Office of Solid Waste and
Emergency Response
(5102G)

EPA-542-R-11-008
November 2011
www.epa.gov/tio
www.clu-in.org/optimization

Remediation System Evaluation (RSE)
Tutu Wellfield Superfund Site

St. Thomas, U.S. Virgin Islands

REMEDIATION SYSTEM EVALUATION

TUTU WELLFIELD SUPERFUND SITE
ST. THOMAS, U.S. VIRGIN ISLANDS

Report of the Remediation System Evaluation
Site Visit Conducted at the Tutu Wellfield Superfund Site on
February 8, 2011

Final Report

September 15, 2011

NOTICE

Work described herein was performed by Tetra Tech GEO for the United States Environmental Protection Agency (USEPA). Work conducted by Tetra Tech GEO, including preparation of this report, was performed under Work Assignment #1-58 of USEPA contract EP-W-07-078 with Tetra Tech EM, Inc., Chicago, Illinois. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

EXECUTIVE SUMMARY

A Remediation System Evaluation (RSE) involves a team of expert hydrogeologists and engineers, independent of the site, conducting a third-party evaluation of the operating remedy. It is a broad evaluation that considers the goals of the remedy, site conceptual model, available site data, performance considerations, protectiveness, cost-effectiveness, closure strategy, and sustainability. The evaluation includes reviewing site documents, potentially visiting the site for one day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Green Remediation

The recommendations are intended to help the site team identify opportunities for improvements. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation, and represent the opinions of the evaluation team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the United States Environmental Protection Agency (USEPA) Region and other site stakeholders.

The Tutu Wellfield Superfund Site is a 1.5 square mile site located on the eastern end of St. Thomas, U.S. Virgin Islands (USVI) within the upper Turpentine Run surface drainage basin in the Anna's Retreat area. It is bounded by steep slopes and surrounding hills and lies slightly east of the city of Charlotte Amalie. There are two comingled groundwater contamination plumes at the site. The higher concentration, northern and upgradient plume has a source near the Curriculum Center. The southern and downgradient plume has a source near the O'Henry Dry Cleaners. Chemicals of concern (COC) in groundwater are specific chlorinated volatile organic compounds (CVOCs). The USEPA identified several parties as potentially responsible for contributing to the contamination plumes. The largest contributor was a source at the Curriculum Center (former LAGA Building). This building was owned and operated by LAGA Textile Company, a clothing manufacturing plant, from 1969 to 1979 when it changed hands to Panex Co. until 1982. Extensive use of tetrachloroethylene (PCE) occurred at the plant via an industrial size dry cleaning process that utilized the PCE as the dry cleaning solvent. Since 1982, the building has been used as a library, warehouse, and school offices.

The groundwater remedy consists of two groundwater treatment facilities (GWTF). GWTF #1 includes groundwater extraction and treatment by air stripping near the Curriculum Center source and previously also included soil vapor extraction (SVE). GWTF #2 includes groundwater extraction and air stripping at the downgradient end of the Curriculum Center plume just upgradient of the O'Henry plume. This RSE focuses on these systems and associated monitoring program.

In general, the RSE team found that the active remedy components are operated by capable and organized operators. The observations and recommendations contained in this report are not intended to imply a deficiency in the work of either the system designers or operators, but are offered as constructive suggestions in the best interest of the USEPA and the public. These recommendations have the benefit of being formulated based on operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of groundwater remediation have changed over time.

Recommendations are provided in effectiveness, cost reduction, technical improvement, site closure, and sustainability.

Recommendations for improving system effectiveness are as follows:

- ***Hydraulic Containment***: Consider a new containment system including a line of wells perpendicular to the flow direction screened through the shallow and deep zones near RD-13 (300 ft downgradient) as the interpreted capture zone associated with GWTF #1 is small relative to the size of the high-concentration portion of the plume. In addition, it is recommended that two monitoring wells be installed east of the depicted plume where data to define plume extents are lacking.

- ***No Additional Downgradient Active Remediation***: CVOC concentrations at down-gradient wells have decreased over time and the plume size has decreased. The site team has analyzed for natural attenuation parameters to help determine the biological portion of the plume reduction and put controls in place to protect potential receptors in this area. Improved containment at GWTF #1 may increase the rate of concentration decreases.

- ***Vapor Intrusion Resampling***: Vapor intrusion was detected in the Curriculum Center during a December 2007 sub-surface and indoor air sampling event. Sampling has not been conducted since the 2007 event and would be worthwhile to determine if conditions have improved or degraded. If indoor air levels are found above standards, a mitigation system or other controls should be considered.

- ***Sampling Parameters***: methyl tertiary butyl ether (MTBE) should be added to the sampling parameters for the next annual event. If MTBE is found at levels of concern in monitoring wells, further analysis will be needed to determine additional investigation and remediation approaches.

Recommendations for cost reduction include the following:

- ***Improve Contracting Efficiency***:

    - Electricity costs should not be part of the fixed-fee payment to reduce markup and factor of safety costs. (This recommendation is made to potentially benefit the USVI Department of Planning and Natural Resources [DPNR]/Division of Environmental Protection [DEP].)

    - Having both CDM Federal Programs Corporation (CDM) and Arrowhead Contracting, Inc. (Arrowhead) provide project management should not be necessary. Eliminating or substantially reducing the project management from one of these parties should result in savings of approximately $30,000 per year.

- ***Consider Shut Down of GWTF #2***:

    - Consider a temporary shutdown of GWTF#2 to evaluate if it is providing meaningful remediation prior to GWTF #1 modifications. CVOC concentrations at MW-12D and RD-7 could be monitored to determine if the decreasing trends continue with GWTF #2 pumping suspended.

    - With effective capture at GWTF #1, the GWTF #2 influent will continue to decline. If not already terminated, GWTF #2 operation should be terminated as soon as GWTF #1 improvements are completed and hydraulic containment is confirmed by reduced downgradient concentrations (based on sampling at MW-12D and RD-7).

- ***Operation and Monitoring***:

    - Reduce number of site visits from daily to once or twice weekly. (This recommendation is made to potentially benefit the USVI DPNR/DEP.)

    - Well gauging frequency should be decreased from monthly to quarterly. Quarterly gauging will provide sufficient information for system operations.

- ***Eliminate GWTF Emissions Sampling***: Eliminate monthly air emission sampling at GWTF #1. Like GWTF #2, air emission mass calculations at GWTF #1 should be based on the assumption that 100% of VOCs in water are removed by the air stripper.

Recommendations for technical improvement include the following:

- Remove the excess pipe between the air stripper discharge and stack to reduce friction loss and required blower head. This should allow for a smaller (about 10 horsepower [HP]) unit to be used to replace the existing 15 HP unit even with the suggested increased flow associated with the new containment system. This is a technical improvement as well as a cost reduction factor due to reduced electricity usage.

- Consider installation of a variable frequency drive (VFD) which could be installed for the existing blower instead of installing a new smaller blower for a similar cost and cost reduction.

- If operation is expected to continue for many years, following optimization of the extraction system (assume to be complete by 2013), consider replacing the tray unit air stripper with a packed tower for additional yearly savings in electricity usage.

- Prior to making any changes, the air stripper design for the proposed extraction system should be evaluated based on proposed influent flow rates and concentrations to confirm blower requirements.

Recommendations for gaining site closure include the following:

- Alternative technologies are not appropriate for further consideration at this time. Focusing on improving containment at GWTF #1 is the key to reducing downgradient impacts and that GWTF #2 may not need to continue operating for much longer. A limited *in-situ* technology ERD action or *in-situ* chemical oxidation could be considered in the O'Henry's area if concentrations in this area persist several years after the improvements at GWTF #1 are made.

Recommendations for improved green remediation include the following:

- Treated water meeting drinking water standards is currently discharged to the storm sewer even though water is a precious commodity on St. Thomas. The water could be used for irrigation or commercial (car washing or laundromat) purposes nearby. Further efforts should be made to have the discharged water accepted for another use. This could possibly help eliminate illegal pumping of private wells for irrigation and commercial purposes.

Table 6-1 summarizes the recommendations, including estimated costs and/or savings associated with the recommendations and is presented in Section 6.0 of this report.

PREFACE

This report was prepared as part of a project conducted by the USEPA Office of Superfund Remediation and Technology Innovation (OSRTI). The objective of this project is to conduct independent, expert reviews of soil and groundwater remedies with public funding with the purpose of optimizing the remedy for protectiveness, cost-effectiveness, and green remediation. The project contacts are as follows:

Organization	Key Contact	Contact Information
U.S. EPA Office of Superfund Remediation and Technology Innovation (OSRTI)	Kathy Yager	U.S. EPA Technology Innovation and Field Services Division 11 Technology Drive (ECA/OEME) North Chelmsford, MA 01863 phone: 617-918-8362 yager.kathleen@epa.gov
Tetra Tech EM, Inc. (Contractor to USEPA)	Jody Edwards, PG	Tetra Tech EM, Inc. 1881 Campus Commons Drive, Suite 200 Reston, VA 20191 phone: 802-288-9485 jody.edwards@tetratech.com
Tetra Tech GEO (Contractor to Tetra Tech EM, Inc.)	Doug Sutton, P.E., PhD.	Tetra Tech GEO 2 Paragon Way Freehold, NJ 07728 phone: 732-409-0344 doug.sutton@tetratech.com

TABLE OF CONTENTS

Tables

Appendices

ACRONYMS AND ABBREVIATIONS

AOC	Administrative Order of Consent
Arrowhead	Arrowhead Contracting, Inc.
CDM	CDM Federal Programs Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
COC	Constituent of Concern
CVOC	Chlorinated Volatile Organic Compound
DCE	Dichloroethylene
DEP	Division of Environmental Protection
DNAPL	Dense Non-Aqueous Phase Liquid
DPNR	Department of Planning and Natural Resources
EPA	Environmental Protection Agency
ERD	Enhanced Reductive Dechlorination
FS	Feasibility Study
ft	feet
gpm	gallons per minute
GWTF	Groundwater Treatment Facility
HDPE	high density polyethylene
HP	horsepower
IC	Institutional Control
in	inches
“ H_2O	inches of water
IC	Institutional Control
KW hr	kilowatt hour
lbs	pounds
MCL	Maximum Contaminant Level
µg/L	micrograms per liter
mg/L	milligrams per liter
MNA	Monitored Natural Attenuation
msl	mean sea level
MTBE	Methyl Tertiary Butyl Ether
NPL	National Priorities List
OSWER	Office of Solid Waste and Environmental Response
OSRTI	Office of Superfund Remediation and Technology Innovation
%	percent
P&T	Pump and Treat
PCE	Tetrachloroethylene
PRP	Potentially Responsible Party
RA	Remedial Action
RAL	Remedial Action Levels
RAO	Remedial Action Objective
RCRA	Resource, Conservation and Recovery Act
RD	Remedial Design

REAC	Response, Engineering, and Analytical Contract
RI	Remedial Investigation
ROD	Record of Decision
RSE	Remediation System Evaluation
scfm	standard cubic feet per minute
SVE	Soil Vapor Extraction
TCE	Trichloroethylene
TOC	Total Organic Carbon
TSS	Total Suspended Solids
TPDES	Territorial Pollutant Discharge Elimination System
TSG	The Solutions Group Water Resources
UAO	Unilateral Administrative Order
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
USVI	United States Virgin Islands
VC	Vinyl Chloride
VFD	Variable Frequency Drive
VOC	Volatile Organic Compound
WAPA	USVI Water and Power Authority

1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000 and 2001 independent reviews called Remediation System Evaluations (RSEs) were conducted at 20 operating Fund-lead pump-and-treat (P&T) sites (i.e., those sites with P&T systems funded and managed by Superfund and the States). Due to the opportunities for system optimization that arose from those RSEs, United States Environmental Protection Agency (USEPA) Office of Superfund Remediation and Technology Innovation (OSRTI) has incorporated RSEs into a larger post-construction complete strategy for Fund-lead remedies as documented in *Office of Solid Waste and Environmental Response* (*OSWER) Directive No. 9283.1-25, Action Plan for Ground Water Remedy Optimization*, and has also started conducting RSEs at some Potential Responsible Party (PRP)-lead sites. A strong interest in green practices has also developed in the private and public sectors. Consistent with this interest, OSRTI has developed a Green Remediation Primer (http://cluin.org/greenremediation/) and, as a pilot effort now considers green remediation during independent evaluations.

