ	15 U	15 U	30 U	19.2 BJ	17.6 BJ	15 U	19.7 B	15 U	15 U
Arsenic		2 U	2 U	5.9 BJ	10.2 J	2 U	2 U	2 U	2.9 BJ	2.3 BJ	2 U	2.9 B	2 U	2 U
Barium		10.1 BJ	20.4 B	145 BJ	778 J	31.7 B	71.9 B	184 B	223 J	224 J	32.3 B	119 B	109 B	42.4 U
Beryllium		1 U	1 U	1 UJ	2.3 BJ	1 U	1 U	2 U	1 UJ	1 UJ	1 U	1 UJ	1 UJ	1 UJ
Cadmium		3 U	3 U	3 UJ	3 UJ	3 U	3 U	60 U	3 UJ	3 UJ	3 U	3 U	3 U	3 U
Calcium		40500	55000	14300 J	86200 J	44600	52900	85700	82500 J	80400 J	55800	49400	47500	54900
Chromium		3 U	3 B	4.9 BJ	33.7 J	3 U	45.3	11.1 B	5.4 BJ	5.6 BJ	3 U	4.8 B	3 U	3 U
Cobalt		3 U	3 U	12.8 BJ	80.8 J	3 U	12.6 B	13.3 B	6.3 BJ	8 BJ	3 U	4.7 B	3.2 B	3 U
Copper		6.3 B	6.3 B	29.4 J	268 J	21.5 BJ	49.4	48.1 B	42.5 J	56.2 J	3 U	30.2	3 U	7 B
Iron		43.2 B	35.6 B	14100 J	108000 J	5140	18600	20300 J	14800 J	19900 J	530	7810	515	1230
Lead		2 U	2 U	4.3 J	143 J	2 U	2.7 B	2 U	70.8 J	93.8 J	2.6 B	9.5 J	2.2 BJ	2 U
Magnesium		39000	55000	15700 J	75900 J	37000	57400	84300	53600 J	53700 J	38400	44600	34300	38500
Manganese		21.2	7 B	943 J	6340 J	165	290	422	4190 J	4150 J	934	1710	1880	1220
Mercury		0.15 B	0.3	0.1 UJ	0.25 J	0.12 B	0.1 U	0.1 U	0.1 UJ	0.1 UJ	0.1 U	0.1 U	0.1 U	0.1 U
Nickel		10 U	10 U	10 UJ	41.8 J	11.3 B	17.2 B	20 U	10 UJ	10 UJ	10 U	16.5 B	10 U	10 U
Potassium		1400 B	1680 B	3370 BJ	4420 BJ	1880 BJ	1500 B	4000 B	1520 BJ	1150 BJ	1090 B	807 B	688 B	490 U
Selenium		8.8 J	2 U	2 UJ	2 UJ	2 U	5.8 J	2 UJ	2 UJ	2 UJ	2 U	2 UJ	2 U	2 U
Silver		3 U	3 U	3 UJ	7 BJ	3 U	3 U	60 U	3 UJ	3 UJ	3 U	3 U	3 U	3 U
Sodium		422000	380000	436000 J	440000 J	248000	349000	641000	294000 J	286000 J	206000	352000	228000	186000
Thallium		2 UJ	2 U	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 U	2 UJ	2 UJ	2 UJ
Vanadium		4.9 B	9.9 B	45 BJ	268 J	76.7	72.3	63.9 B	33.3 BJ	43.1 BJ	71.6	20.9 B	15.7 B	42.7 B
Zinc		39.5	6.8 B	59.8 J	515 J	21.3 J	67.3	62	103 J	141 J	27.7	17.6 B	12.8 B	9.8 B

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Ensco-East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B Concentration is between the instrument detection limit (IDL) and the contract required detection limit (CRDL).

J Estimated result.

U The analyte was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

♦♦ Sample results were not validated.

TUT 005 0686

Table 5-12. Concentrations of Total Metals in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID:	TT-2 FR	TT-3D	TT-4	TT-5	VIHA I **	Field Blank	Field Blank	Field Blank	Field Blank	Field Blank **
	Date:	9-Jun-94	14-Jun-94	10-Jun-94	9-Jun-94	19-Jul-94	17-May-94	6-Jun-94	16-Jun-94	24-Jun-94	27-Jul-94
Aluminum		1720 J	R	60 U	787 J	60 U	60 U	60 U	60.8 B	60 U	60 U
Antimony		15 U	19 B	15 U	15 U	20.6 B	15 UJ	15 U	15 U	15 U	15 U
Arsenic		2 U	2 U	7.8 B	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Barium		48.2 B	26.3 BJ	39.7 B	67.9 B	1.8 B	1 B	1.2 B	2.2 B	2.9 B	1 U
Beryllium		1 UJ	1 U	1 U	1 UJ	1 U	1 U	1 UJ	1 U	1 U	1 U
Cadmium		3 U	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Calcium		59400	24200	28500	47500	54200	201 B	270 B	891 B	354 B	287 B
Chromium		3 U	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Cobalt		3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Copper		9 B	3 U	3 U	4.5 B	6.3 B	3 B	3 U	3 U	4.4 B	3 U
Iron		1980	126	44.6 B	1130	93.7 B	27.6 B	14.4 B	59.9 B	18.5 B	16.3 B
Lead		2 U	2 U	5 J	2 U	2 U	2 U	2 U	2 U	2 UJ	2 U
Magnesium		41100	23100	32400	40200	29700	66.8 B	45.5 B	70.1 B	95.8 B	37.8 B
Manganese		1350	236	957	1110	1 U	1 U	1 U	2.3 B	1 U	1 U
Mercury		0.1 U	0.1 U	0.24	0.1 U	0.1 U	0.1 U	0.1 U	0.12 B	0.1 U	0.1 U
Nickel		13.3 B	10 U	17.1 B	18.8 B	10 U	10 U	10 U	10 U	10 U	10 U
Potassium		490 U	48100 J	490 U	490 U	943 B	490 U	490 U	490 U	490 U	490 U
Selenium		2 U	2 UJ	2 UJ	2 U	2 U	2 U	2 U	3.4 B	2 U	2 U
Silver		3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Sodium		193000	202000	395000	249000	165000	1240 U	1240 U	1240 U	1240 U	1240 U
Thallium		2 UJ	2 UJ	2 UJ	2 UJ	2 U	2 U	2 U	2 U	2 U	2 U
Vanadium		45 B	24.8 B	21.3 B	5.1 B	60.4	3 U	3 U	3 U	3 U	3 U
Zinc		11.3 B	12.4 B	11.9 B	18 B	5.4 B	5 U	5 U	5 U	5 U	5 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B Concentration is between the instrument detection limit (IDL) and the contract required detection limit (CRDL).

J Estimated result.

U The analyte was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

TUT 005 0687

Table 5-14. Concentrations of Indicator Parameters in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID: CHT-3	CHT-6D	CHT-7D	Delegarde	DW-1	DW-2	Eglin I **	Eglin III **	Four Winds I **	Four-Winds II **	Four-Winds II FR **	Gassett **	Harthman Race Track	
Analyte	Date:	1-Jun-94	1-Jun-94	2-Jun-94	26-May-94	3-Jun-94	27-May-94	19-May-94	18-May-94	22-Jul-94	21-Jul-94	21-Jul-94	17-May-94	17-May-94
Total Dissolved Solids		1320	850	870	1440	910	870	1180	1330	1240	NA	NA	700	1100
Total Suspended Solids		12300	10 U	10 U	10 U	10 U	15	10 U	10 U	18	NA	NA	10 U	10 U
Alkalinity, Total as CaCO3 at pH 4.5		779	516	557	646	510	540	528	509	556	NA	NA	566	613
Hardness as CaCO3		1970	245	241	5590	244	1360	292	329	264	260	243	194	280
Ferrous Iron		0.16	0.1 U	NA	0.1 U	NA	0.1 U	0.1 U	0.1 U	NA	NA	NA	0.1 U	0.1 U
Chloride		85.1	97.3	39	226	78.2	110	269	368	95.5	NA	NA	63.4	129
Cyanide, Total (ug/L)		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	NA	NA	NA	10 U	10 U
Nitrite as N		0.05 U	0.7	0.25 U	2 U	0.5 U	0.5 Q	0.25 U	0.1 U	0.02 U	NA	NA	1 U	1 U
Nitrate as N		0.05 U	6.5	6.5	9.5	6.9	6.3	2.6	2.2	8.4	NA	NA	11.3	13.6
Phosphorous, Total as P		26.4	0.05 U	0.11	0.05 U	0.38	0.05 U	NA	0.05 U	0.2 U	NA	NA	0.35	0.05 U
Sulfate		115	37	16.5	77	14.1	43.8	84	113	20.1	NA	NA	42.5	46.1
Sulfide, Total		0.73	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.04 U	0.14	0.1 U	0.1 U	0.1 U
Chemical Oxygen Demand (Regular)		218	20 U	20 U	20 U	20 U	20 U	NA	20 U	20 U	20 U	20 U	20 U	20 U
Lead, Organic		0.37	0.42	0.4	0.31	0.4	0.31	NA	NA	NA	NA	NA	NA	NA

Analyte concentrations in milligrams per liter (parts per million [ppm]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

G Reporting limit raised due to matrix interference.

