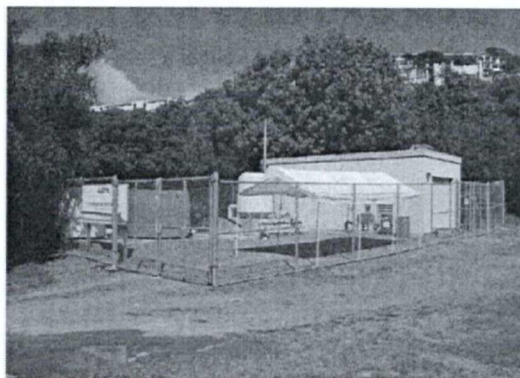


**SECOND FIVE-YEAR REVIEW REPORT
TUTU WELLFIELD SUPERFUND SITE
ST. THOMAS, U.S. VIRGIN ISLANDS**



Prepared by

**U.S. Environmental Protection Agency
Region 2
New York, New York**

September 2014

Approved by:

A handwritten signature in dark ink, which appears to read "Walter E. Mugdan", is written over a horizontal line.

**Walter E. Mugdan, Director
Emergency and Remedial Response Division**

Date:

September 29, 2014

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Table of Contents

Executive Summary	iii
Five-Year Review Summary Form	iii
Introduction.....	1
Site Chronology	1
Background	1
<i>Site Description.....</i>	<i>1</i>
<i>History of Contamination</i>	<i>1</i>
<i>Summary of Site Groundwater Contamination.....</i>	<i>3</i>
<i>Summary of Site Soil Contamination</i>	<i>3</i>
<i>Basis for Taking Action.....</i>	<i>4</i>
Remedial Actions	5
<i>Remedy Selection</i>	<i>5</i>
<i>Remedy Implementation.....</i>	<i>7</i>
<i>Remedy Implementation for Curriculum Center Soils and Site-Wide Groundwater.....</i>	<i>8</i>
<i>Remedy Implementation for the Texaco Service Station.....</i>	<i>10</i>
<i>Remedy Implementation and System Operations, Maintenance, and Monitoring Programs for the Esso Service Station.....</i>	<i>11</i>
<i>System Operations/Operation and Maintenance</i>	<i>13</i>
Progress Since Last Five-Year Review	13
Five-Year Review Process	16
<i>Administrative Components.....</i>	<i>16</i>
<i>Community Involvement.....</i>	<i>16</i>
<i>Document Review.....</i>	<i>16</i>
<i>Data Review</i>	<i>16</i>
<i>Site Inspection.....</i>	<i>20</i>
<i>Interviews.....</i>	<i>20</i>
<i>Institutional Controls Verification.....</i>	<i>21</i>
Technical Assessment	21
<i>Question A: Is the remedy functioning as intended by the decision documents?</i>	<i>21</i>
<i>Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy still valid?.....</i>	<i>22</i>
<i>Question C: Has any other information come to light that could call into question the protectiveness of the remedy?.....</i>	<i>23</i>
<i>Technical Assessment Summary</i>	<i>23</i>

Issues, Recommendations and Follow-Up Actions	24
Protectiveness Statement.....	24
Next Review	25
Tables	26
<i>Table 1: Chronology of Site Events</i>	<i>26</i>
<i>Table 2: Documents, Data and Information Reviewed in Completing the Five-Year Review .</i>	<i>28</i>
Figures.....	29
<i>Figure 1: Site Location Map.....</i>	<i>29</i>
<i>Figure 2: Topographic Site Map</i>	<i>30</i>
<i>Figure 3: Total CVOC concentrations in RD-9 over five-year review period.</i>	<i>31</i>
<i>Figure 4: Concentrations in RD-9 from baseline sampling in March 2004 to present-day.....</i>	<i>31</i>
<i>Figure 5: Total CVOC concentrations in transect downgradient of RD-9.</i>	<i>32</i>
<i>Figure 6: Total CVOC concentrations in RD-5 over five-year review period.</i>	<i>32</i>
<i>Figure 7: Total CVOC Concentrations further downgradient from the Curriculum Center ...</i>	<i>33</i>
<i>Figure 8: Monitoring well Steele is situated in the source area of the Southern plume</i>	<i>33</i>
<i>Figure 9: BTEX concentrations in VE-1 and TT-1 over this five-year review period.....</i>	<i>34</i>
<i>Figure 10: Site Illustration.</i>	<i>35</i>