The RSE process involves a team of expert hydrogeologists and engineers that are independent of the site, conducting a third-party evaluation of the operating remedy. It is a broad evaluation that considers the goals of the remedy, site conceptual model, available site data, performance considerations, protectiveness, cost-effectiveness, closure strategy, and green remediation. The evaluation includes reviewing site documents, potentially visiting the site for one day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Green remediation

The recommendations are intended to help the site team identify opportunities for improvements. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation, and represent the opinions of the evaluation team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the Region and other site stakeholders.

The Tutu Wellfield Superfund Site was selected by the USEPA OSRTI based on a nomination from USEPA Region 2. The site is located on the eastern end of St. Thomas, U.S. Virgin Islands (USVI) within the upper Turpentine Run surface drainage basin in the Anna's Retreat area. It is bounded by steep slopes and surrounding hills and lies slightly east of the city of Charlotte Amalie. There are two comingled groundwater contamination plumes at the site (Appendix A). The higher concentration, northern and upgradient plume has a source near the Curriculum Center. The southern and downgradient plume has a source near the O'Henry Dry Cleaners. Chemicals of concern (COC) in groundwater are specific chlorinated volatile organic compounds (CVOCs):

- Tetrachloroethylene (PCE)
- Trichloroethylene (TCE)
- cis-1,2-Dichloroethylene (cis-1,2-DCE)
- trans-1,2-Dichloroethylene (trans-1,2-DCE)
- Vinyl chloride (VC)

The groundwater remedy consists of two groundwater treatment facilities (GWTF). GWTF #1 includes groundwater extraction and treatment by air stripping near the Curriculum Center source and previously (2004 to 2006) also included soil vapor extraction (SVE). GWTF #2 includes groundwater extraction and air stripping at the downgradient end of the Curriculum Center plume just upgradient of the O'Henry plume (Southern Plume) (see Appendix A). The RSE provides an opportunity for an independent third-party review of these remediation efforts.

1.2 TEAM COMPOSITION

The RSE team consisted of the following individuals:

Table 1-1. Tetra Tech GEO RSE Team

Name	Affiliation	Telephone	Email
Peter Rich	Tetra Tech GEO	410-990-4607	peter.rich@tetratech.com
Greg Council	Tetra Tech GEO	770-619-9950	greg.council@tetratech.com
Kirby Biggs	USEPA/HQ TIFSD	703-823-3081	biggs.kirby@epa.gov

1.3 DOCUMENTS REVIEWED

The following documents were reviewed. The reader is directed to these documents for additional site information that is not provided in this report.

- April 2010 Annual Remedial Action Progress Report (CDM Federal Programs Corporation) – April 2010

- Five-Year Review Report (USEPA Region 2) – April 2009

- Work Assignment 0-291 – Air Sampling Trip Report (Lockheed Martin Technology Services) – March 2008

- Final Operations and Maintenance Manual Groundwater Treatment Facilities #1 and #2 Volume I of II (CDM Federal Programs Corporation) – June 2004

- Phase I Enhanced Anaerobic Bioremediation (EAB) Pilot Study Technical Memorandum (CDM Federal Programs Corporation) – December 2004

- Groundwater Modeling Report, Tutu Wellfield Site, Site-Wide Groundwater Remedial Design (CDM Federal Programs Corporation) – March 2002

- Record of Decision (USEPA Region 2) – July 1996

- Draft Final Phase II Remedial Investigation (Geraghty & Miller, Inc.) – January 1995

- Final Pre-Design Report: Tutu Wells (Groundwater), Tutu Wells (Soil) Remedial Design (CDM Federal Programs Corporations) – unknown date

1.4 PERSONS CONTACTED

The following individuals associated with the Tutu Wellfield Superfund Site were present for the visit:

Table 1-2. Participants of Site Visit

Name	Affiliation	Telephone	Email
Greg Council	Tetra Tech GEO	770-619-9950	greg.coucil@tetratech.com
Peter Rich	Tetra Tech GEO	410-990-4607	peter.rich@tetratech.com
Caroline Kwan	USEPA – R2	212-637-4275	kwan.caroline@epa.gov
Kirby Biggs	USEPA/HQ TIFSD	703-823-3081	biggs.kirby@epa.gov
Demetrios Klerides	CDM	212-785-9123	kleridesd@cdm.com
Chris Guenther	TSG	321-394-6661	cguenther@tsgwater.com
Bob Petersen	TSG	340-513-0447	bpetersen@tsgwater.com
Maritza Araud	DPNR/DEP	340-773-1082 ext.9023	maraudpza@hotmail.com
Diana Joshua	DPNR/DEP	340-774-3320 ext. 5277	diana.joshua@dpnr.gov

Note: DPNR/DEP = USVI Department of Planning and Natural Resources, Division of Environmental Protection

CDM Federal Programs Corporation (CDM) is the contractor to USEPA Region 2; the CDM project manager and support staff are based in New York. CDM subcontracts Arrowhead Contracting, Inc. (Arrowhead), based in Kansas City, to provide full service operation and sampling at the site. Arrowhead was the original installer of the treatment systems and they continue to provide engineering support and groundwater sampling services. Arrowhead subcontracts The Solutions Group Water Resources (TSG) to provide plant operations, process sampling services and other local support.

1.5 BASIC SITE INFORMATION AND SCOPE OF REVIEW

1.5.1 LOCATION

The Tutu Wellfield Superfund Site is a 1.5 square mile site located on the eastern end of St. Thomas, USVI within the upper Turpentine Run surface drainage basin in the Anna's Retreat area. The Turpentine Run surface drainage basin trends north-south and is ultimately bounded by steep slopes. Locally, the site is surrounded by densely developed commercial and residential areas including a school to the north of the main CVOC source. The nearest city is Charlotte Amalie which lies west of the site.

1.5.2 SITE HISTORY, POTENTIAL SOURCES, AND RSE SCOPE

The USEPA identified the following parties as potentially responsible for contributing to the contamination plumes at the Tutu Wellfield Superfund Site: Tutu Texaco Service Station, Esso Tutu Service Station, Ramsay Motor Company, Antilles Auto Parts, Virgin Island Housing Authority, Curriculum Center, O'Henry Dry Cleaners, Tillet Gardens and Western Auto. The largest contributor to the groundwater plumes was a source at the Curriculum Center (former LAGA Building). This building was owned and operated by LAGA Textile Company (LAGA), a clothing manufacturing plant, from 1969 to 1979 when it changed hands to Panex Co. until 1982. Extensive use of PCE occurred at the plant via an industrial size dry cleaning process that utilized the PCE as the dry cleaning solvent. Since 1982, the building has been used as a library, warehouse, and school offices. Groundwater contamination from this location is thought to have occurred from poor waste storage and disposal. Evidence suggests that volatile organic compound (VOC)-contaminated wastes were dumped into a sink at the rear of the building and wastes were discharged to the subsurface through an unidentified pipe to a suspected unlined sump/septic system. In addition, badly corroded and perforated 55-gallon drums were found abandoned at the site. Investigation of the site was initiated in July 1987. The 1996 Record of Decision (ROD) and the Five-Year Review (April 2009) provides the following information:

- July 1987: Investigation at the site begins pursuant to a complaint from Mr. Tillett, owner of Tillett Gardens, of an odor emanating from his groundwater supply well. Six supply wells are sampled in the Tutu area.

- July – September 1987: Groundwater sampling and screening investigation is expanded to include 24 supply wells. Based on groundwater sampling results, the USVI Department of Planning and Natural Resources (DPNR) closes 13 commercial and five private wells in the Tutu area.

- January 1988: USEPA initiates a limited Comprehensive Environment Response, Compensation, and Liability Act (CERCLA) removal action that includes the decontamination and cleaning of five residential cisterns contaminated by hazardous substances, modification of plumbing, delivery of water by tank truck as a temporary alternate water supply, and implementation of a well-water monitoring program.

- 1988 – 1990: USEPA sends Information Request letters under Section 104 of CERCLA and Section 3007 of the Resource, Conservation and Recovery Act (RCRA) to many businesses regarding operations and waste disposal at these businesses. Based on the findings, Unilateral Administrative Orders (UAOs) are issued to Texaco, Esso, and O'Henry Dry Cleaners to implement a well-water monitoring program, provide potable water to affected residents, and coordinate design plans to connect affected residents to public water supply.

- February 1992: A Hazard Ranking System package is prepared and the site is proposed for addition to the National Priorities List (NPL). USEPA issues Administrative Order of Consent (AOC) to Texaco and Esso to implement a Remedial Investigation (RI) and Feasibility Study (FS).

- 1992 – 1995: Various RI and FS activities are conducted.

- August 1994: Western Auto removes underground storage tank (UST) and paves the area with a concrete cap.

- March 1995: USEPA issues Consent Order to O'Henry Dry Cleaners for soil cleanup. Pursuant to the Order, O'Henry Dry Cleaners performs soil removal.

- September 1995: Tutu Wellfield Superfund Site is added to the NPL.

- August 1996: A ROD is signed.

- 1998: Construction completed for the Texaco Service Station groundwater and soil treatment system and Vitelco groundwater treatment system. Texaco Service Station system is placed in operation.

- May 1998: USEPA issues UAOs to Texaco, Esso, and Western Auto/Four Winds Plaza for Remedial Designs (RDs) and Remedial Actions (RAs) to address site contamination.

- August 1998 – November 1999: Pre-design investigation is performed for Curriculum Center soils and site-wide groundwater.

- 1999: Esso groundwater and soil treatment system construction is completed and system is placed in operation.

- January – February 1999: Pre-design investigation is performed at Western Auto/Four Winds Plaza.

- May 1999: USEPA issues UAO to O'Henry Dry Cleaners for RDs and RAs to address site contamination.

- November 1999: O'Henry Dry Cleaners performs pre-design soil delineation investigation.

- January 2000: USEPA approves No Further Action recommendation regarding ROD-specified soil contamination for Western Auto/Four Winds Plaza.