J Estimated result.

Q Reporting limit raised due to high level of another analyte.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

** Sample results were not validated.

NA Not analyzed.

TUT 005 0688

Table 5-14. Concentrations of Indicator Parameters in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID: Harvey ..	KFC-1	La Place ..	Mathias ..	MW-1	MW-1D	MW-2	MW-3	MW-4	MW-4D	MW-5	MW-6D	MW-6R	
Analyte	Date:	27-Jul-94	22-Jun-94	19-May-94	25-May-94	8-Jun-94	9-Jun-94	17-Jun-94	14-Jun-94	13-Jun-94	13-Jun-94	22-Jun-94	7-Jun-94	6-Jun-94
Total Dissolved Solids	1190	1070	970	1360	920	880	910	900	920	1180	810	840	910	
Total Suspended Solids	47	3040	10 U	10 U	331	158	136	82	10 U	10 U	164	10 U	926	
Alkalinity, Total as CaCO3 at pH 4.5	488	814	539	611	577	530	546	587	577	540	613	503	561	
Hardness as CaCO3	404	389	217	240	386	230	326	311	236	232	282	217	441	
Ferrous Iron	NA	NA	0.1 U	0.1 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Chloride	1700	99.2	103	294	103	75.9	94.5	95.4	87.2	79.5	86	77.3	90.6	
Cyanide, Total (ug/L)	NA	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 U	
Nitrite as N	0.05 U	0.05 U	0.25 U	1 U	0.05 U	0.5 U	1 U	0.1 Q	0.5 Q	0.5 Q	0.05 U	0.05 U	0.5 U	
Nitrate as N	3.3	0.05 U	5.3	6.8	12.4	5	15.9	3.4	3.9	7.3	0.45	6.2	9.3	
Phosphorous, Total as P	0.057	1.3	0.05 U	0.05 U	0.22	0.09	0.7	0.21	0.4	0.38	0.1	0.05 U	0.53	
Sulfate	70	16	126	78	41.9	36.8	53.3	25.3	58.4	43.6	5 U	38.8	18.9	
Sulfide, Total	0.1 U	0.2	0.1 U	0.1 U	0.12	0.13	0.12	0.1 U	0.13	0.1 U	0.1 U	0.1 U	0.2 U	
Chemical Oxygen Demand (Regular)	25.3	52.4	20 U	29.3	47.7	71.2	20 U	20 U	20 U	20 U	39.8	20 U	20 U	
Lead, Organic	NA	NA	NA	0.3	1	1.2	NA	NA	NA	NA	NA	1	0.99	

Analyte concentrations in milligrams per liter (parts per million [ppm]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.
 G Reporting limit raised due to matrix interference.
 J Estimated result.
 Q Reporting limit raised due to high level of another analyte.
 U The compound was analyzed for, but not detected at the corresponding reporting limits.
 ** Sample results were not validated.
 NA Not analyzed.

TUT 005 0689

Table 5-13. Concentrations of Dissolved Metals in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: CHT-3 Date:	CHT-6D 1-Jun-94	CHT-7D 2-Jun-94	Delegarde 26-May-94	DW-1 3-Jun-94	DW-2 27-May-94	Eglin I 19-May-94	Eglin III 18-May-94	Four Winds I ** 22-Jul-94	Four-Winds II ** 21-Jul-94	Four-Winds II FR ** 21-Jul-94	Gassett ** 17-May-94	Harthman Race Track 17-May-94
Aluminum	R	60 U	60 UJ	60 U	60 U	60 U	60 U	60 U	60 U	60 U	60 U	60 U	60 U
Antimony	75 U	15 U	15 UJ	26.4 B	15 U	15 U	15 U	15 U	15 U	15 U	15 U	15 U	15 UJ
Arsenic	6.7 BJ	2 U	2 UJ	2 UJ	2 UJ	2 UJ	2 U	2 U	2 U	2 U	2 U	2.2 B	2 UJ
Barium	R	4.2 B	13.5 BJ	5.4 B	3.7 B	7.3 B	28 B	42.5 B	2.5 B	4.8 B	4.2 B	33.1 B	1.3 B
Beryllium	5.6 B	1 U	1 UJ	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Cadmium	15 U	3 U	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Calcium	R	40000	44500 J	38300	48000	45000	53200	61700	49900	53500	52600	46200	56700 J
Chromium	R	3 U	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U	3 B	3 U	3 U	3 U
Cobalt	R	3.1 B	3 UJ	3 U	3 U	3 U	3 U	3.4 B	3 U	3 U	3 U	3 U	3 U
Copper	R	3 U	3 UJ	3.9 B	3 U	3 U	3 U	3.6 B	3 U	3.1 B	3 U	38.8	3 BJ
Iron	R	3 U	3 UJ	3 U	3.6 B	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Lead	R	11.4	12.2 J	2 UJ	2 UJ	3.6 J	2 U	2 U	2 U	2 U	2 U	163	2 UJ
Magnesium	R	35100	33600 J	39900	35200	36900	43500	46800	36000	37400	37500	24900	41400 J
Manganese	R	8.6 B	159 J	1 U	8.7 B	109	1 B	7.2 B	1 U	125	125	7.7 B	1 UJ
Mercury	R	0.1 U	0.1 UJ	0.1 UJ	0.1 UJ	0.1 UJ	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 UJ
Nickel	R	10 U	22 BJ	10 U	10.1 B	49	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Potassium	R	2170 B	4410 BJ	847 B	6140	987 B	2150 B	2280 B	8030	2010 B	1810 B	2620 B	1660 B
Selenium	20 UJ	2 U	2 UJ	2.1 BJ	R	2 UJ	2.3 B	3.7 B	2 B	10 U	10 U	2 U	2 UJ
Silver	15 U	3 U	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Sodium	290000	233000	232000 J	466000	227000 J	253000	346000	380000	228000	251000	251000	178000	299000 J
Thallium	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 U	2 U	2 U	2 U	2 U	2 U	2 UJ
Vanadium	R	46.5 B	54.4 J	13.2 B	69.4	46 B	32.7 B	18.8 B	57.8	53.8	53.8	7.9 B	122 J
Zinc	R	208	9 BJ	53	5 U	14.8 B	13.9 B	6.2 B	5 U	15.1 B	16.4 B	39.4	7.7 B

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B Concentration is between the instrument detection limit (IDL) and the contract required detection limit (CRDL).

J Estimated result.