Executive Summary

This is the second five-year review for the Tutu Wellfield Superfund Site located in Anna's Retreat section of St. Thomas, U.S. Virgin Islands (USVI). The purpose of this five-year review is to review information to determine if the remedy is and will continue to be protective of human health and the environment. The triggering action for this policy review is the date of the first five-year review report. A five-year review is required at this Site is required due to the fact that the remedial action will not leave hazardous substances, pollutants or contaminants on site above levels that allow for unlimited use and unrestricted exposure, but requires five or more years to complete

The remedy for the Site currently protects human health and the environment in the short term because no one is being exposed to Site-related contamination at levels of concern. Residential wells with site-related constituents that exceed drinking water standards are no longer used for potable purposes and residents have been hooked up to public supply wells. In order for the remedy to be protective in the long-term, a capture zone analysis should be conducted on the Southern Plume, and the Northern Plume monitoring results, in conjunction with the conceptual site model, should be reviewed to determine strategies to address residual source, including dense non-aqueous phase liquid (DNAPL) in the bedrock.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Tutu Wellfield		
EPA ID: VID982272569		
Region: 2	State: USVI	City/County: St. Thomas
SITE STATUS		
NPL Status: Final		
Multiple OUs? no	Has the site achieved construction completion? Yes	
REVIEW STATUS		
Lead agency: Choose an item. [If "Other Federal Agency", enter Agency name]: EPA		
Author name (Federal or State Project Manager): Caroline Kwan		
Author affiliation: Remedial Project Manager		
Review period: 4/17/2009 to 4/30/2014		
Date of site inspection: 8/6-7/2014		

Type of review: Policy
Review number: 2
Triggering action date: 4/17/2009
Due date (five years after triggering action date): 4/17/2014

Issues/Recommendations

OU(s) without Issues/Recommendations Identified in the Five-Year Review:				
<i>none</i>				
Issues and Recommendations Identified in the Five-Year Review:				
OU(s): 1	Issue Category Remedy Performance			
	Issue The potential presence of DNAPL may be an ongoing source of groundwater contamination in the deep aquifer of the Northern Plume			
	Recommendation: Additional monitoring of wells in the Northern Plume to further evaluate the presence of DNAPL. Evaluate Northern Plume monitoring results, in conjunction with the conceptual site model, to determine in strategy for addressing source including DNAPL. This evaluation will be conducted under a separate operable unit.			
Affect Current Protectiveness	Affect Future Protectiveness	Party Responsible	Oversight Party	Milestone Date
No	Yes	EPA	EPA	9/1/2018
Issues and Recommendations Identified in the Five-Year Review:				
OU(s): 1	Issue Category Monitoring			
	Issue: Downgradient Southern Plume may not be fully captured.			
	Recommendation: Conduct a capture zone analysis for GWTF#2.			
Affect Current Protectiveness	Affect Future Protectiveness	Party Responsible	Oversight Party	Milestone Date
No	Yes	EPA	EPA	9/1/2018

Protectiveness Statement(s)

Operable Unit:
OU 1

Protectiveness Determination:
Short-term Protective

*Addendum Due Date
(if applicable):*
[Click here to enter a date.](#)

Protectiveness Statement:

The remedy at Tutu Wellfield protects human health and the environment in the short term because residential wells with site-related constituents that exceed drinking water standards are no longer used for potable purposes and residents have been hooked up to public supply wells. In order for the remedy to be protective in the long-term, additional evaluation of potential DNAPL in the Northern Plume is needed and further evaluation of groundwater capture in the Southern Plume is needed.

Sitewide Protectiveness Statement

Protectiveness Determination:
Short-term Protective

*Addendum Due Date
(if applicable):*
[Click here to enter a date.](#)

Protectiveness Statement:

The remedy at Tutu Wellfield protects human health and the environment in the short term because residential wells with site-related constituents that exceed drinking water standards are no longer used for potable purposes and residents have been hooked up to public supply wells. In order for the remedy to be protective in the long-term, additional evaluation of potential DNAPL in the Northern Plume is needed and further evaluation of groundwater capture in the Southern Plume is needed.

Introduction

The purpose of a five-year review is to evaluate the implementation and performance of a remedy in order to determine if the remedy is and will continue to be protective of human health and the environment and is functioning as intended by the decision documents. The methods, findings, and conclusions of reviews are documented in the five-year review. In addition, five-year review reports identify issues found during the review, if any, and document recommendations to address them.