- July 2001: USEPA approves No Further Action recommendation for O'Henry Dry Cleaners.

- September 2001: USEPA completes design for Curriculum Center groundwater treatment and SVE system, and side-wide groundwater treatment.

- 2001 – 2002: Contaminated soils at Esso Service Station are excavated and treated in bio-cells. Esso "Hot-Spot" remediation system is constructed.

- 2002 – 2005: Operation of the Esso Service Station "Hot-Spot" remediation system occurs.

- July 2003: Texaco Service Station groundwater and SVE systems are shut down after a period of pulsed extraction.

- July 2003 – present: Monitored Natural Attenuation (MNA) activities are conducted for Texaco Service Station.

- March 2004: Site construction is completed for Curriculum Center soils and site-wide groundwater. System is placed in operation.

- March 2004 – March 2006: Operation, maintenance, and monitoring activities for Curriculum Center SVE and off-gas systems.

- March 2004 – present: Operation, maintenance, and monitoring activities performed for site-wide groundwater.

- 2005 – present: MNA activities are conducted for Esso Service Station.

- December 2006: Removal and replacement of three USTs and associated fuel lines are performed at the Texaco Service Station.

- January 2007: Enhanced bioremediation application is performed at the Texaco Service Station.

1.5.3 GEOLOGIC/HYDROGEOLOGIC SETTING

The geologic and hydrogeologic setting at the Tutu Wellfield Superfund Site is complex and includes overburden (surficial silty, clayey fill and weathered bedrock) and volcanic bedrock. In the March 2002 Groundwater Modeling Report, the aquifer system is divided into six layers which are described as follows:

> Layer 6 (Overburden) represents low-permeability, silt/clay overburden, excluding localized areas where it is known to be absent (e.g., bedrock outcrop, stream beds). The ground surface corresponds to the top of Layer 6. The thickness of Layer 6 was defined based upon existing boring logs and overburden thickness iso-contour maps and generally varies from 5 to 40 feet in thickness across the valley.

Layers 5 through 2 represent bedrock. Layers 5 (Upper Productive Zone), 4 (Lower Productive Zone), and 3 (Lower Aquifer) correspond to the productive aquifer zones, where groundwater flow predominantly occurs at the site along controlling fracture sets (i.e., "lineaments"), represented in the model as areas of higher hydraulic conductivity. Most of the extraction/supply wells and monitoring wells constructed at the site are screened within Layers 4 and/or 5. Layer 2 (Non-Productive Unit) corresponds to a non-productive portion of the aquifer. The thicknesses corresponding to Layers 4 and 5 (20-30 feet) each and Layer 3 (60-75 feet) were generally defined based upon the results of pump tests, drilling/coring logs, and down-hole geophysics. Layer 2 was assigned a constant thickness of 290 feet.

Layer 1 represents the deep bedrock. The base of the model (impervious boundary condition) corresponds to the bottom of Layer 1. The bottom of this layer corresponds to the depth of freshwater based upon the Ghyben-Herberg principle, and is beyond the influence of pumping at the Tutu Wellfield Superfund Site. This layer varies in thickness from 1,068 to 8,375 feet.

The weathered bedrock at the site is red-brown or greenish grey andesitic breccia with a clay matrix. The moderately weathered bedrock is underlain by lithified pyroclastic flow deposits consisting of green andesitic breccias, calcite veins, and iron staining along fractures.

1.5.4 POTENTIAL RECEPTORS

Based on discussions during the RSE site visit, the primary potential receptors are:

- Groundwater users: There are residential and commercial properties with groundwater wells within the contamination area. The DPNR issued Orders to close down those supply wells and the residential properties have been receiving potable water (by truck delivery). According to the terms of those Orders, authorization must be obtained from the Virgin Islands Government prior to the use of these existing wells or the installation of any new wells. However, it is suspected that sporadic illegal pumping of private wells for irrigation and commercial purposes may be occurring at the Site.

- Nearby residences/businesses: Nearby residences and businesses located above the plume are potential receptors via vapor intrusion.

1.5.5 DESCRIPTION OF GROUNDWATER PLUME

There are two CVOC (including PCE and its degradation products) groundwater contamination plumes associated with the Tutu Wellfield Superfund Site. Contaminants in the Northern Plume (upgradient plume) migrate southwest from north of the Curriculum Center. This plume extends vertically from 15 to 30 feet (ft) below ground surface (bgs) to approximately 80 ft bgs. Contaminants in the Southern Plume (downgradient plume) migrate southeast from O'Henry Dry Cleaners and along Turpentine Run. These two groundwater plumes are co-mingled. The contaminants above federal maximum contaminant levels (MCLs) for these two plumes are CVOCs. Maximum PCE concentrations from April 2010 (see Section 4.2.2) are 15,211 micrograms per liter (µg/L) and 85 µg/L near the Curriculum Center source and O'Henry's source, respectively. (The PCE Remedial Action Level (RAL) is 5 µg/L.)

Two petroleum product plumes (including benzene, toluene, ethylbenzene and xylenes) also existed on the site and near the Texaco and Esso Service Stations. These plumes appear to have been confined to smaller areas than the CVOC plumes and have been addressed by remediation efforts. The petroleum plumes appear to have had some impact on dechlorination of the CVOC plume at select locations near the petroleum plume sources. It appears that testing for methyl tertiary butyl ether (MTBE) has not been conducted. MTBE is a common gasoline additive that frequently migrates further from a source than other petroleum related compounds.

2.0 SYSTEM DESCRIPTION

The operating systems at the site include:

- GWTF #1: A groundwater extraction and treatment system to remediate the Northern Plume near the source. This system was also equipped with SVE capabilities which are no longer used.

- GWTF #2: A groundwater extraction and air stripping system to remediate the downgradient extent of the Northern Plume (“Northern Edge Plume”).

These active remedy components are discussed in more detail below.

2.1 EXTRACTION SYSTEMS

Extraction systems currently include only groundwater extraction wells:

- Groundwater Extraction – The groundwater extraction systems consist of five groundwater extraction wells. Three of these extraction wells (RW-6, RW-7 and RW-9) are connected to GWTF #1. RW-6 contains an electric submersible well pump with a ½ horsepower (HP) motor and is pumped weekly with approximately 120 gallons removed each week. RW-7, which formerly extracted groundwater and soil vapor, now only extracts groundwater. This well contains an electric submersible well pump with a 1.5 HP motor and variable frequency drive. It operates continuously at approximately 18 gallons per minute (gpm) to maintain a head level of 148 ft above mean sea level (msl). RW-9 contains an electric submersible well pump with a ¾ HP motor. It operates during system startup and during high rainfall events to supplement pumping from RW-7 to maintain the design head level.

  The remaining two extraction wells (RW-1 and RW-1S) are connected to GWTF #2. RW-1 is equipped with an electric submersible well pump with a ½ HP motor and is only operated periodically to prevent the pump from seizing. RW-1S contains an electric submersible well pump with a 1.5 HP motor. It operates at a continuous pumping rate of approximately 18 gpm to maintain a head level of 122 ft msl.

  The groundwater extraction wells each have separate 1.5 inch (in) high density polyethylene (HDPE) discharge lines to a manifold with a strainer, flow meter, check valve and isolation valves. Groundwater is transported to each of the treatment facilities via underground and above-ground piping. Electric power is run to the well pumps in conduit.

2.2 TREATMENT SYSTEMS

- GWTF #1: The separate 1.5-inch HDPE discharge lines are combined, and the blended influent passes through a digital flow meter. An influent equalization tank is present but is bypassed except when RW-6 is pumped and the higher concentration water from RW-6 is mixed with the RW-7 water prior to treatment. The water is treated with anti-scale (Caltrol 100) then put through two parallel 50 micron (µ) bag filters then another flow meter prior to a six-tray Carbonair air stripper. The air stripper has a 15 HP regenerative blower providing 360 standard cubic feet per minute (scfm) at approximately 60 inches of water (" H2O). Air is discharged directly to the atmosphere; a formerly used vapor treatment system is bypassed. Acid is added to the treated water to decrease the pH from the natural value of pH 9 to below the discharge limit for the storm drain (pH 8.3).

- GWTF #2: The separate 1.5-inch HDPE discharge lines are combined, and the blended influent passes through a digital flow meter. The equalization tank is bypassed. The water is treated with anti-scale (Caltrol 100) then put through two parallel 50µ bag filters then another flow meter prior to a six tray Carbonair air stripper. The air stripper has a 5 HP regenerative blower providing approximately 180 scfm. Air is discharged directly to the atmosphere. Acid is added to the treated water to decrease the pH from the natural value of pH 9 to below the discharge limit for the storm drain (pH 8.3).

2.3 MONITORING PROGRAM

The monitoring program at the site consists of daily, weekly, monthly, semi-annual, and annual sampling/monitoring events. These events include process sampling/monitoring, off-gas sampling, groundwater sampling, groundwater level monitoring, system checks and air stripper cleaning. The following is a schedule of sampling/monitoring events:

- Daily system checks are conducted for flow rates, pressure, and pH readings for both treatment facilities.

- Weekly effluent water process samples are collected from both treatment facilities to verify permit compliance. These samples are analyzed for total organic carbon (TOC) and total suspended solids (TSS). System acid is also batched (diluted for injection into the process water for pH adjustment) on a weekly basis.

- Monthly influent and effluent water process samples are collected to verify permit compliance. These samples are analyzed for VOCs. Off-gas samples are also collected on a monthly basis from the discharge stack of GWTF #1 and analyzed for VOCs. Air emissions are calculated monthly at GWTF #2 using the influent groundwater concentrations and an assumed 100 percent (%) VOC removal. Other monthly activities include groundwater level monitoring, bag filter change-outs and anti-scale batching.

- Semi-annual activities consist of cleaning the air stripper trays using an acid wash.

- Annual groundwater sampling is conducted at 30 groundwater monitoring wells and samples are analyzed for VOCs. Samples from five of the groundwater monitoring wells located in the Southern Plume (O'Henry's plume) area are additionally analyzed for natural attenuation parameters including nitrate, sulfate, chloride, TOC and ethane/ethene to determine the biological contribution to attenuation.

3.0 SYSTEM OBJECTIVES, PERFORMANCE, AND CLOSURE CRITERIA

3.1 CURRENT SYSTEM OBJECTIVES AND CLOSURE CRITERIA

The 1996 ROD identifies the following groundwater Remedial Action Objectives (RAOs):

- Remove and/or control the sources of groundwater contamination.

- Remove contamination in groundwater. Restore the aquifer to drinking water standards (Remedial Action Levels [USEPA MCLs at the date of the ROD]included in Table 3-1) except to the extent that such full groundwater restoration proves to be technically impracticable due to the presence of Dense Non-Aqueous Phase Liquids (DNAPLs).

- Control the migration of impacted groundwater.

- Prevent human ingestion of groundwater exhibiting excess lifetime cancer risk greater than 1 in 10,000 or a hazard index greater than 1.

- Eliminate leaching of contaminants of concern from soils into groundwater at concentrations which adversely impact groundwater quality and which might ultimately have negative ecological effects.