U The analyte was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

TUT 005 0690

Table 5-13. Concentrations of Dissolved Metals in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID: Harvey **	KFC-1	La Place **	Mathias **	MW-1	MW-1D	MW-2	MW-3	MW-4	MW-4D	MW-5	MW-6D	MW-6R
Analyte	Date: 27-Jul-94	22-Jun-94	19-May-94	25-May-94	8-Jun-94	9-Jun-94	17-Jun-94	14-Jun-94	13-Jun-94	13-Jun-94	22-Jun-94	7-Jun-94	6-Jun-94
Aluminum	60 U	60 UJ	60 U	60 U	60 U	60 U	60 U	60 U	60 U	60 U	60 UJ	60 U	60 U
Antimony	15 U	15 UJ	15 U	22 B	15 U	15 U	15 U	15 U	15 U	16.7 B	15 UJ	15 U	17.4 B
Arsenic	2 U	2 UJ	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2.4 BJ	2 U	2 UJ
Barium	49.8 B	74.6 BJ	60 B	9.7 B	8.2 B	5.4 B	7.4 B	43.6 B	28.6 B	3.1 B	47.9 BJ	3.4 B	3.9 B
Beryllium	1 U	1 UJ	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 UJ	1 U	1 U
Cadmium	3 U	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 UJ	3 U	3 U
Calcium	76100	38600 J	38800	38300	66100	29400	49600	63600	42000	39400 J	43600 J	41300	46600
Chromium	3 U	3 UJ	3 U	3 U	3 U	17.4	3 U	3 U	3 U	3 U	3 UJ	26.4	3 U
Cobalt	3 U	3 UJ	3 U	3.8 B	3 U	3 U	3 U	3 U	3 U	3 U	3 UJ	3 U	3 U
Copper	3 U	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 UJ	3 U	3 U
Iron	40.8 B	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	316 J	3 U	3 U
Lead	2 U	2 UJ	2 U	2 U	2 U	2 U	2 U	2 U	2 U	4.8 J	2 UJ	3.1 J	2 UJ
Magnesium	59500	30100 J	32000	36100	31200	13000	39300	34600	31400	36600	38400 J	32100	35900
Manganese	256	331 J	1.8 B	1 U	11.8 B	43.4	10.8 B	2210	707	7.2 B	1030 J	1 U	14.8 B
Mercury	0.1 U	0.1 UJ	0.11 B	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 UJ	0.1 U	0.1 UJ
Nickel	10 U	11.5 BJ	10 U	10 U	10.9 B	10 U	47.8	10 U	34.5 B	259	11.4 BJ	23.3 B	10 U
Potassium	2600 B	1810 BJ	1220 B	1400 B	1060 B	8030	1500 B	490 U	1800 B	1640 B	3470 BJ	5370	1080 B
Selenium	6.5	2 UJ	2 U	2 U	2.3 BJ	3.6 BJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ
Silver	3 U	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 UJ	3 U	3 U
Sodium	300000	365000 J	271000	420000	241000	265000	240000	227000	269000	238000	248000 J	227000	238000
Thallium	2 U	R	2 U	2 U	2 UJ	2 UJ	R	2 UJ	2 UJ	2 UJ	R	2 UJ	2 UJ
Vanadium	17.9 B	11 BJ	32.6 B	11.6 B	54 J	33.6 BJ	56.2	13.4 B	35.3 B	42.9 B	3 UJ	70.1 J	65.9
Zinc	84.9	5 UJ	5.2 B	12.9 B	5 U	11.4 B	5 U	6.2 B	5.4 B	14.7 B	5 UJ	331	5 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

- FR Field replicate of previous sample.
 B Concentration is between the instrument detection limit (IDL) and the contract required detection limit (CRDL).
 J Estimated result.
 U The analyte was analyzed for, but not detected at the corresponding reporting limits.
 R Result rejected.
 ** Sample results were not validated.

Table 5-13. Concentrations of Dissolved Metals in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID: MW-7	MW-8	MW-9S	MW-10	MW-10D	MW-11D	MW-11D FR	MW-12D	MW-13	MW-13D	MW-15	MW-16	MW-17	
Analyte	Date:	6-Jun-94	3-Jun-94	31-May-94	31-May-94	31-May-94	27-May-94	27-May-94	20-May-94	15-Jun-94	16-Jun-94	7-Jun-94	10-Jun-94	7-Jun-94
Aluminum		60 U	60 U	60 U	60 U	60 U	62.7 B	60 U	60 U	60 U	5390 J	60 U	60 U	60 U
Antimony		15.6 B	15 U	15 U	15 U	15 U	15 U	15 U	15 U	18.3 B	15 UJ	15 U	15 U	21.1 B
Arsenic		2 UJ	2 UJ	60 BJ	4.2 BJ	2 UJ	2 UJ	2 UJ	2 U	2 U	2 UJ	2 U	2 U	2 U
Barium		1.6 B	38.9 B	406	246	2.7 B	2.4 B	2.8 B	16.1 BJ	5.7 B	75.8 BJ	4.6 B	47.9 B	23.7 B
Beryllium		1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 UJ	1 U	1 UJ	1 U
Cadmium		3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 UJ	3 U	3 U	3 U
Calcium		41700	47500	56800	31400	39800	9860	9910	27800	82400	53800 J	43400	60500 J	51800
Chromium		3 U	3 U	3 U	3 U	3 U	130	128	101	3 U	109 J	3 U	3 U	3 U
Cobalt		3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 UJ	3 U	3 U	3 U
Copper		3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	16.2 BJ	3 U	3 U	3.2 B
Iron		9.2 B	3 U	106	7.8 B	3 U	3 U	3 U	5.3 B	3 U	3 UJ	3 U	35.3 B	3 U
Lead		2 UJ	2 UJ	2.7 BJ	3.8 J	3.4 J	3.4 J	3.4 J	10.2 J	2 U	2 UJ	2.3 BJ	2 U	2 U
Magnesium		27800	34100	29200	25300	29700	4860 B	4900 B	21700	42500	34 UJ	33400	34600 J	32000
Manganese		3.8 B	6 B	2510	578	146	1.6 B	1.2 B	104	37.6	1 UJ	3.2 B	581	144
Mercury		0.1 UJ	0.1 UJ	0.1 UJ	0.1 UJ	0.1 UJ	0.1 UJ	0.1 UJ	0.1 U	0.1 U	0.1 UJ	0.1 U	0.1 U	0.1 U
Nickel		15 B	22.5 B	10 U	10 U	189	10 U	10 U	10 U	10 U	23.8 BJ	10 U	10.5 B	44.4
Potassium		15400 J	12900	2070 B	5720	9460	6510	6950	15100 J	490 U	41300 J	1260 B	1250 B	2060 B
Selenium		2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 U	3.4 BJ	2 UJ	3.2 BJ	2 UJ	4 BJ
Silver		3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 UJ	3 U	3 U	3 U
Sodium		209000	227000	225000	259000	215000	44300	44900	171000	144000	346000 J	262000	282000 J	222000
Thallium		2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	R	2 UJ	2 UJ	2 UJ
Vanadium		106	25.4 B	3 U	25.4 B	71	8.9 B	9.8 B	38.1 BJ	51.4	3 UJ	54.6 J	56.2	32.7 BJ
Zinc		5 U	5 U	15.1 B	10.4 B	5 U	10.2 B	9.8 B	25.2	5 U	6.8 BJ	8.4 B	5 U	6.1 B

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B Concentration is between the instrument detection limit (IDL) and the contract required detection limit (CRDL).

J Estimated result.

U The analyte was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

Table 5-13. Concentrations of Dissolved Metals in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID: MW-18	MW-19	MW-20	MW-20D	MW-21D	MW-22D	MW-24	MW-25	OHMW-1	OHMW-2	OHMW-3	OHMW-4	Ramsay
Analyte	Date: 24-Jun-94	20-Jun-94	16-Jun-94	15-Jun-94	14-Jun-94	21-Jun-94	3-Jun-94	2-Jun-94	24-May-94	24-May-94	24-May-94	24-May-94	26-May-94
Aluminum	60 U	60 U	60 U	60 U	122 B	60 UJ	60 U	60 UJ	60 UJ	60 U	60 U	647 J	60 U
Antimony	19.7 B	15 U	16.7 B	15 U	15 U	15.8 BJ	15 U	15 UJ	15 UJ	15 U	15 U	20.6 BJ	15 U
Arsenic	2.4 B	2 U	2 U	2 U	2 U	2 UJ	2 UJ	2 UJ	2 UJ	89.3 J	3.2 BJ	2 UJ	2 UJ
Barium	118 B	24.1 B	2.4 BJ	6.8 B	63.6 B	1.3 BJ	4.1 B	11.6 BJ	31.3 BJ	40.3 B	47.6 B	39 BJ	2.8 B
Beryllium	1 UJ	1 U	1 U	1 U	1 U	1 UJ	1 U	1 UJ	1 UJ	1 U	1 U	1 UJ	1 U
Cadmium	3 U	3 U	3 U	3 UJ	3 U	3 UJ	3 U	3 UJ	3 UJ	3 U	3 U	3 UJ	3 U
Calcium	49500	40700	61300	32600	98400	2250 BJ	44900	46300 J	57700 J	57100	58100	51300 J	46400
Chromium	3 U	3 U	3 U	3 U	3 U	14.4 J	5.2 B	3 UJ	3 UJ	5.2 B	3 U	4.3 BJ	3 U
Cobalt	3 U	3 U	3 U	3 U	3 U	3 UJ	3 U	3 UJ	3 UJ	3.4 B	3 U	3 UJ	3 U
Copper	3 U	3 U	3 U	3 U	3 U	3 UJ	3 U	3 UJ	3 UJ	3 U	3 U	3 UJ	3 U
Iron	58 B	3 U	3 U	3 U	34.8 B	3 UJ	33.1 B	3 UJ	35.3 BJ	3 U	3 U	518 J	3 U
Lead	2 U	2 U	2 U	2 U	10 U	2 UJ	2 UJ	2 UJ	2 UJ	14.9 J	2 UJ	2 UJ	2 UJ
Magnesium	25500	38100	30800	22400	70000	29700 J	38100	34500 J	60000 J	47600	43700	45500 J	35300
Manganese	2170	33.8	53.4	19.6	57.7	1 UJ	1.8 B	83.6 J	162 J	88.9	18.6	12.1 BJ	1 U
Mercury	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 UJ	0.1 UJ	0.1 UJ	0.1 UJ	0.1 UJ	0.1 UJ	0.1 UJ	0.1 UJ
Nickel	14.8 B	32.8 B	10 U	10 U	10 U	10 UJ	10 U	10 UJ	21.6 BJ	10 U	172	10 UJ	10 U
Potassium	2320 B	2140 B	4850 B	6570 J	3130 BJ	34400 J	2370 B	1360 BJ	1140 BJ	3080 B	1830 B	1550 BJ	498 B
Selenium	2 UJ	2.6 BJ	2 UJ	2.6 BJ	2 BJ	2 UJ	2.7 BJ	2 UJ	4.7 BJ	2.7 BJ	4.3 BJ	2.5 BJ	2 UJ
Silver	3 U	3 U	3 U	3 U	3 U	3 UJ	3 U	3 UJ	3 UJ	3 U	3 U	3 UJ	3 U
Sodium	220000	321000	81300	216000	623000	693000 J	255000	253000 J	360000 J	334000	370000	269000 J	231000
Thallium	R	R	R	2 UJ	20 UJ	R	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ
Vanadium	20.6 B	27.2 B	3.1 BJ	60.9	3 U	3.5 BJ	66.9	73 J	5.9 BJ	40.2 B	46.4 B	9.4 BJ	56.2
Zinc	13.1 B	5 U	7.6 B	7.7 B	5 U	5 UJ	10.6 B	5 UJ	5 UJ	8.4 B	5 U	10.1 BJ	5.1 B