This is the second five-year review for the Tutu Wellfield (Site), located in Anna's Retreat, St. Thomas, US Virgin Islands (USVI). This five-year review was conducted by the United States Environmental Protection Agency (EPA) Remedial Project Manager (RPM) Caroline Kwan. The review was conducted pursuant to Section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, 42 U.S.C. §9601 *et seq.* and 40 CFR 300.430(f)(4)(ii), and in accordance with the *Comprehensive Five-Year Review Guidance*, OSWER Directive 9355.7-03B-P (June 2001). This report will become part of the site file.

The triggering action for this policy review is the date of the first five-year review report. A five-year review is required at this site due to the fact that the remedial action will not leave hazardous substances, pollutants or contaminants on site above levels that allow for unlimited use and unrestricted exposure, but requires five or more years to complete.

Site Chronology

See Table 1 for the Site chronology.

Background

Site Description

The Tutu Wellfield Site is located on the eastern end of St. Thomas, U.S. USVI, in the Anna's Retreat section (Figures 1 and 2). The Site contains a variety of commercial establishments, schools, churches, and residential units. The site is situated within the upper Turpentine Run surface drainage basin. This basin, which covers approximately 2.3 square miles, trends roughly north-south and is bounded by the steep slopes of the surrounding hills. Land surface elevations along the Turpentine Run decrease from about 200 feet above mean sea level (msl) at the northern end of the site to approximately 100 feet above msl at the southern end of the Site. The Turpentine Run is an intermittent stream that traverses the length of the basin. Surface water runoff is collected in a stormwater catchment system with stormwater as well as secondary sewage eventually discharging to the Turpentine Run. The Turpentine Run is partially channelized and ultimately discharges into Mangrove Lagoon and the Caribbean Sea.

History of Contamination

Investigation work began at the Tutu Wellfield Site in 1987 in response to complaints from local residents of an odor emanating from their groundwater supply wells. Subsequent groundwater sampling by the EPA's Technical Assistance Team revealed the presence of chlorinated volatile organic compounds (CVOCs) and benzene, toluene, ethylbenzene, and xylenes (BTEX)

contaminants in the groundwater above Federal maximum contaminant levels (MCLs) for drinking water. Several of the wells in this area were large commercial wells used for public drinking water supply. The incident led the U.S. Virgin Islands Department of Planning and Natural Resources (DPNR) Commissioner to request EPA to assume the role of lead agency. EPA condemned the contaminated supply wells, made arrangements to provide an alternate drinking water supply to the affected residents and initiated investigations to identify the sources of the contamination. Several residences were identified as being impacted by the contaminated plume. They were the Mathias, Laplace, Harvey, Steele, Smith and Delegard residences.

The site was proposed for addition on the National Priorities List (NPL) in February 1992. Remedial investigation and feasibility study (RI/FS) activities were completed at the site from 1992 to 1995. The Tutu Wellfield site was added to the NPL on September 29, 1995.

The results of the remedial investigations identified four sources of groundwater CVOCs and/or BTEX contamination. The sources are briefly described below:

- **Curriculum Center** – The northern-most (upgradient) source of CVOC groundwater contamination is located on the Curriculum Center property, which is currently owned and operated by the USVI Department of Education. The Curriculum Center building and property were previously occupied by LAGA Industries, Ltd., who owned and operated a textile manufacturing plant at this location from 1971 to 1978. The plant included an industrial size dry cleaning process that utilized tetrachloroethene (PCE) as the dry cleaning solvent. The RI work revealed the presence of CVOC contaminants in the soils and groundwater at the Curriculum Center property. The portion of the CVOC plume extending downgradient from the Curriculum Center to O'Henry Dry Cleaners, Inc., (O'Henry) is herein referred to as the Northern Plume.
- **Texaco Service Station** – RI work revealed the presence of BTEX and petroleum hydrocarbon contaminants in the soils and groundwater at the operating Texaco Caribbean, Inc., (Texaco) service station, which is located immediately downgradient (southwest) of the Curriculum Center building. Historically, the facility also included an automotive service station. This is located within the Northern Plume.
- **Esso Service Station** – RI work revealed the presence of CVOC, BTEX, and petroleum hydrocarbon contaminants in the soils and groundwater at the operating Esso Standard Oil, U.S.A., Inc., (Esso) service station, which is located downgradient (southwest) of Texaco. Historically, the facility also included an automotive service station. This is located within the Northern Plume.
- **O'Henry Dry Cleaners** – RI work revealed the presence of CVOC contaminants in soils and potentially in groundwater at O'Henry, an operating dry cleaning facility, which is located downgradient (south) of Esso. The portion of the CVOC plume extending south of O'Henry is herein referred to as the Southern Plume.