Table 3-1. Chemicals in Groundwater Above Remedial Action Levels (RALs)

Chemical of Concern	RAL (µg/L)
Vinyl chloride	2
1,2-Dichloroethene (total)	100
1,2-Dichlorethane	5
Trichloroethylene	5
Tetrachloroethylene	5
Benzene	5
Toluene	1000
Ethylbenzene	700
Xylenes (total)	10000
Aluminum	50 to 200
Antimony	5
Arsenic	50
Barium	2000
Beryllium	4
Chromium	100
Copper	1,300
Iron	300
Lead	15
Manganese	50
Mercury	2
Nickel	100
Thallium	2
Chloride	250,000
Nitrate	10,000,000

3.2 TREATED WATER DISCHARGE STANDARDS

The Tutu Wellfield Superfund Site is required to comply with the USVI DPNR Territorial Pollutant Discharge Elimination System (TPDES) permit limits, listed in Table 3-2:

Table 3-2. TPDES Permit Limits

Constituent	Permit Limit
CVOCs	99% removal or Non-Detect
TOC	< 20 mg/L
TSS	< 40 mg/L
pH	7.0 – 8.3

Notes: mg/L = milligrams per liter

The site team reports that these standards are not exceeded with the exception of occasional, brief pH excursions due to natural groundwater pH above 8.3.

3.3 VAPOR DISCHARGE STANDARDS

The Tutu Wellfield Superfund Site is required to comply with the USVI Air Pollution Control permit limits, listed in Table 3-3:

Table 3-3. Air Pollution Control Permit Limits

Constituent	Permit Limit (lbs per day)
PCE	0.42
TCE	0.16
cis-1,2-DCE	14.29
Vinyl chloride	0.01
Total CVOCs	14.48

The systems are operated with emissions far below these standards. Total VOC emissions from GWTF #1 and GWTF #2 combined are <0.05 lbs per day total VOCs and vinyl chloride is a minor (<5 % of total VOCs) constituent.

4.0 FINDINGS

4.1 GENERAL FINDINGS

The RSE team observed that the active remedy components are operated by capable and organized operators. The observations provided below are not intended to imply a deficiency in the work of the system designers, system operators, or site managers but are offered as constructive suggestions in the best interest of the USEPA and the public. These observations have the benefit of being formulated based upon operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of groundwater remediation have changed over time.

4.2 SUBSURFACE PERFORMANCE AND RESPONSE

4.2.1 PLUME CAPTURE

Plume capture was evaluated for each of the two active groundwater extraction systems operated by the site team. Plume capture was assessed by:

(a) Reviewing potentiometric surface maps generated from water-level measurements;

(b) Reviewing measured concentrations of CVOCs in groundwater wells downgradient of extraction wells;

(c) Calculating the expected flow needed for capture using available estimates of aquifer transmissivity, hydraulic gradient, and plume width; and,

(d) Reviewing the results of numerical groundwater modeling.

This approach to evaluating plume capture is consistent with USEPA guidelines documented in *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (EPA 600/R-08/003). Under these guidelines, adequate capture is indicated if the weight of evidence obtained from evaluations such as those listed above suggests that the plume (or target capture zone) is being captured under prevailing conditions.

4.2.1.1 **Curriculum Center Area (GWTF #1) Plume Capture Evaluation**

It is assumed in this discussion that a primary goal of the GWTF #1 extraction system is to capture the CVOC plume where the total CVOC concentration is greater than 100 µg/L. This is consistent with the April 2009 Five-Year Review Report which noted that natural attenuation was appropriate for total CVOC concentrations below 100 µg/L.

Potentiometric Surface Evaluation

The first figure in Appendix A shows the interpreted potentiometric surface in and around the CVOC plume(s) associated with the Tutu Wellfield Superfund Site in April 2010. The northern and upgradient end of the plume is at the Curriculum Center near GWTF #1. In this area, the potentiometric contours (particularly at 175 feet above mean sea level) are interpreted by the contractor (CDM) to bend in a way that suggests converging flow (toward the extraction wells). However, the exact location and shape of these contours is not entirely supported by the water-level data posted on the map (two of the four water levels posted upgradient of the 175-ft contour are less than 175 ft). It is likely that the shape of the head contours reflects the conceptual model of groundwater flow converging from the east and west into the bedrock valley that controls the migration of the regional CVOC plume. In any case, the contours as drawn suggest that the capture width from extraction wells RW-7 and RW-9 would be approximately 75 ft or less. However, the 100-µg/L CVOC plume is approximately 200 ft wide in this area. Water-level data at approximately twelve wells in very close proximity to the extraction wells (within approximately 100 ft of RW-7) could probably be analyzed in further detail on a zoomed-in map to better define the shape of potentiometric contours and capture zone. For such an analysis, measured water-levels at active extraction wells should not be used due to well losses. However, this type of analysis could be complicated by vertical hydraulic gradients. It does not appear that such an analysis would indicate a capture zone width greater than approximately 75 ft and certainly it would be much less than 200 ft.

Based on the above review, the potentiometric-surface data presented for April 2010 suggest that extraction at RW-7 (with intermittent extraction at RW-9 and RW-6) does not capture the entire width of the CVOC plume.

Evaluation of CVOC Concentrations

Concentrations at most of the monitoring wells in the vicinity of GWTF #1 have decreased since installation of the system (Table 4-1). The nearest monitoring wells downgradient of the GWTF #1 extraction wells are MW-1D and RD-13. The total CVOC concentration at MW-1D has decreased from 701 µg/L to 125 µg/L from 2004 to 2010. However, the concentration at RD-13 has shown very little decrease in that period: from 780 µg/L to 736 µg/L. RD-13 is screened approximately 30 ft deeper than MW-1D. Wells on the western fringes of the plume downgradient of the GWTF #1 extraction wells have shown either increasing concentrations (MW-14) or slightly decreasing concentrations (MW-15).

The most likely explanation for these trends is that groundwater extraction at RW-7 (and occasionally at RW-9 and RW-6) is capturing a portion of the highest-concentration CVOC plume, but not all of the plume. Meanwhile, natural attenuation mechanisms (e.g., biodegradation, dispersion) are also slowly reducing dissolved-phase concentrations in some areas such as along lateral plume edges. Portions of the plume exceeding 100 µg/L, 500 µg/L, and probably even 1,000 µg/L are apparently migrating beyond the extraction wells. The interpreted CVOC concentration contours shown in Appendix A (CDM interpretation) do not close or break at the extraction wells in a manner that would indicate capture.

This evaluation of CVOC concentrations near GWTF #1 suggests that capture from the associated extraction system is incomplete.

Table 4-1. Total CVOC Remediation from 2004 to 2010

Area	Well ID	2004 CVOC Concentration (µg/L)	2010 CVOC Concentration (µg/L)
GWTF #1 (Northern Plume, near source)	MW-1D	701	125
	MW-13D	0	2
	MW-14	11	23
	MW-15	55	39
	MW-2	11	1
	MW-6D	31	2
	MW-7	1	19
	RD-13	780	736
	RD-9	152,020	15,211
	RD-5	204	70
	TT-6	165	28
	Tillett	100	36
	MW-10D	48	3
	MW-24	26	2
	MW-8	44	2
GWTF #2 (Northern Plume, downgradient extent)	DW-2	16	1
	Eglin-3	33	48
	MW-11D	0	4
	MW-12D	71	12
	RD-7	74	7
Southern Plume	Delegard	12	1
	Laplace	24	5
	MW-21D	72	31
	RD-1	6	1
	RD-2	1	0
	RD-3	4	0
	RD-6	8	0
	RD-8	14	3
	Smith	11	4
	Steele	169	85

Calculation of Expected Flow for Capture

Simple calculations can be made to estimate the flow that would be needed to fully capture the plume. Such calculations are described in the USEPA guidance on capture-zone evaluation. While the calculations assume ideal and non-realistic conditions (e.g., homogeneity, two-dimensional porous-media flow, no recharge), they are informative for making initial approximations of extraction rates required for hydraulic containment.

One of the simplest calculations provides an estimate of minimum flow (Q) needed for capture of a plume of known width (w) given uniform aquifer transmissivity (T) and hydraulic gradient (J): $Q = TJw$. The aquifer transmissivity is the product of aquifer hydraulic conductivity and aquifer thickness: $T = Kb$.

For purposes of this evaluation, it is assumed that the target capture zone is the CVOC plume greater than 100 µg/L (total) at the Curriculum Center. It is assumed that lower concentrations of CVOCs would be remediated by natural attenuation or captured in the downgradient system at GWTF #2. The width (*w*) of the target capture zone is approximately 200 ft as measured from the figure in Appendix A.

Using this same figure, the hydraulic gradient (*J*) is estimated to be 0.02 (10 ft head drop over approximately 500 ft distance) on average at the Curriculum Center. However, the gradient apparently increases toward the south and is somewhat uncertain. Therefore, calculations were made using a reasonable range of hydraulic gradient between 0.015 (5 ft drop over 330 ft) and 0.025 (5 ft drop over 200 ft).

In a 2002 groundwater modeling report, CDM reviewed aquifer-test data and conducted groundwater-model calibration to estimate aquifer characteristics. They estimated that the productive portion of the bedrock aquifer in the Curriculum Center area has an effective hydraulic conductivity (*K*) of 40 feet/day (ft/d). Recognizing that this is an uncertain estimate, a reasonable hydraulic-conductivity range of 30 to 50 ft/d is used in making capture-zone flow calculations.

Based on the layer information presented by CDM (Appendix A) and based on boring logs and well depth details, it appears that the upper, productive portion of the bedrock aquifer is approximately 50 ft thick (from water table to base of productive zone). This thickness (*b*) is also uncertain and variable, and a reasonable range of 30 to 70 ft is used in capture-zone flow calculations.

Table 4-2 shows the calculation of transmissivity (*T*) and minimum flow required for capture (*Q*) using best-estimate, low-end, and high-end values for hydraulic conductivity (*K*), aquifer thickness (*b*), and hydraulic gradient (*J*).

It is noted that the best-estimate transmissivity (*T*) is in good agreement with the aquifer-test results presented by CDM in their 2002 modeling report. As a best-estimate calculation by this method, at least 42 gpm would be required to capture the plume at the 100 µg/L CVOC level. If low-end values are used for all input parameters, then the required flow rate would drop to 14 gpm (a very optimistic scenario). Conversely, if high-end assumptions are made, the required flow would be 91 gpm (a very conservative scenario). A factor of safety of 1.5 to 2.0 is also often applied to account for some of the simplifying assumptions associated with this capture zone calculation method. This factor of safety, if applied would further increase the estimated extraction rate required to provide capture of the 100 µg/L contour.

The actual extraction rate averages 18 gpm at GWTF #1. By this analysis, this flow is adequate for capture only if very optimistic assumptions are used for the input assumptions. Again, this analysis suggests that, most likely, the plume is not being captured by the existing extraction system at GWTF #1.