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B Concentration is between the instrument detection limit (IDL) and the contract required detection limit (CRDL).

J Estimated result.

U The analyte was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

Table 5-13. Concentrations of Dissolved Metals in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID:	Smith	Steele **	SW-2	SW-3	SW-4	SW-5	SW-6	SW-7	SW-7 FR	Tillett	TT-1	TT-1D	TT-2
Analyte	Date:	20-May-94	18-May-94	22-Jun-94	23-Jun-94	16-Jun-94	25-May-94	26-May-94	23-Jun-94	23-Jun-94	25-May-94	9-Jun-94	9-Jun-94	9-Jun-94
Aluminum		60 U	60 U	60 UJ	60 UJ	60 U	60 U	60 U	60 U	60 UJ	60 U	60 U	60 UJ	60 U
Antimony		15 U	15 U	17.4 BJ	29 BJ	15 U	15 U	15 U	29.2 B	28.3 BJ	15 U	15 U	15 UJ	15.1 B
Arsenic		2 U	2 U	5.7 BJ	14.3 J	2 U	2 UJ	2 UJ	2 U	2 UJ	2 UJ	4.6 BJ	2 UJ	2 U
Barium		7 B	20.4 B	106 BJ	472 J	9.8 BJ	30.4 B	55.2 B	188 B	180 BJ	28.9 B	108 B	114 BJ	46.5 B
Beryllium		1 U	1 U	1 UJ	1 UJ	1 U	1 U	1 U	1 U	1 UJ	1 U	1 U	1 UJ	1 U
Cadmium		3 U	3 U	3 UJ	3 UJ	3 U	3 U	3 U	3 U	3 UJ	3 U	3 U	3 UJ	3 U
Calcium		44200	57100	14500 J	50100 J	45500	53700	41800	81600	80400 J	53700	47600	48800 J	61800
Chromium		3 U	3 U	3 UJ	3 UJ	3 U	3 U	3 U	3 U	3 UJ	3 U	3 U	3 UJ	3 U
Cobalt		3 U	3 U	3 UJ	6.1 BJ	3 U	3 U	3 U	3 U	3 UJ	3 U	3 B	4.4 BJ	3.1 B
Copper		3.6 B	5.8 B	3 UJ	3 UJ	3 U	3 U	3 U	3 U	3 UJ	3 U	3 U	3 UJ	3 U
Iron		3 U	15.9 B	3 UJ	3.5 BJ	3 U	12.8 B	3 U	3 U	3 UJ	184	10.2 B	232 J	3 U
Lead		2 U	2 U	2 UJ	12.6 J	2 U	2 UJ	2 UJ	4.9	4.7 J	2 UJ	2 UJ	2 UJ	2 U
Magnesium		43300	58200	14500 J	40000 J	37600	52800	40000	50600	50100 J	36800	42400	35000 J	41900
Manganese		21.2	7.5 B	696 J	3230 J	8.6 B	1.2 B	85.4	3550	3560 J	885	1640	1950 J	1400
Mercury		0.13 B	0.27	0.1 UJ	0.1 UJ	0.1 U	0.1 UJ	0.1 UJ	0.1 U	0.1 UJ	0.1 UJ	0.1 U	0.1 UJ	0.1 U
Nickel		10 U	10 U	10.5 BJ	11.7 BJ	10 U	10 U	10 U	40.5	11.8 BJ	10 U	10 U	10 UJ	10 U
Potassium		1480 B	1420 B	3270 BJ	2880 BJ	970 B	1130 B	490 U	1770 B	1340 BJ	1380 B	1240 B	1750 BJ	674 B
Selenium		3.9 B	2 B	2 UJ	2 UJ	2 UJ	4.3 BJ	2 UJ	2 U	2 UJ	2 UJ	10 UJ	2 UJ	2 UJ
Silver		3 U	3 U	3 UJ	3 UJ	3 U	3 U	3 U	3 U	3 UJ	3 U	3 U	3 UJ	3 U
Sodium		470000	400000	461000 J	464000 J	263000	373000	340000	302000	297000 J	197000	365000	234000 J	202000
Thallium		2 UJ	2 U	R	20 UJ	R	2 UJ	2 UJ	10 U	10 UJ	2 UJ	10 UJ	2 UJ	2 UJ
Vanadium		3.8 B	6.4 B	12.1 BJ	4.7 BJ	68.2 J	14.6 B	8.8 B	6.9 B	7.4 BJ	66.3	3 U	17.3 BJ	44.1 BJ
Zinc		42.8	5 U	6.6 BJ	8.1 BJ	5 U	9.6 B	6.4 B	5 U	5 UJ	19.9 B	5.1 B	8.1 BJ	5.2 B

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Ensco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B Concentration is between the instrument detection limit (IDL) and the contract required detection limit (CRDL).

J Estimated result.

U The analyte was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

TUT 005 0694

Table 5-13. Concentrations of Dissolved Metals in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: TT-2 FR TT-3D TT-4 TT-5 VIHA I **										
	Date:	9-Jun-94	14-Jun-94	10-Jun-94	9-Jun-94	19-Jul-94	17-May-94	6-Jun-94	16-Jun-94	24-Jun-94	27-Jul-94
Aluminum		60 U	60 U	60 UJ	60 UJ	60 U	60 U	60 U	60 U	60 U	60 U
Antimony		15 U	15 U	24.8 BJ	15 UJ	15 U	15 UJ	15 U	15 U	15 U	15 U
Arsenic		2 UJ	2 U	8 BJ	2 UJ	2 U	2 UJ	2 UJ	2 U	2 U	2 U
Barium		46.6 B	7.5 B	39.3 BJ	72.2 BJ	1 U	1 U	1 U	1 U	1 U	1 U
Beryllium		1 U	1 U	1 UJ	1 UJ	1 U	1 U	1 U	1 U	1 U	1 U
Cadmium		3 U	3 U	3 UJ	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U
Calcium		61000	6420	30800 J	50300 J	64600	20 U	20 U	20 U	20 U	20 U
Chromium		3 U	3 U	3 UJ	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U
Cobalt		3 U	3 U	3 UJ	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U
Copper		3 U	3 U	3 UJ	3 UJ	3 U	3 UJ	3 U	3 U	3 U	3 U
Iron		4.2 B	3 U	23.4 BJ	51.4 BJ	3 U	3 U	3 U	3 U	3 U	3 U
Lead		2 U	2 U	4.5 J	2 UJ	2 U	2 UJ	2 UJ	2 U	2 U	2 U
Magnesium		41700	21800	34800 J	41900 J	33700	34 U	34 U	34 U	34 U	34 U
Manganese		1370	20.7	1010 J	1200 J	1 U	1 UJ	1 U	1 U	1 U	1 U
Mercury		0.1 U	0.1 U	0.1 UJ	0.1 UJ	0.1 U	0.1 UJ	0.1 UJ	0.1 U	0.1 U	0.1 U
Nickel		10 U	10 U	10.9 BJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Potassium		822 B	72700 J	733 BJ	739 BJ	1410 B	490 U	490 U	490 U	490 U	490 U
Selenium		2 UJ	10 UJ	2 UJ	2 UJ	2 U	2 UJ	2 UJ	2 U	2 U	2 U
Silver		3 U	3 U	3 UJ	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U
Sodium		203000	209000	421000 J	264000 J	188000	1240 U	1240 U	1240 U	1240 U	1240 U
Thallium		2 UJ	2 UJ	10 UJ	2 UJ	2 U	2 UJ	2 UJ	2 U	2 U	2 U
Vanadium		42.4 BJ	15 B	21.3 BJ	3 UJ	70.7	3 U	3 U	3 U	3 U	3 U
Zinc		5 B	6.2 B	5 UJ	5 UJ	5 U	5 U	5 U	5 U	5 U	5 U

Analyte concentrations in micrograms per liter (parts per billion [ppb]).

Analyses were performed by Ensco- East of Somerset, New Jersey, using March 1990 Contract Laboratory Program (CLP) protocols.

FR Field replicate of previous sample.

B Concentration is between the instrument detection limit (IDL) and the contract required detection limit (CRDL).

J Estimated result.

U The analyte was analyzed for, but not detected at the corresponding reporting limits.

R Result rejected.

** Sample results were not validated.

TUT 005 0695

Table 5-14. Concentrations of Indicator Parameters in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID:	MW-7	MW-8	MW-9S	MW-10	MW-10D	MW-11D	MW-11D FR	MW-12D	MW-13	MW-13D	MW-15	MW-16	MW-17
	Date:	6-Jun-94	3-Jun-94	31-May-94	31-May-94	31-May-94	27-May-94	27-May-94	20-May-94	15-Jun-94	16-Jun-94	7-Jun-94	10-Jun-94	7-Jun-94
Total Dissolved Solids		760	920	830	830	790	160	190	640	900	1520	990	980	870
Total Suspended Solids		286	478	108	45	10 U	10 U	6660	10 U	65	18700	10 U	190	1100
Alkalinity, Total as CaCO ₃ at pH 4.5		485	542	592	509	495	97.2	94.7	341	492	7400	556	643	518
Hardness as CaCO ₃		268	328	269	182	213	46	49.5	165	385	30200	254	261	418
Ferrous Iron		NA	NA	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	NA	NA	NA	NA	NA
Chloride		65.4	69.6	80.4	98.8	70.1	31.9	32	64.6	70.9	86.7	80.4	108	82.5
Cyanide, Total (ug/L)		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10	10 U	10 U	10 U
Nitrite as N		0.25 U	0.5 U	0.05 U	0.05 U	0.25 U	0.05 U	0.05 U	0.25 U	0.5 U	2.7	1 U	0.5 U	1 U
Nitrate as N		3.2	7.4	0.05 U	1.7	5.7	1.2	1.3	2.8	10.6	2.8	8.6	6	22.7
Phosphorous, Total as P		1.1	0.87	0.41	0.14	0.05 U	0.05 U	0.05 U	0.05 U	0.36	0.24	0.05 U	0.2	0.44
Sulfate		5 U	29	5 U	93	99.7	8.6	19.8	29.6	37.5	36.2	36.6	5 U	28.6
Sulfide, Total		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.18	0.1 U	0.1 U	0.1 U	0.16
Chemical Oxygen Demand (Regular)		20 U	20 U	64.4	36.2	20 U	25.4	20 U	20 U	20 U	22.3	26.3	20.2	26.3
Lead, Organic		1	0.41	0.38	0.36	0.37	0.31	0.35	NA	NA	NA	1	0.96	0.98

Analyte concentrations in milligrams per liter (parts per million [ppm]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.
 G Reporting limit raised due to matrix interference.
 J Estimated result.
 Q Reporting limit raised due to high level of another analyte.
 U The compound was analyzed for, but not detected at the corresponding reporting limits.
 ** Sample results were not validated.
 NA Not analyzed.

TUT 005 0696

Table 5-14. Concentrations of Indicator Parameters in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

	Sample ID: MW-18	MW-19	MW-20	MW-20D	MW-21D	MW-22D	MW-24	MW-25	OHMW-1	OHMW-2	OHMW-3	OHMW-4	Ramsay	
Analyte	Date:	24-Jun-94	20-Jun-94	16-Jun-94	15-Jun-94	14-Jun-94	21-Jun-94	3-Jun-94	2-Jun-94	24-May-94	24-May-94	24-May-94	24-May-94	26-May-94
Total Dissolved Solids	800	1040	500	780	2260	1890	940	950	1520	1110	1290	1040	870	
Total Suspended Solids	3360	52	406	1290	701	47	144	658	18500	227	1200	23500	10 U	
Alkalinity, Total as CaCO3 at pH 4.5	666	653	341	500	454	662	557	570	662	484	507	530	496	
Hardness as CaCO3	497	263	310	301	582	159	310	333	1210	385	557	1510	537	
Ferrous Iron	NA	NA	NA	NA	NA	NA	NA	NA	1.8	0.1 U	0.1 U	1.5	0.1 U	
Chloride	81.1	120	27.5	69.5	910	458	105	88.4	354	332	351	217	112	
Cyanide, Total (ug/L)	10 U	NA	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	
Nitrite as N	0.11	0.1 Q	1 U	0.25 U	0.05 U	0.43	1 U	0.5 U	0.1 U	0.05 U	0.1 U	0.25 U	2.5 U	
Nitrate as N	0.63	2.3	2.9	8.6	0.05 U	0.33	13.3	9.2	2.6	1.5	1.9	3.5	10	
Phosphorous, Total as P	0.67	0.082	0.45	0.86	0.49	0.071	0.19	15.4	4	0.21	1.6	6.8	0.05 U	
Sulfate	38.2	59.5	34.8	48.3	192	470	29.1	34.7	85.5	63.5	104	51.8	52.6	
Sulfide, Total	0.75 U	0.1 U	0.1 U	0.29	0.1 U	0.2	0.1 U	0.1 U	0.2 U	0.11	0.2 U	0.22	0.1 U	
Chemical Oxygen Demand (Regular)	20 U	20 U	20 U	20 U	39.7	33.6	22.7	20 U	49.1	46.9	49.1	29.3	20 U	
Lead, Organic	NA	NA	NA	NA	NA	NA	0.66	0.4	0.3	0.3	0.28	0.3	0.3	

Analyte concentrations in milligrams per liter (parts per million [ppm]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.
 G Reporting limit raised due to matrix interference.
 J Estimated result.
 Q Reporting limit raised due to high level of another analyte.
 U The compound was analyzed for, but not detected at the corresponding reporting limits.
 ** Sample results were not validated.
 NA Not analyzed.

TUT 005 0697

Table 5-14. Concentrations of Indicator Parameters in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: Smith Steele **													
	Date:	20-May-94	18-May-94	22-Jun-94	23-Jun-94	16-Jun-94	25-May-94	26-May-94	23-Jun-94	23-Jun-94	25-May-94	9-Jun-94	9-Jun-94	9-Jun-94
Total Dissolved Solids		1570	1370	1230	1400	970	1330	1100	1230	780	790	1270	880	870
Total Suspended Solids		10 U	10 U	284	324	117	182	159	783	926	10 U	102	10 U	67
Alkalinity, Total as CaCO ₃ at pH 4.5		621	549	855	962	586	486	690	928	931	521	891	549	562
Hardness as CaCO ₃		262	364	100	528	264	368	561	427	422	297	307	260	295
Ferrous Iron		0.1 U	0.1 U	NA	NA	NA	0.27	0.1 U	NA	NA	0.1 U	NA	NA	NA
Chloride		335	366	105	226	40.6	378	31.8	42.2	42.7	73.4	72.4	72.9	75
Cyanide, Total (ug/L)		10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Nitrite as N		0.5 U	0.25 U	0.15	0.05 U	1 U	0.1 U	0.05 U	0.05 U	0.05 U	0.5 U	0.05 U	0.1 U	0.5 U
Nitrate as N		5.1	3.5	0.97	0.05 U	5.8	2.3	0.05 U	0.05 U	0.05 U	2.1	0.05 U	2.1	4.7
Phosphorous, Total as P		0.05 U	0.05 U	0.56	3.4	0.44	0.11	0.11	1.5	2.6	0.05 U	0.36	0.05 U	0.46
Sulfate		95.5	111	7.3	5 U	38.5	112	5 U	5 U	5 U	90.5	5 U	27.9	31.9
Sulfide, Total		0.1 U	0.1 U	0.1 U	0.1 U	0.33	0.1 U	0.1 U	0.1 U	0.23	0.1 U	0.1 U	0.12	0.1 U
Chemical Oxygen Demand (Regular)		46.9	20 U	105	537	20 U	71	20 U	124	128	20 U	1020	253	20 U
Lead, Organic		NA	NA	NA	NA	NA	0.3	0.28	NA	NA	0.32	1.1	1	1

Analyte concentrations in milligrams per liter (parts per million [ppm]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

G Reporting limit raised due to matrix interference.