Table 4-2. Calculation of Flow Required for Capture at Curriculum Center

Parameter		Low Estimate	Best Estimate	High Estimate	Comments
Hydraulic Conductivity	*K* (ft/d)	30	40	50	CDM Modeling Report (3/26/2002) (Table 2-2)
Aquifer Thickness	*b* (ft)	30	50	70	Review of Cross Sections, Well Depths
Transmissivity	T (ft^2/d) = $K * b$	900	2000	3500	Agrees with CDM Modeling Report (Table 2-1)
Hydraulic Gradient	*J*	0.015	0.02	0.025	Measured from CDM 4/2010 Pot. Surf. Map
Target Capture Zone Width	*w* (ft)	200	200	200	Measured from CDM 4/2010 Plume Map
Required Flow Rate	Q (ft^3/d) = $T * J * w$	2700	8000	17500	
	Q (gpm)	14	42	91	

Note: The above calculations do not include a factor of safety to account for simplifying assumptions associated with this capture zone calculation.

4.2.1.2 Northern Plume Edge (GWTF #2) Plume Capture Evaluation

The total CVOC concentration at the GWTF #2 extraction well (RW-1S) is approximately 25 µg/L, with only PCE above its RAL of 5 µg/L. It is assumed in this discussion that a desired outcome of GWTF #2 extraction is to capture the CVOC plume where the total CVOC concentration is greater than 10 µg/L. This would result in all CVOCs meeting (or very nearly meeting) RALs at downgradient points.

Potentiometric Surface Evaluation

Review of the map in Appendix A indicates that there are insufficient water-level data in the vicinity of RW-1S from which to draw a potentiometric surface of sufficient detail to evaluate plume capture near GWTF #2.

Evaluation of CVOC Concentrations

Concentrations of CVOCs in monitoring wells downgradient of RW-1S have declined significantly since 2004 (Table 4-1: e.g., MW-12D, RD-7). However, MW-12D continues to have total CVOCs above 10 µg/L. The declines in CVOC concentrations have been similar to declines in wells upgradient of RW-1S (e.g., MW-10D, MW-8). It is therefore not clear whether pumping at RW-1S is having a significant effect on groundwater CVOC concentrations at downgradient wells MW-12D and RD-7.

Calculation of Expected Flow for Capture

As depicted in Appendix A, the width (*w*) of the 10-µg/L plume is approximately 75 ft at RW-1S. Using the same best-estimate assumptions for hydraulic conductivity (K = 40 ft/d), thickness (b = 50 ft), and hydraulic gradient (J = 0.02), as used for the calculation of capture flow at the Curriculum Center, the estimated extraction rate required for capture is at least 16 gpm. This estimate compares well with the actual average extraction rate of 18 gpm. However, the extraction appears to be occurring at the western edge of the plume rather than at the center, and the eastern extent of the plume is uncertain. The 16 gpm estimate also does not account for a factor of safety to address the simplifying assumptions associated with the calculation. Therefore, it is not clear whether the 18 gpm extraction rate is sufficient for full capture of the of the 10 µg/L plume.

4.2.1.3 **Combined Northern Plume Capture Evaluation**

When initially designed, the extraction systems at GWTF #1 and GWTF #2 were expected to work together in containing the entire northern portion of the CVOC plume (not including the plume apparently originating at the O'Henry dry cleaning facility). CDM conducted modeling evaluations to determine the design flow rates at the two facilities.

Review of Groundwater Modeling Results

Numerical groundwater modeling was previously conducted by CDM (in 2002) to evaluate extraction rates necessary for plume capture. Numerical groundwater modeling overcomes many of the simplifying assumptions required to apply simple calculations such as those described above. Numerical modeling can result in more realistic estimates of capture, especially where the hydrogeologic setting is complex and/or where extraction is distributed geographically to different wells in a somewhat complex manner.

At that time of the CDM modeling analysis there were groundwater extraction systems operating at the Texaco and Esso stations near the Curriculum Center. These two systems have since been shut off.

CDM estimated through model scenarios that total extraction of between 30 and 36 gpm would be required to capture the Northern Plume (Curriculum Center) (>100 µg/L total CVOCs) during "average" recharge conditions. The total extraction required during wet/peak recharge periods was estimated to be between 63 and 73 gpm. This total extraction amount includes extraction at the Curriculum Center, the two gasoline stations, and the Northern Plume Edge (near GWTF #2).

Currently, the total extraction at GWTF #1 and GWTF #2 is approximately 36 gpm, and is consistent with the model-estimated extraction required for capture under average conditions. While the estimated required total extraction rate is comparable to the current actual extraction, it is not known if the particular placement of wells and extraction rates currently used would result in modeled capture with the service-station extraction wells removed.

The RSE team did not conduct a comprehensive review of the model development and calibration. The RSE team therefore cannot confirm the accuracy of the model predictions.

4.2.1.4 **Overall Assessment of Capture**

Based on the above evaluations, the weight-of-evidence approach to capture-zone evaluation suggests the following:

- Only a small part of the high-concentration portion of the CVOC plume is being captured by the GWTF #1 extraction system at the Curriculum Center.

- Capture of the 10-µg/L CVOC plume at RW-1S (GWTF #2) is uncertain.

4.2.2 GROUNDWATER CONTAMINANT CONCENTRATIONS

Groundwater concentrations of CVOCs have declined significantly with the SVE and groundwater extraction implementation (2004 versus 2010 data) across the site. Table 4-1 shows total CVOC concentrations from March 2004 (Baseline) and April 2010 at various wells associated with GWTF #1, GWTF #2 and the Southern Plume (O'Henry's plume).

However, recent progress to reach RAOs has been relatively stalled with concentrations remaining elevated and stable at many wells. For example, the CVOC concentration at RD-9 remains over 15,000 µg/L, the CVOC concentration at RD-13 has remain unchanged at 700 µg/ for approximately six years, and concentrations at MW-14 and MW-15 have remained relatively constant at levels in the 10 µg/L to 50 µg/L range.

4.2.3 INSTITUTIONAL CONTROLS TO PREVENT USE OF IMPACTED GROUNDWATER

The following description is provided in the 2009 Five-Year Review regarding the procedures for preventing use of impacted groundwater:

> *The remedy included institutional controls [ICs] in the form of Governmental controls and/or proprietary controls to prohibit unauthorized use of groundwater or the installation of new wells including decommissioning of existing domestic and commercial wells within the confines of the groundwater plume. In March 2003, the VI Government prepared and IC workplan pursuant to the executed State Superfund Contract to implement appropriate governmental and/or proprietary controls on these properties. This IC workplan cited specific local laws to prohibit withdrawal or removal of any water and soil without first obtaining a permit from the Commissioner of DPNR. As of April 2009, the IC workplan has been implemented with the exception of seven wells which were identified in the IC workplan. These wells were installed prior to the enactment of these local laws. EPA is working closely with the VI government to ensure that the owners of these wells will comply with pertinent local laws.*

Allegedly, illegal pumping of private wells for irrigation and commercial purposes has been occurring in wells located in the plume areas.

4.2.4 SOIL VAPOR EXTRACTION/VAPOR INTRUSION

As previously noted, GWTF #1 is equipped with SVE capabilities which are no longer used. The SVE system was in operation from 2004 to 2006 and included extraction points SVE-1 and RW-7. The system operation was discontinued in April 2006 when mass removal had decreased and the SVE system was no longer cost-effective. At that time, SVE influent concentrations had significantly decreased since start-up and an asymptotic pattern was established.

In December 2007, Lockheed Martin personnel under the Response, Engineering, and Analytical Contract (REAC) installed and sampled 16 soil vapor intrusion monitoring points under the floor of the Curriculum Center building. Of these 16 locations, three were installed in the maintenance area, nine in the warehouse area, and four in the curriculum area. At the same time, 30 indoor air samples were collected: three from the maintenance area, 12 from the warehouse area and 15 from the curriculum area. Also, two ambient air samples were collected. The analytical results are presented in Table 4-3.

Table 4-3. Analytical Results of Vapor Intrusion Study

	Sub-Slab Samples				Indoor Air Samples		
Location	**# Samples Collected**	**PCE Exceed.**	**TCE Exceed.**		**# Samples Collected**	**PCE Exceed.**	**TCE Exceed.**
Maintenance Area	3	3	2		3	2	0
Warehouse Area	9	8	5		12	0	0
Curriculum Area	4	4	0		15	0	0
Total	**16**	**15**	**7**		**30**	**2**	**0**

Note: PCE Action Levels: 100 µg/m³ for sub-slab; 10 µg/m³ for indoor air. TCE Action Levels: 5 µg/m³ for sub-slab; 0.5 µg/m³ for indoor air.

Soil vapor and indoor air sampling has not been conducted since 2007. The SVE equipment is still at the site and potentially could be used for future operation of a vapor intrusion mitigation system, if needed.

4.3 COMPONENT PERFORMANCE

4.3.1 GROUNDWATER EXTRACTION SYSTEM

The groundwater extraction system consists of five Grundfos electric submersible pumps with varying horsepower motors. At GWTF #1 during the reporting period from May 1, 2009 to April 30, 2010, RW-6 operated for 1.0 to 1.5 hours weekly and pumped approximately 520 gallons per month. RW-7 pumped at approximately 15 gpm continuously and RW-9 was non-operational during this reporting period. Through this reporting period, about 6.7 million gallons of groundwater were extracted, bringing the total of groundwater extracted from system startup through April 30, 2010 to 58.3 million gallons.

At GWTF #2, during the reporting period from May 1, 2009 to April 30, 2010, RW-1 was non-operational and RW-1S pumped at an average rate of 16 gpm. Through this reporting period, about 8.1 million gallons of groundwater were extracted, bringing the grand total of groundwater extracted from system startup through April 30, 2010 to 51.3 million gallons.

4.3.2 TREATMENT SYSTEM FOR EXTRACTED WATER

During the operating period from May 1, 2009 to April 30, 2010, GWTF #1 was in operation 95.6 % of the time. Down-times were typically due to power losses. CVOCs are typically removed by the air stripper to below detection limits. No significant operational problems were encountered.

During this monitoring period, GWTF #2 was in operation 96.4 % of the time. Similarly to GWTF #1, down-times were typically due to power loss. CVOCs are typically removed by the air stripper to below detection limits. No significant operational problems were encountered.

4.3.3 VOCs Removed by Systems

The groundwater system at GWTF #1 currently has total VOC influent concentrations of approximately 125 µg/L which results in a mass removal of approximately 8 pounds (lbs) per year. The groundwater system at GWTF #2 currently has total VOC influent concentrations of approximately 25 µg/L, for a mass removal of approximately 1.5 lbs per year.

4.4 Components Or Processes That Account For Majority of Annual Costs

Annual cost estimates for operating this remedy are summarized below (Table 4-4), based on information provided by the site team and/or estimated by the RSE team based on discussions with the site team.

Table 4-4. Annual Operations and Maintenance Costs

Item Description	Approximate Annual Cost
CDM Project Management supporting USEPA	$40,000
Arrowhead Fixed Fee	$279,600
Project Management	*$30,000*
Materials	*$33,600*
TSG Labor	*$103,200*
Power ($0.36/kWh.)	*$105,600*
Equipment Costs	*$7,200*
Annual Sampling	$13,000
CLP Costs (well monitoring)	$6,000
CLP Costs (process monitoring)	$13,000
Total Annual Operating Cost	**$351,600**

Notes: Italicized = cost included in Arrowhead's fixed fee.
kWh. = kilowatt hour

Additional details regarding these items are provided below.