J Estimated result.

Q Reporting limit raised due to high level of another analyte.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

** Sample results were not validated.

NA Not analyzed.

TUT 005 0698

Table 5-14. Concentrations of Indicator Parameters in Groundwater Samples Collected from May to July 1994 at the Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Analyte	Sample ID: TT-2 FR	TT-3D	TT-4	TT-5	VIHA I **	Field Blank	Field Blank	Field Blank	Field Blank	Field Blank **
	Date: 9-Jun-94	14-Jun-94	10-Jun-94	9-Jun-94	19-Jul-94	17-May-94	6-Jun-94	16-Jun-94	24-Jun-94	27-Jul-94
Total Dissolved Solids	920	930	1230	980	740	20 U	20 U	20 U	20 U	201
Total Suspended Solids	55	24	1080	15	10 U	10 U	10 U	10 U	10 U	12
Alkalinity, Total as CaCO ₃ at pH 4.5	565	558	1040	658	530	5 U	5 U	5 U	5 U	5 U
Hardness as CaCO ₃	318	156	205	284	258	4 U	4 U	4 U	4 U	4 U
Ferrous Iron	NA	NA	NA	NA	NA	0.1 U	NA	NA	NA	NA
Chloride	71.4	82.8	42.7	199	57.2	1 U	1 U	1 U	1 U	1 U
Cyanide, Total (ug/L)	10 UJ	10 UJ	10 UJ	10 UJ	NA	10 U	10 U	10 U	10 U	NA
Nitrite as N	0.5 U	0.25 Q	0.05 U	0.05 U	0.5 G	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Nitrate as N	5.1	8.3	0.05 U	0.05 U	6.5	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Phosphorous, Total as P	0.15	0.16	1.3	0.25	0.05 U	0.05 U	0.05 U	0.07	0.05 U	0.12
Sulfate	20.7	35	8.4	24.5	NA	5 U	5 U	5 U	5 U	5 U
Sulfide, Total	0.1 U	0.1 U	0.2 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Chemical Oxygen Demand (Regular)	20 U	20 U	472	47.7	20 U	20 U	20 U	20 U	20 U	20 U
Lead, Organic	0.98	NA	0.96	1	NA	NA	1	NA	NA	NA

Analyte concentrations in milligrams per liter (parts per million [ppm]).

Analyses were performed by Enseco- East of Somerset, New Jersey, using standard U.S. Environmental Protection Agency methodology.

FR Field replicate of previous sample.

G Reporting limit raised due to matrix interference.

J Estimated result.

Q Reporting limit raised due to high level of another analyte.

U The compound was analyzed for, but not detected at the corresponding reporting limits.

** Sample results were not validated.

NA Not analyzed.

TUT
005
0699

Table 5-15. Summary of Total Chlorinated Volatile Organic Compounds and Benzene, Toluene, Ethylbenzene, and Xylenes Detected in Supply Wells During Sampling Events Conducted by Geraghty & Miller, Inc., Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well Identification	Round 1 Oct-90 (ug/L)	Round 2 Feb-91 (ug/L)	Round 3 Jun-91 (ug/L)	Round 4 Oct-91 (ug/L)	Round 5 Feb-92 (ug/L)	Round 6 May-92 (ug/L)	Round 7 Sep-92 (ug/L)	Round 8 Mar-93 (ug/L)	Phase II RI May-94 to Jun-94 (ug/L)	Range of Total Chlorinated VOC Concentrations (ug/L)
Bryan	ND	ND	NS	NS	NS	NS	NS	NS	NS	ND
Dede	ND	1.5	NS	NS	ND	NS	NS	ND	NS	ND - 1.5
Delegarde	NS	NS	NS	NS	NS	NS	NS	NS	26.3/28.7 **	ND - 28.7
Demitri	ND	ND	NS	NS	NS	NS	NS	NS	NS	ND
Dench/FR	1	ND/ND	NS	NS	NS	NS	NS	ND	NS	ND - 1
Devcon I	ND	R	NS	NS	NS	NS	NS	NS	NS	ND
Devcon II	NS	NS	NS	NS	NS	NS	NS	ND	NS	ND
Devcon III	ND	ND	NS	NS	NS	NS	NS	NS	NS	ND
Eglin I	110	95	111	76.6	40	33.35	27.5	25.63	15	15 - 111
Eglin II	213	125	210	139.12	42.7	81.09	26.7	NS	NS	26.7 - 213
Eglin III	110	91	124	99.16	96	56.07	79	69.39	74	56.07 - 124
Four Winds I	NS	NS	NS	135.08	247.51	NS	270.6	225.5	95.2	135.08 - 270.6
Four Winds II/FR	106/83	341	176	295	145.5	NS	148	NS	89/88	83 - 341
Gassett/FR	NS	1	NS	0.11	1.19/ND	0.06	NS	ND	ND	ND - 1.19
Harthman II (Crusher)/FR	13	16	14	8.57	1.47/10.45	NS	23.3	NS	NS	1.47 - 23.3
Harthman III (Racetrack)	3	1	ND	0.91	1.47	NS	NS	NS	0.15	0.15 - 3.0
Harvey/FR	890	1720	649	735.25	564.36	430	355	417.7/388.087	137	137 - 1720
LaPlace/FR	262	605/321	376/266.8	300.6	247.46/244.48	179.44	220.4	191.2	168	168 - 605
Leonard	ND	ND	NS	NS	1.12	NS	NS	0.12	NS	0.12 - 1.12
Matthias	153	104	111	108.72	84.59	NS	NS	NS	51	51 - 153
Ramsay/FR	3	18	19	24.89	45.3	33.64	22.22/21.98	21.9	11	3 - 45.3
Rodriguez	ND	ND	NS	NS	ND	NS	NS	ND	NS	ND
Smith/FR	408	230	278	326.41	299.38	195/396.2	251	243.7	168	168 - 408
Steele	298	121	376	233.36	195.4	219	241.3	256	173	121 - 376
Tillett/FR	473/427	343	661.9	274.6/249	306.6	733.4	495.6	393	585	249 - 733.4
VIHA I	11	NS	NS	NS	NS	NS	NS	NS	2.15	2.15 - 11
VIHA III	3	ND	NS	NS	NS	NS	NS	NS	NS	3.0

Total chlorinated VOCs include 1,2-dichloroethene (DCE, cis- or trans- isomer), trichloroethene (TCE), tetrachloroethene (PCE), vinyl chloride (VC), and 1,1,1-trichloroethane.

RI Remedial Investigation
 VOCs Volatile organic compounds.
 BTEX Benzene, toluene, ethylbenzene, and total xylenes.
 NS Not sampled.
 ND Not detected.
 FR Field replicate.
 R Results rejected.
 ** The Delegarde Supply Well was resampled on July 27, 1994.
 ug/L Micrograms per liter.