4.4.1 Project Management

CDM provides project management support to USEPA for approximately $40,000 per year. This value does not include water supply or technical and litigation support. Arrowhead also provides $30,000 of project management type services (see Section 4.4.2).

4.4.2 Arrowhead Fixed Fee

CDM contracts Arrowhead for a fixed monthly fee of approximately $23,300 per month ($279,600 per year). From the fixed fee, Arrowhead pays TSG approximately $8,600 per month ($103,200 per year) for operating the systems. Approximately $2,500 per month ($30,000 per year) is used towards Arrowhead's project management, data validation, and engineering support.

4.4.3 Materials

Materials cost approximately $2,800 per month ($33,600 per year) of which acid is about $800 per month ($9,600 per year) and anti-scale is about $1,200 per month ($14,400 per year).

4.4.4 Utilities

The major utilities associated with both systems are electrical costs. This along with a few other utility costs is approximately $8,800 per month ($105,600 per year). Currently, the rate for electricity on the island is approximately $0.36 per kWh, which translates to an approximate electricity usage of 290,000 kWh per year. The air stripper blowers (15 HP at GWTF #1 and 5 HP at GWTF #2) are the largest users of power. The 15 HP blower uses approximately $45,000 per year of power assuming the motor is operating at about 75 % efficiency.

4.4.5 Sampling

Annual sampling is conducted by Arrowhead with TSG assistance and costs approximately $13,000 per year for sampling 30 wells. Additional analysis costs include $6,000 per year Contract Laboratory Program (CLP) costs for groundwater monitoring and $13,000 per year for process monitoring.

4.5 Approximate Environmental Footprints Associated with The Remedy

Direct energy usage for the site includes electricity and diesel/gasoline associated with materials transportation. The large majority of the energy use is associated with electricity use, which is generated from combustion of fuel oil. Based on emissions factors from the National Renewable Energy Laboratory Life-Cycle Inventory Database (www.nrel.gov/lci), each kWh of electricity generated from combusting oil emits approximately 2 lbs of carbon dioxide, 0.002 lbs of nitrogen oxides, and 0.0005 lbs of sulfur dioxides. Using these values, the approximate 290,000 kWh of electricity usage for the Tutu Wellfield Superfund Site results in the emission of 580,000 lbs of carbon dioxide, 580 lbs of nitrogen oxides, and 145 lbs of sulfur oxides each year. Actual emission factors are likely higher if resource extraction and transmission and distribution losses are considered.

Monthly system effluent air samples are collected to ensure compliance with the Air Pollution Control Permit. The constituents monitored include PCE, TCE, cis-1,2-DCE and vinyl chloride. Emissions of other pollutants may also be of concern, but these common pollutants were selected because emissions information is more readily available for them and they may be adequate indicators for other potential air emissions. Air emissions due to operation and maintenance of both groundwater systems are summarized in Tables 4-5 and 4-6.

Table 4-5. Summary of GWTF #1 Air Emissions

Constituent Emitted into Atmosphere	Emissions (lbs/yr)
PCE emissions	4.43
TCE emissions	0.43
cis-1,2-DCE emissions	3.21
Vinyl Chloride	0.14

Note: PCE, TCE, and Vinyl Chloride are carcinogens.
Values based off of daily emission rates for May 2009 through April 2010 from April 2010 Annual Remedial Action Progress Report (CDM Federal Programs Corporations) – October 2010.

Table 4-6. Summary of GWTF #2 Air Emissions

Constituent Emitted into Atmosphere	Emissions (lbs/yr)
PCE emissions	<0.97
TCE emissions	<0.16
cis-1,2-DCE emissions	<0.33
Vinyl Chloride	<0.05

Note: PCE, TCE, and Vinyl Chloride are carcinogens.
Values based on daily emission rates for May 2009 through April 2010 from April 2010 Annual Remedial Action Progress Report (CDM Federal Programs Corporations) – October 2010.

With respect to water usage, essentially all of the water use is from the groundwater extraction systems. The water that is extracted and treated from these systems is discharged into the storm sewer, and therefore is unavailable as a resource for groundwater usage.

Waste disposal associated with this remedy is minimal. With respect to more qualitative issues, the remedy does not cause any significant aesthetic issues (noise, visual, odor) and there are no major traffic issues associated with the remedy that would impact the surrounding land or ecosystems.

4.6 RECURRING PROBLEMS OR ISSUES

- Allegedly, illegal pumping of private wells for irrigation and commercial purposes has been occurring in wells located in the plume areas.
- USVI Water and Power Authority (WAPA) power outages.

4.7 REGULATORY COMPLIANCE

During the RSE process, the site team did not report any exceedances of discharge standards or other compliance related standards other than some minor pH excursions.

4.8 SAFETY RECORD

During the RSE process, the site team did not report any health and safety concerns or incidents related to the remedial activities.

5.0 EFFECTIVENESS OF THE SYSTEMS TO PROTECT HUMAN HEALTH AND THE ENVIRONMENT

5.1 GROUNDWATER

The following protectiveness statement was included in the 2009 Five-Year Review:

> *Implemented actions protect human health and the environment in the short term. Currently, there are no exposure pathways that could result in unacceptable risks and none are expected, as long as the site use does not change and the implemented engineered and institutional controls are properly operated, monitored, and maintained.*
>
> *However, in order for the site to be protective in the long term the (*following issues) *need to be resolved:*
>
> - *The source area Institutional Controls (ICs) not fully implemented.*
> - *Full remediation of the groundwater is uncertain.*
> - *Some monitoring wells are damaged.*

The site team alleged that there is probably illegal pumping of private wells for irrigation and commercial purposes in the plume area.

5.2 SURFACE WATER

The site team reported that sampling at the surface water discharge point indicated no detection of CVOCs. The RSE did not focus on surface water.

5.3 AIR

The RSE team noted that based on a study completed in 2007, vapor intrusion is a potential issue in the warehouse/Curriculum Center. Vapor intrusion is not likely to be an issue at other buildings based on the decreased concentrations downgradient of the Curriculum Center.

5.4 SOIL

Not addressed as part of the RSE.

5.5 WETLANDS AND SEDIMENTS

Not addressed as part of the RSE, but not expected to be a concern.

6.0 RECOMMENDATIONS

Cost estimates provided herein have levels of certainty comparable to those done for CERCLA Feasibility Studies (-30 %/+50 %), and these cost estimates have been prepared in a manner consistent with USEPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July, 2000.

The estimated effects on costs and green remediation associated with the recommendations provided in this section are summarized in Tables 6-1 and 6-2, respectively.

6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS

6.1.1 HYDRAULIC CONTAINMENT

As indicated in Section 4.2.1, the interpreted capture zone associated with GWTF #1 is small relative to the size of the high-concentration portion of the plume (e.g., greater than 100 µg/L CVOCs). RW-7 is too far upgradient to effectively contain the Curriculum Center source area. A new containment system including a line of wells perpendicular to the flow direction screened through the shallow and deep zones near RD-13 (300 ft downgradient) should be considered. The plant is designed for up to 60 gpm so additional flow can be taken.

Based on preliminary calculations/evaluations presented in Section 4.2.1, the total extraction rate required to capture the 100-µg/L CVOC plume is approximately 50 gpm. This is based on the best-estimate calculation of capture flow presented in Table 4-2, with a safety factor of 1.2. It is also consistent with total extraction rates estimated in prior groundwater modeling (CDM 2002; 50 gpm is between flows required for average and wet/peak conditions).

To attain 50 gpm extraction, approximately four new extraction wells are likely to be needed, each capable of pumping up to approximately 18 gpm (similar to the extraction rate at existing well RW-7). This will allow 50 gpm to be attained when one well is off line for maintenance. The number and spacing of wells to add should be evaluated based on: (1) review of the available geologic information and the currently available hydrogeologic data (e.g., boring logs for existing/past nearby monitoring and pilot scale treatment wells and historical water level data under operating conditions); and (2) field testing (e.g. specific-capacity testing) of the new wells during installation. The new extraction well system should be designed to attain capture of the high-concentration portion of the CVOC plume; this will also address deep contamination that slowly partitions upward into the capture zone of the extraction system.

The addition of four new extraction wells would cost approximately $180,000. This includes drilling four approximately 100 ft deep extraction wells, well pumps, vaults, and installing piping and conduit to each well (approximately 300’ from GWTF #1). We include an assumed 50% premium for doing this work and other work in the USVI. Operating and sampling the additional extraction wells would require approximately $15,000 per year which is mainly for power for the pumps. The existing air stripper is sized for the increased flow rate.

In addition to installing a new containment system, it is recommended that two monitoring wells be installed east of the depicted plume where data to define plume extents are lacking. This would cost approximately $30,000. Potential locations for two new monitoring wells are: (1) approximately 150 ft southeast of existing well RD-5; and (2) approximately 150 east of existing well MW-10D (see Appendix A for existing well locations). The number and location of new monitoring wells can be adjusted based on access restrictions, availability of groundwater concentration information not reviewed during this RSE, or other available hydrogeologic information.

Monitoring costs for these new wells can be offset by removing redundant existing wells from the sampling program such as RD-1, RD-2 and RD-6.

6.1.2 NO ADDITIONAL DOWNGRADIENT ACTIVE REMEDIATION

The site team has not actively contained or treated groundwater impacts from the O'Henry's remaining source. CVOC concentrations at the Steele well and wells further downgradient have decreased over time and the plume size has decreased. The site team has analyzed for natural attenuation parameters to help determine the biological portion of the plume reduction. The site team has put controls in place to protect potential receptors in this area. We do not recommend changes in the current approach. Improved containment at GWTF #1 may increase the rate of concentration decreases. If continued monitoring does not show continued decreases in plume size, the site team could consider further investigation and remediation (perhaps chemical oxidation or enhanced bioremediation at the O'Henry's site).

6.1.3 VAPOR INTRUSION RESAMPLING

Vapor intrusion was detected in the Curriculum Center during a December 2007 sub-surface and indoor air sampling event. Sub-slab CVOC concentrations were elevated above screening guidance levels for sub-slab and indoor air concentrations for most locations sampled and indoor air quality samples in the maintenance area were elevated. Sampling has not been conducted since the 2007 event and would be worthwhile to determine if conditions have improved or degraded. A similar study with up to 12 sampling points for sub-slab and indoor air concentrations should be considered. If indoor air levels are found above standards, a mitigation system or other controls should be considered (components from the mothballed SVE system could potentially be used). The RSE team defers to the site team for costs of conducting this investigation because the site team likely has cost information associated with the 2007 event. For cost evaluation purposes, we assume the study would cost $45,000.

6.1.4 SAMPLING PARAMETERS

MTBE should be added to the sampling parameters for the next annual event at a cost of less than $1,000. If MTBE is found at levels of concern in monitoring wells, further analysis will be needed to determine additional investigation and remediation approaches. For cost evaluation purposes, we assume MTBE will not be found at elevated levels.