Table 5-15. Summary of Total Chlorinated Volatile Organic Compounds and Benzene, Toluene, Ethylbenzene, and Xylenes Detected in Supply Wells During Sampling Events Conducted by Geraghty & Miller, Inc., Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Well Identification	Round 1 Oct-90 (ug/L)	Round 2 Feb-91 (ug/L)	Round 3 Jun-91 (ug/L)	Round 4 Oct-91 (ug/L)	Round 5 Feb-92 (ug/L)	Round 6 May-92 (ug/L)	Round 7 Sep-92 (ug/L)	Round 8 Mar-93 (ug/L)	Phase II RI May-94 to Jun-94 (ug/L)	Range of Total BTEX Concentrations (ug/L)
Bryan	ND	ND	NS	NS	NS	NS	NS	NS	NS	ND
Dede	ND	ND	NS	NS	ND	NS	NS	ND	NS	ND
Delegarde	NS	NS	NS	NS	NS	NS	NS	NS	ND/0.32**	ND - 0.32
Demitri	ND	ND	NS	NS	NS	NS	NS	NS	NS	ND
Dench/FR	ND	ND/ND	NS	NS	NS	NS	NS	ND	NS	ND
Devcon I	ND	R	NS	NS	NS	NS	NS	NS	NS	ND
Devcon II	NS	NS	NS	NS	NS	NS	NS	ND	NS	ND
Devcon III	ND	ND	NS	NS	NS	NS	NS	NS	NS	ND
Eglin I	1	ND	ND	ND	0.06	0.06	ND	0.054	ND	0.054 - 1
Eglin II	ND	ND	ND	ND	ND	0.07	0.081	NS	NS	0.07 - 0.081
Eglin III	ND	ND	ND	0.05	ND	ND	ND	0.18	ND	0.05 - 0.18
Four Winds I	NS	NS	NS	0.33	0.8	NS	ND	ND	ND	0.33 - 0.88
Four Winds II/FR	ND/ND	ND	ND	ND	2.7	NS	ND	NS	ND/ND	ND - 2.7
Gassett/FR	NS	44	NS	ND	0.06/0.07	ND	NS	0.064	ND	0.06 - 44
Harthman II (Crusher)/FR	ND	ND	ND	ND	ND/ND	NS	ND	NS	NS	ND
Harthman III (Racetrack)	ND	ND	ND	ND	ND	NS	NS	NS	ND	ND
Harvey/FR	ND	ND	ND	ND	0.06	ND	ND	ND/0.229	ND	0.06 - 0.229
LaPlace/FR	ND	ND/ND	ND/ND	ND	0.26/0.14	ND	1.14	ND	ND	0.14 - 1.14
Leonard	ND	ND	NS	NS	ND	NS	NS	ND	NS	ND
Matthias	ND	ND	ND	ND	ND	NS	NS	NS	ND	ND
Ramsay/FR	ND	ND	ND	ND	ND	ND	ND/ND	ND	ND	ND
Rodriguez	ND	ND	NS	NS	ND	NS	NS	0.07	NS	ND - 0.07
Smith/FR	ND	ND	ND	0.1	0.12	ND/ND	ND	ND	ND	0.1 - 0.12
Steele	ND	ND	ND	0.08	ND	ND	ND	ND	ND	ND - 0.08
Tillett/FR	32/26	29	3.8	91/74.1	1.75	0.8	9	6.92	4	0.8 - 91
VIHA I	ND	NS	NS	NS	NS	NS	NS	NS	0.3	0.3
VIHA III	ND	ND	NS	NS	NS	NS	NS	NS	NS	ND

Total chlorinated VOCs include 1,2-dichloroethene (DCE, cis- or trans- isomer), trichloroethene (TCE), tetrachloroethene (PCE), vinyl chloride (VC), and 1,1,1-trichloroethane.

RI Remedial Investigation

VOCs Volatile organic compounds.

BTEX Benzene, toluene, ethylbenzene, and total xylenes.

NS Not sampled.

ND Not detected.

FR Field replicate.

R Results rejected.

** The Delegarde Supply Well was resampled on July 27, 1994.

ug/L Micrograms per liter.



Table 5-16. Split Samples Collected During the Comprehensive Groundwater Sampling Event, May through July 1994, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Date	Monitoring Well	Consultant	Parameters Analyzed
May 24, 1994	OHMW-1	IT Corporation	VOCs
May 24, 1994	OHMW-2	IT Corporation	VOCs
May 24, 1994	OHMW-3	IT Corporation	VOCs
May 24, 1994	OHMW-4	IT Corporation	VOCs
June 1, 1994	CHT-6D	ENSR	VOCs, BNAs
June 2, 1994	MW-25	ENSR	VOCs, BNAs, total and dissolved metals, and cyanide
June 3, 1994	DW-1	ENSR	VOCs, BNAs
June 3, 1994	MW-8	ENSR	VOCs, BNAs
June 3, 1994	MW-24	ENSR	VOCs, BNAs, total and dissolved metals, and cyanide
June 7, 1994	MW-15	Cooper Environmental	VOCs, BNAs, pest/herb, total metals, and cyanide
June 7, 1994	MW-17	Cooper Environmental	VOCs, BNAs, total metals

VOCs Volatile organic compounds.
 BNAs Base/neutral and acid extractable organic compounds.
 Pest Pesticides.
 Herb Herbicides.



Table 6-1. Physical and Chemical Properties of Organic Constituents of Concern, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Page 1 of 2

Constituent	Molecular Weight (g/mol)	Water Solubility (mg/L 25 °C)	Specific Gravity	Vapor Pressure (mm Hg 20 - 25 °C)	Henry's Law Constant (atm-m³/mol) (25 °C)	Diffusivity (cm²/sec)	Koc (mL/g)	Log Kow	Fish BCF (L/kg)	Groundwater T ½		Soil T ½	
										Low (days)	High	Low	High
VOCs													
Acetone	58	miscible	0.79	2.7E+02	3.97E-05	0.11498	0.37	-0.24	0.69	2 -	14	1 -	7
Benzene	78	1,780	0.88	9.5E+01	5.48E-03	0.09320	49 - 100	1.56 - 2.15	5.2	10 -	720	5 -	16
2-Butanone	72	239,000	0.80	1.0E+02	4.66E-05	0.08944	1.2	0.26 - 0.29	1.0	2 -	14	1 -	7
Carbon disulfide	76	2,300 (22 °C)	1.26	3.6E+02	1.33E-02	0.10252	240 - 355	1.84 - 2.16	7.9	ND		ND	
Chloroform	119	7,222 - 9,600	1.48	2.0E+02	3.20E-03	0.08868	44	1.90 - 1.97	3.8	56 -	1,825	28 -	180
1,2-Dichlorobenzene	147	92.7 - 156	1.3	1.5E+00	2.40E-03	0.07113	180 - 1,700	3.38 - 3.55	55.6	56 -	360	28 -	180
Dibromomethane	174	11,442	ND	3.4E+02	8.88E-04	0.09674	10.2 - 39	1.22	5	14 -	56	7 -	28
1,1-Dichloroethane	99	5,060	1.17	2.3E+02	5.87E-03	0.09590	30	1.78 - 1.79	14	64 -	154	32 -	154
cis-1,2-Dichloroethene	97	3,500	1.28	2.0E+02	3.37E-03	0.09980	49	1.86	15	56 -	2,850	28 -	180
trans-1,2-Dichloroethene	97	6,300	1.25	2.7E+02	6.74E-03	0.09980	59	2.09	1.58	56 -	2,850	28 -	180
Ethylbenzene	106	152 - 208	0.87	9.5E+00	8.68E-03	0.06667	95 - 260	3.05 - 3.15	37.5	6 -	228	3 -	10
Methyl-tert-butyl ether	88	48,000	0.74	2.5E+02	5.92E-04	0.08871	12	1.2	1.5	56 -	360	28 -	180
4-Methyl-2-pentanone	100	17,000 (20 °C)	0.80	6.0E+00 - 1.6E+01	1.49E-05	0.07867	6.2	1.09	5	ND		ND	
2-Methylphenol	108	26,000	1.03	2.4E-01	1.20E-06	0.07532	20	1.9	18	2 -	14	1 -	7
4-Methylphenol	108	18,000 - 23,000	1.02	8.0E-02 - 1.3E-01	7.90E-07	0.07496	49	1.67 - 3.01	18	0.083 -	28	0 -	0.67
n-Propylbenzene	120	60 (15 °C)	0.862	2.5E+00	6.6E-03 (15 °C)	0.07112	ND	3.57 - 3.68	ND	ND		ND	
Tetrachloroethene	166	150 - 485	1.6	1.9E+01	2.87E-03	0.07404	210 - 363	2.1 - 2.88	30.6	360 -	730	180 -	365
Toluene	92	490 - 627	0.87	2.8E+01	6.74E-03	0.07828	115 - 150	2.11 - 2.80	10.7	7 -	28	4 -	22
1,2,4-Trichlorobenzene	181	30 - 48.8	1.45	2.9E-01	2.32E-03	0.06542	500 - 9,500	3.93 - 4.23	114	56 -	360	28 -	180
1,2,4-Trimethylbenzene	120	57 (20 °C)	0.88	1.4E+00	3.9E-01 (20 °C)	0.07118	1.6E+03*	3.4*	230*	14	56	7	28
1,1,1-Trichloroethane	133	300 - 1,334	1.34	1.2E+02	1.62E-02	0.07965	104 - 151	2.17 - 2.49	5.6	140 -	546	140 -	273
Trichloroethene	131	1,100 - 1,500	1.46	7.3E+01	9.90E-03	0.08116	65 - 126	2.29 - 3.30	10.6	321 -	1,643	180 -	365
Vinyl chloride	63	1,100 - 2,700	0.91	2.7E+03	5.60E-02	0.10726	2.5	0.60	1.17	56 -	2,850	28 -	180
Xylenes (total)	106	162 - 200	0.87	6.6E+00 - 8.8E+00	6.30E-03	0.07164	128 - 1,580	2.77 - 3.20	132	14 -	360	7 -	28
Semi-VOCs													
Acenaphthene	154	3.47 - 3.93	ND	1.6E-03	7.92E-05	0.05951	4,600	3.92 - 4.33	242	24.6 -	204	12 -	102
Acenaphthylene	152	3.93	0.898	2.9E-02	1.14E-04	0.06703	4,790	4.1	30	85 -	120	43 -	60
Anthracene	178	0.030 - 0.1125	1.24	1.7E-05 - 1.95E-04	6.51E-05	0.05904	16,000 - 26,000	4.34 - 4.54	30	100 -	920	50 -	460
Benzo(a)anthracene	228	0.0094 - 0.014	1.27	1.1E-07	8.00E-06	0.04564	1,400,000	5.61 - 5.91	30	204 -	1,361	102 -	679
Benzo(b)fluoranthene	252	0.0012	ND	5.0E-07	1.20E-05	0.04392	550,000	6.57	30	719.1 -	1,219	360 -	610
Benzo(g,h,i)perylene	276	0.00026	ND	1.0E-10	1.40E-07	0.04197	7,800,000	7.1	30	1,168 -	1,314	590 -	650
Benzo(a)pyrene	252	0.0038 - 0.004	1.35	5.5E-09	2.40E-06	0.04653	398,000 - 1,900,000	5.81 - 6.50	30	114 -	1,059	57 -	529
Bis(2-Ethylhexyl)phthalate	391	0.047 - 0.4	0.98	6.2E-08	1.10E-05	0.03542	100,000	4.2 - 5.1	130	10 -	389	5 -	23
Butylbenzylphthalate	312	2.0 - 2.9	1.12	8.6E-06	1.30E-06	0.04114	68 - 347	4.05 - 4.91	414	2 -	180	1 -	7
Chrysene	228	0.0018 - 0.006	1.27	6.3E-09	3.15E-07	0.04531	240,000	5.60 - 5.91	30	744.6 -	2,000	372 -	993
Dibenzofuran	168	10	ND	3.4E-05	7.45E-07	0.05780	8,100 - 13,000	4.12 - 4.31	ND	8.5 -	35	7 -	28
Diethylphthalate	222	680 - 1,200	1.12	3.5E-03	8.46E-07	0.05118	69	1.40 - 3.00	73	6 -	112	3 -	56
Di-n-octylphthalate	390	3	0.98	1.4E-04	1.40E-12	0.03223	977,000,000	9.2	ND	14 -	365	7 -	28

Footnotes appear on page 2.

g:\project\stut\pr0013.034\data\physprop.xls



Table 6-1. Physical and Chemical Properties of Organic Constituents of Concern, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Constituent	Molecular Weight (g/mol)	Water Solubility (mg/L 25 °C)	Specific Gravity	Vapor Pressure (mm Hg 20 - 25 °C)	Henry's	Diffusivity (cm²/sec)	Koc (mL/g)	Log Kow	Fish BCF (L/kg)	Groundwater		Soil	
					Law Constant (atm·m³/mol)					T ½		T ½	
					(25 °C)					Low	High	Low	High
										(days)	(days)	(days)	(days)
Fluoranthene	202	0.206 - 0.373	1.25	5.0E-06	1.69E-02	0.04941	42,000	5.22	1,150	280 -	880	140 -	440
Fluorene	166	1.66 - 1.98	1.2	1.0E-03 - 1.0E-02	2.10E-04	0.05710	5,000	4.12 - 4.38	30	64 -	120	32 -	60
Indeno(1,2,3-c,d)pyrene	276	0.062	ND	1.0E-09	2.96E-20	0.05728	31,000,000	5.91 - 7.70	30	1,201 -	1,460	599 -	730
2-Methylnaphthalene	142	25	1.00	4.5E-02	3.36E-04	0.06196	7,400 - 8,500	3.86 - 4.11	190	ND		ND	
Naphthalene	128	30 - 34	1.16	2.3E-01 - 8.7E-01	4.60E-04	0.08205	550 - 3,160	3.2 - 4.7	10.5	1 -	258	17 -	48
N-Nitrosodiphenylamine	198	35.1	ND	1.0E-01	2.33E-08	0.06710	575	3.13	136	20 -	68	10 -	34
Phenanthrene	178	0.71 - 1.29	1.18	6.8E-04	2.56E-05	0.05430	5,250 - 38,900	4.2 - 4.6	30	32 -	402	16 -	200
Phenol	94	67,000 - 93,000	1.06	3.4E-01	3.97E-07	0.08924	17 - 27	1.46 - 1.48	1.4	0.5 -	7	1 -	10
Pyrene	202	0.013 - 0.171	1.27	6.85E-07 - 2.5E-06	1.10E-05	0.05039	46,000 - 135,000	4.88 - 5.32	30	420 -	3,796	210 -	1,898

References: Budavari (ed.) (1989); Howard et al. (1991); Howard (1989, 1990, and 1993); Lugg (1968); Lyman et al. (1990); Mabey et al. (1982); Mackay et al. (1983); Montgomery and Welkom (1990); Shen (1982); Streng and Peterson (1989); USEPA (1992b); Veith and Kosian (1982); and Verschuere (1983).

* Values are for mixed trimethylbenzenes (methyl xylenes).

atm-m³/mol Atmospheres-cubic meters per mole.
 BCF Bioconcentration factor.
 °C Degrees Celsius.
 cm²/sec Square centimeters per second.
 g/mol Grams per mole.
 Koc Organic carbon partition coefficient.
 Kow Octanol-water partition coefficient.
 L/kg Liters per kilogram.
 mg/L Milligrams per liter.
 mL/g Milliliters per gram.
 mm Hg Millimeters of mercury.
 ND No data.
 T ½ Half-life.
 VOCs Volatile organic compounds.

TUT 005 0704



Table 7-1. Summary of Carcinogenic Risks Exceeding the U.S. Environmental Protection Agency Guidance Value, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Media	Receptor Population	Exposure Routes	Total Pathway RME Value	Individual RME Values Contributing the Greatest Risks	
Groundwater (Sitewide)	Adult residents	Ingestion	6.6×10^{-4}	PCE Vinyl chloride	1.2×10^{-4} 4.5×10^{-4}
	Children (0 to 6 years)	Ingestion	3.1×10^{-4}	Vinyl chloride	2.1×10^{-4}
	Site Worker	Ingestion	2.0×10^{-4}	Vinyl chloride	1.3×10^{-4}
Surface soil (Tillett Property)	Adult residents	Ingestion	4.4×10^{-4}	Aroclor 1242 Arsenic	4.3×10^{-4} 8.2×10^{-6}
	Children (0 to 6 years)	Ingestion	1.0×10^{-3}	Aroclor 1242 Arsenic	1.0×10^{-3} 1.9×10^{-5}

RME Reasonable maximum exposure.

PCE Tetrachloroethene.

Source: CDM Federal Programs Corporation. 1995.

g:\aproject\tutu\pr0013.034\data\carcrisk.tab

TUT 005 0705



Table 7-2. Summary of Noncarcinogenic Risks Exceeding the U.S. Environmental Protection Agency Hazard Quotient of 1, Tutu Wells Site, St. Thomas, U.S. Virgin Islands.

Media	Receptor Population	Exposure Routes	Total Pathway HI	Individual HQs Contributing the Greatest Risks	
Groundwater	Adult residents	Ingestion	2.9×10^0	Total DCE	1.2×10^0
				Manganese	2.6×10^0
	Children (0 to 6 years)	Ingestion	6.7×10^0	Total DCE	2.8×10^0
				PCE	1.3×10^0
				Manganese	6.0×10^1
				Antimony	1.6×10^0
				Vanadium	1.0×10^0
Groundwater	Site worker	Ingestion	1.0×10^0	Manganese	9.2×10^0
	Future construction worker	Ingestion	9.1×10^0	Manganese	8.2×10^0
Surface soil (Tillett property)	Children (0 to 6 years)	Ingestion	3.0×10^0	Manganese	2.2×10^0
		Inhalation	3.1×10^0	Arsenic	4.3×10^{-1}
				Manganese	3.1×10^0

HI Hazard Index.

HQ Hazard Quotient.

DCE 1,2-Dichloroethene.

PCE Tetrachloroethene.

Source: CDM Federal Programs Corporation. 1995.

g:\aproject\tutu\pr0013.034\data\noncarc.tab

TUT 005 0706