6.2 Recommendations to Reduce Costs

6.2.1 Improve Contracting Efficiency

Electricity costs should not be part of the fixed-fee payment. Arrowhead has no control over the unit cost for power and will have to put a factor of safety and markup in to cover unexpected increases. CDM will also mark this cost up. With an assumed 5% markup by Arrowhead, 5% contingency by Arrowhead, and 5% markup by CDM, removing power from the fixed-fee payment could save approximately $15,000 per year.

Three levels of contracting are excessive and having both CDM and Arrowhead provide project management should not be necessary. Eliminating or substantially reducing the project management from one of these parties should result in savings of approximately $30,000 per year. CDM has provided the RSE team with a cost for project management but not for litigation support and community issues. The RSE team therefore cannot comment on the litigation support and community related services provided by CDM or the cost for those services.

Because of the projected April 17, 2013 date for turnover of O&M responsibility to the USVI DPNR/DEP, we understand that USEPA's contracting requirements would not allow cost savings prior to the turnover date. We also understand that the USEPA cannot pay the electrical costs directly. This recommendation, therefore, is made to potentially benefit the USVI DPNR/DEP; the cost savings shown in Table 6-1 reflect a change made in 2013.

6.2.2 Consider Shut Down of GWTF #2

GWTF #2 is located at the downgradient end of the Curriculum Center (northern) plume. Groundwater extraction and treatment at GWTF#2 appears to provide little benefit to controlling plume migration or restoring the aquifer. Concentrations in wells upgradient (MW-8 and MW-10D) and downgradient of RW-1S (RD-7 and MW-12D) have a similar declining trend suggesting that the effects of RW-1S to restore the aquifer may be limited. Concentrations at RD-7 already meet RALs and concentrations at MW-12D nearly meet RALs already (the measured PCE concentration in April 2010 was 8.1 µg/L and the RAL is 5 µg/L; all other RALs were met). With more effective capture at GWTF #1, the concentrations near GWTF #2 will decline even further. The site team should consider a temporary shutdown of GWTF#2 to evaluate if it is providing meaningful remediation prior to GWTF #1 modifications. CVOC concentrations at MW-12D and RD-7 could be monitored to determine if the decreasing trends continue with GWTF #2 pumping suspended.

GWTF #2 should not be needed and operation should be terminated after GWTF #1 improvements are completed and hydraulic containment is confirmed by reduced downgradient concentrations. After shutdown, monitoring frequency should be temporarily increased at MW-12D and RD-7 (e.g. monthly for six months) to ensure that CVOC concentrations do not increase significantly as a result of shutdown. Though not expected, if concentrations do increase significantly at MW-12D or RD-7, GWTF #2 could be restarted.

When modifications to GWTF #1 are complete, that system will provide effective capture of the Curriculum Center source. With effective capture at GWTF #1, the GWTF #2 influent will continue to decline. If not already terminated, GWTF #2 operation should be terminated as soon as GWTF #1 improvements are completed and hydraulic containment is confirmed by reduced downgradient concentrations (based on sampling at MW-12D and RD-7). Assuming there is a savings of $30,000 in power, $10,000 in project management, $15,000 in materials and equipment, and $5,000 in analysis, termination of GWTF #2 operation could save $60,000 per year.

6.2.3 OPERATION AND MONITORING

Based on substantial experience in operating air stripping systems and in reviewing over 50 Fund-lead P&T systems, the RSE team believes that daily site visits are excessive for the treatment systems at this site. Once or twice weekly would suffice. Reducing this frequency of system checks should reduce operator costs from $8,600 per month to about $4,000 per month for operating two systems and possibly less for one system.

Because of the projected April 17, 2013 date for turnover of O&M responsibility to the USVI DPNR/DEP, we understand that USEPA's contracting requirements would not allow cost savings prior to the turnover date. This recommendation, therefore, is made to potentially benefit the USVI DPNR/DEP; the cost savings shown in Table 6-1 reflect a change made in 2013.

Well gauging frequency should be decreased from monthly to quarterly. Monthly data does not appear to be used for determination of system effectiveness. Quarterly gauging will provide sufficient information for system operations.

6.2.4 ELIMINATE GWTF EMISSIONS SAMPLING

Monthly air emission sampling at GWTF #1 is not needed. Like GWTF #2, air emission mass calculations at GWTF #1 should be based on the assumption that 100% of VOCs in water are removed by the air stripper. Eliminating this monthly air sampling would save approximately $5,000 per year in analysis costs. As an alternative, reducing the sampling frequency to quarterly (as proposed by the site team) is a reasonable approach that will save about $3,300 per year.

6.3 RECOMMENDATIONS FOR TECHNICAL IMPROVEMENT

Removing the excess pipe between the air stripper discharge and stack will reduce the friction loss and the blower head required. This should allow for a smaller (about 10 HP) unit to be used to replace the existing 15 HP unit even with the suggested increased flow associated with Recommendation 6.1.1. This is a technical improvement as well as a cost reduction factor because a 10 HP unit would reduce electricity usage by approximately 44,000 kWh per year, resulting in savings of approximately $15,000 to $16,000 per year. Changing the blower size might cost up to $10,000, so this modification should pay for itself in less than a year. A variable frequency drive (VFD) could be installed for the existing blower for a similar cost and cost reduction. If operation is expected to continue for many years beyond the expected 2013 turnover to USVI DPNR/DEP direction, following optimization of the extraction system (assume to be complete by 2013) the site team should consider replacing the tray unit air stripper with a packed tower including an approximate 2 HP fan based on packed tower vendor estimates. This would be an initial investment of approximately $60,000 and an additional yearly savings of $25,000 in electricity usage.

Prior to making any changes, the air stripper design for the proposed extraction system should be evaluated based on proposed influent flow rates and concentrations to confirm blower requirements. The current tray air stripper is cleaned by acid washing approximately twice per year. Cleaning the packing in a tower-type air stripper can be done by periodic acid washings. Acid is available at the system and cleaning labor should be similar to the tray unit.

6.4 CONSIDERATIONS FOR GAINING SITE CLOSE OUT

In-situ source treatment (enhanced reductive dechlorination [ERD]-bioremediation) was considered by the site team but rejected due to high velocity preferential flow in fractures and back diffusion of contamination from smaller fractures and primary porosity. These same properties limit most *in-situ* technologies. Steam injection or other forms of heating would be a potential consideration for the site but it is extremely expensive, energy intensive, and would have a price premium on St. Thomas. The source area is approximately 500,000 cubic feet, and it is reasonable to assume that thermal remediation of this volume might require $3,000,000. This translates to over eight years of operation of the existing P&T systems or 15 to 20 years of operation of an optimized P&T remedy. Although thermal remedies have been successful in some applications, DNAPL contamination in bedrock is a challenging problem, and despite the substantial investment of a thermal remedy at this site, aquifer restoration or discontinuation of the P&T systems would not be guaranteed. The RSE team agrees that alternative technologies are not appropriate for further consideration at this time. The RSE team believes that focusing on improving containment at GWTF #1 is the key to reducing downgradient impacts and that GWTF #2 may not need to continue operating for much longer. A limited *in-situ* technology ERD action or *in-situ* chemical oxidation could be considered in the O'Henry's area if concentrations in this area persist several years after the improvements at GWTF #1 are made.

Table 6-1 summarizes the recommendations and associated change in annual costs discussed previously.

6.5 RECOMMENDATIONS FOR IMPROVED GREEN REMEDIATION

6.5.1 WATER DISCHARGE

Treated water meeting drinking water standards is currently discharged to the storm sewer even though water is a precious commodity on St. Thomas. The water could be used for irrigation or commercial (car washing or laundromat) purposes nearby. The site team (including DPNR) should make further efforts to have the discharged water accepted for another use. This could possibly help eliminate illegal pumping of private wells for irrigation and commercial purposes.

6.5.2 ALTERNATIVE ENERGY SOURCES

Power costs are extremely high on St. Thomas and alternative energy sources including solar and wind should be considered to potentially offset power use at GWTF #1. The payoff of capital costs for these systems should be evaluated against the potential reduced power costs. At an approximately cost of $70,000 for a 10kW photovoltaic system and electricity savings of approximately $5,000 per year, a photovoltaic system will have a payback period of approximately 14 years and will not be an attractive investment unless substantial incentives or subsidies are provided. The costs and potential savings for a wind system are more variable and would require additional study to determine cost effectiveness. A feasibility study, including a cost analysis, for a wind energy system should be approximately $5,000. If the results are favorable, field information could be collected to confirm results prior to making the investment.

Table 6-2 provides a green remediation summary for the recommendations provided in this report.

Table 6-1. Recommendations Cost Summary Table

Recommendation	Reason	Additional Capital Costs ($)	Estimated Change in Annual Costs ($/yr)	Estimated Change in Life-Cycle Costs $*	Estimated Change in Life-Cycle Costs (net present value) $**
1. Section 6.1.1 – New containment system (assume four new extraction wells)	Effectiveness	180,000	15,000	480,000	403,163
2. Section 6.1.1 – New monitoring wells to the East (assume two wells)	Effectiveness	30,000	0	30,000	30,000
3. Section 6.1.3 – VI resample	Effectiveness	45,000	0	45,000	45,000
4. Section 6.2.1 – Eliminate redundant PM (Arrowhead/CDM) and assumed 5% markup on TSG***	Cost-Effectiveness	0	(30,000)	(540,000)	(338,920)
5. Section 6.2.1 – Remove power from fixed cost (USEPA pay directly)***	Cost-Effectiveness	0	(15,000)	(270,000)	(194,460)
6. Section 6.2.2 – Termination of GWTF #2***	Cost-Effectiveness	0	(60,000)	(1,080,000)	(777,840)
7. Section 6.2.3 – Decrease daily site visits/gauging frequency***	Cost-Effectiveness	0	(55,200)	(993,600)	(715,613)
8. Section 6.3 – Remove excess pipe between air stripper discharge and stack/install smaller HP unit.	Technical Improvement	10,000	(15,000)	(290,000)	(213,163)
9. Section 6.3 – Replace tray unit with a packed tower consisting of a 1 or 2 HP fan.***	Technical Improvement	60,000	(25,000)	(390,000)	(264,100)
10. Section 6.2.3 – Air Emissions Sampling Reduction	Cost-Effectiveness	0	(3,300)	(66,000)	(49,096)
TOTAL		325,000	(188,500)	(3,074,600)	(2,075,029)

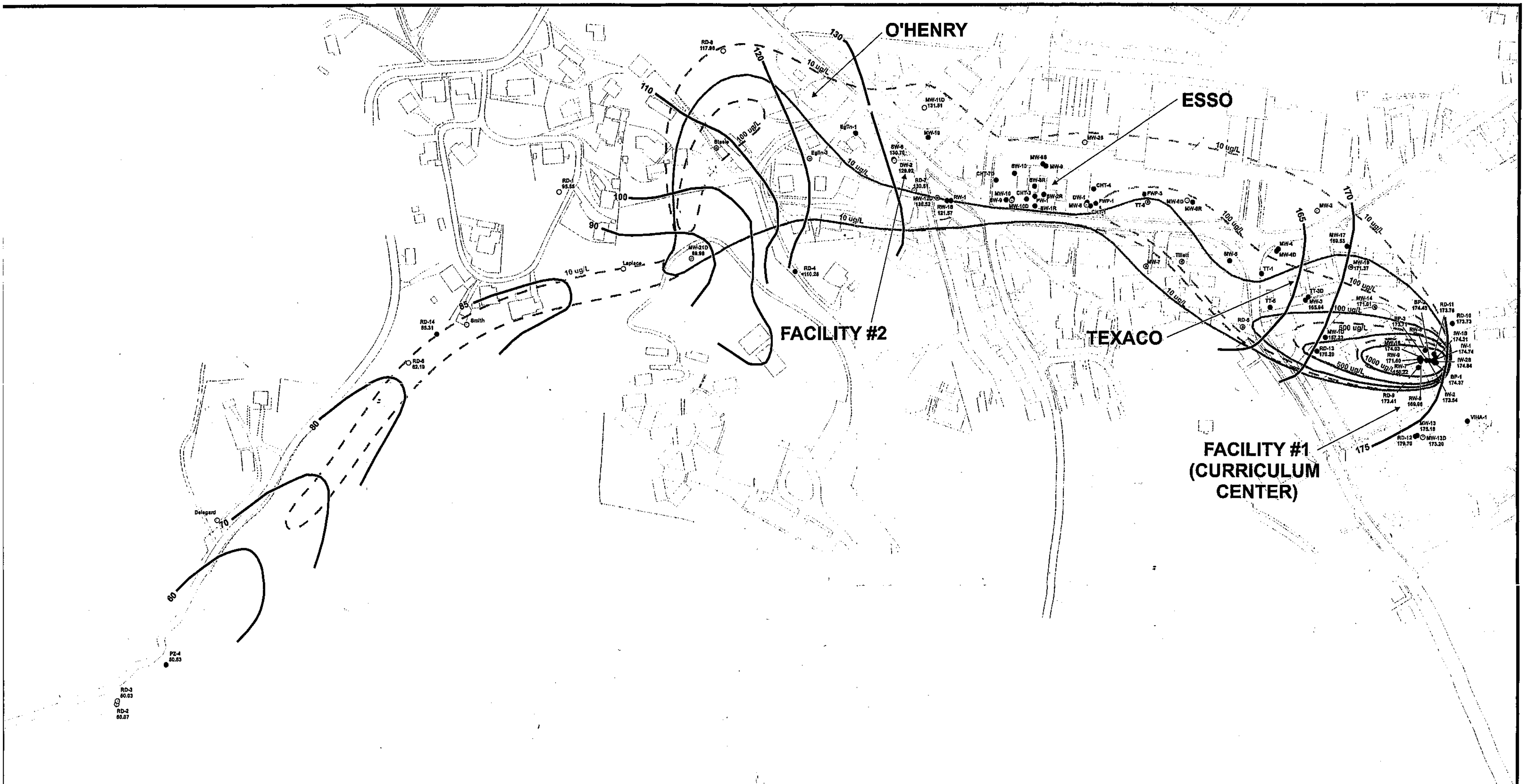
Costs in parentheses imply cost reductions
* assumes 20 years of operation starting in mid-2011with a discount rate of 0% (i.e., no discounting)
** assumes 20 years of operation with a discount rate of 3% (P/A = 14.8775)
*** assumes savings start in mid-2013 after GWTF#1 extraction is optimized and USEPA contracting ends (P/A= 12.964)

Table 6-2. Green Remediation Summary Table for Recommendations

Recommendation	Reason	Effects on Green Remediation
1. Section 6.1.1 – New containment system (assume four new extraction wells)	Effectiveness	Minor effects on footprints for all green remediation core elements for installation of extraction. Relatively significant increase in energy use and air emissions (e.g., ~15%) due to increased electricity usage to operate pumps. Increase in groundwater extraction and discharge to the storm sewer.
2. Section 6.1.1 – New monitoring wells (assume two wells)	Effectiveness	Minor effects on footprints for all green remediation core elements for installation of monitoring wells and routine sampling.
3. Section 6.1.3 – VI resample	Effectiveness	Minor effects on footprints for all green remediation core elements associated with laboratory analysis of samples.
4. Section 6.2.1 – Eliminate redundant PM (Arrowhead/CDM) and assumed 5% markup on TSG	Cost-Effectiveness	None
5. Section 6.2.1 – Remove power from fixed cost	Cost-Effectiveness	None
6. Section 6.2.1 – Hire TSG directly	Cost-Effectiveness	None
7. Section 6.2.2 – Termination of GWTF #2	Cost-Effectiveness	Significant reductions (e.g., ~30%) in energy use and air emissions due to reduced electricity usage. Significant decrease in materials usage due to reduced usage of anti-scale formula. Very significant decrease (e.g., ~50%) in groundwater extraction.
8. Section 6.1.1 – Decrease daily site visits/gauging frequency	Cost-Effectiveness	Minor decreases in energy and air emissions due to decreased transport to the site.
9. Section 6.2.3 – Remove excess pipe between air stripper discharge and stack/install smaller HP unit.	Technical Improvement	Significant reductions (e.g., ~15%) in energy use and air emissions due to reduced electricity usage.
10. Section 6.3 – Replace tray unit with a packed tower consisting of a 1 or 2 HP fan.	Technical Improvement	Very significant reductions (e.g., ~40%) in energy use and air emissions due to reduced electricity usage. Minor materials use associated with purchasing new equipment.

APPENDIX A

SELECT FIGURES FROM SITE DOCUMENTS



Legend

Groundwater Monitoring Well
Total CVOC Concentrations (ug/L)

- ◎ 0 - 9.99
- ⊛ 10 - 99.99
- ● 100 - 499.99
- ● 500 - 999.99
- ● 1,000 - 15,211
- ● Not Sampled

128.57 — Posted Groundwater Elevation (feet above mean sea level)

170 — Groundwater Elevation Iso-contours (feet above mean sea level)

10 ug/L — April 2010 Groundwater Total CVOC Concentration Iso-contours (ug/L)

10 ug/L — Baseline (April 2004) Groundwater Total CVOC Concentration Iso-contours (ug/L)

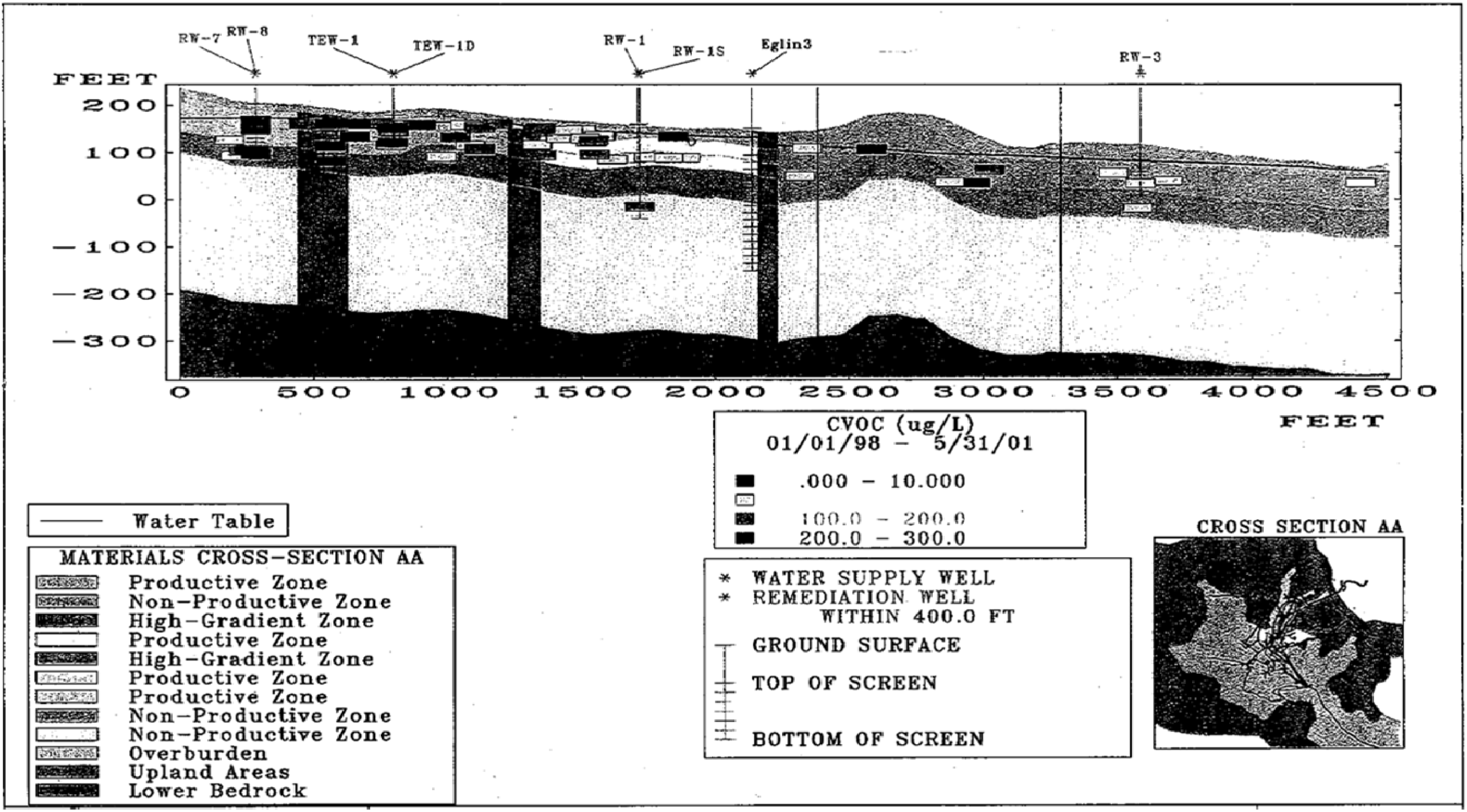
Notes:
1. Groundwater samples were collected in April 2010.
2. Groundwater elevations were recorded in April 2010.
3. Only the groundwater elevations from wells spanning the productive zone were used to develop groundwater elevation iso-contours.

N

0 75 150 300
Feet

Figure 2-1
Site-Wide Groundwater Elevations and CVOC Concentrations
April 2010 RA Progress Report
Tutu Wellfield Site, St Thomas, USVI

CDM



RW-7
RW-8
TEW-1
TEW-1D
RW-1
RW-1S
Eglin3
RW-3
FEET
200
100
0
-100
-200
-300
0
500
1000
1500
2000
2500
3000
3500
4000
4500
FEET
CVOC (ug/L)
01/01/98 - 5/31/01
.000 - 10.000
100.0 - 200.0
200.0 - 300.0
Water Table
MATERIALS CROSS-SECTION AA
Productive Zone
Non-Productive Zone
High-Gradient Zone
Productive Zone
High-Gradient Zone
Productive Zone
Productive Zone
Non-Productive Zone
Non-Productive Zone
Overburden
Upland Areas
Lower Bedrock
* WATER SUPPLY WELL
* REMEDIATION WELL
WITHIN 400.0 FT
GROUND SURFACE
TOP OF SCREEN
BOTTOM OF SCREEN
CROSS SECTION AA