Additionally, BTEX-impacted soils were encountered at the Ramsey Motors property, located just to the north of the Texaco Service Station and at the Western Auto facility, which is located within the Four Winds Plaza shopping facility, west of the Esso Service Station.

Summary of Site Groundwater Contamination

The Northern Plume originates at the Curriculum Center property, which is located near the intersection of Routes 38 and 384 within the upper northeast reaches of the Turpentine Run Basin Aquifer. The Northern Plume extends site-wide to the lower reaches of the Tutu Valley and is historically believed to have co-mingled with the Southern Plume. Based upon the measured and observed convergent nature of groundwater flow within the Tutu valley, lateral dispersion of contaminants in this zone appears to be limited to a narrow strip along controlling faults and fractures. Vertically, the hydrogeology and contaminant distribution near the Curriculum Center can broadly be subdivided into:

- An upper, more productive zone, extending from the water table (15 to 30 feet below ground surface [bgs]) to a depth of approximately 80 feet.
- A lower, less productive zone, extending from approximately 80 to 140 feet bgs.

Contaminant transport is believed to be controlled by advection, with a discrete plume (with concentrations in excess of 1,000 micrograms per liter [ug/L] CVOCs) extending from north of the Curriculum Center to just north of the Texaco service station (approximately 500 feet downgradient of the center). The Northern Plume is also co-mingled with BTEX plumes that originate from the Texaco and Esso Service Stations. Anaerobic biodegradation of CVOC contaminants may be currently occurring in these sources, based upon the presence of dechlorination products such as trichloroethylene (TCE) and 1,2-dichloroethylene (1,2-DCE).

RI results indicated that a shallow BTEX plume located near the Texaco Tutu Service Station was approximately 400 feet long from north to south and approximately 200 feet wide from east to west. In the deep zone, it was approximately 300 feet by 130 feet in areal extent. The plume was elongated in the direction of shallow groundwater flow and appeared to have migrated past the Tillett Supply Well. The maximum concentrations of benzene, ethylbenzene, and xylenes were 21,000 µg/L, 3,700 µg/L and 18,000 µg/L, respectively. The shallow BTEX plume located near the Esso Service Station measured approximately 250 feet by 175 feet. The maximum concentrations of benzene, ethylbenzene, and xylenes detected at this location were 10,000 µg/L, 4,100 µg/L and 22,000 µg/L. Direct observations of floating product and sheens in some monitoring wells at the Esso and Texaco Service Stations confirmed the presence of light non-aqueous phase liquid (LNAPL).

The Southern Plume originates near the O'Henry facility and in this area there is a noticeable and measurable change in regional groundwater flow direction, from south to southeast. This change is believed to be controlled by regional fault and fracture zones along Turpentine Run, which "channel" groundwater flow toward the lower reaches of Turpentine Run and ultimately the Mangrove Lagoon. The Southern Plume CVOC contamination, therefore, travels within a relatively narrow zone along the southeast-northwest trending Turpentine Run.

Summary of Site Soil Contamination

During the RI, surface and subsurface soil samples were collected from borings and monitoring well boreholes. Soil quality data was collected from 15 properties in the project study area to identify impacted soils.

Three properties were identified as having significant CVOC impact to soil, based on exceedance of EPA's site-specific soil screening levels (SSLs) for impact to groundwater. At the Curriculum Center, contamination was detected at the north-central side of the main building in the vicinity of the former discharge pipe and presumed former waste pit, with PCE concentration up to 1,800 micrograms per kilogram ($\mu\text{g/kg}$) and TCE concentrations up to 130 $\mu\text{g/kg}$. The CVOC 1,1,1-trichloroethane (1,1,1-TCA), was also detected above the EPA's SSLs. The elevated concentrations of CVOCs in groundwater adjacent to and immediately downgradient of the Curriculum Center indicate a high probability that pure product is present in the unsaturated zone as dense non-aqueous phase liquid (DNAPL) at the Curriculum Center. At the Esso Tutu Service Station, PCE, TCE, 1,1,1-TCA, 1,2-DCE, and 1,1-dichloroethane (DCA) were detected above EPA's SSLs at the western portion of the property, near the north oil/water separator at concentrations up to 3,200 $\mu\text{g/kg}$. PCE was found in the vicinity of the O'Henry Dry Cleaners above EPA's SSLs in the southwestern portion of the property at concentrations up to 440,000 $\mu\text{g/kg}$. There is a potential for DNAPL to be present in the subsurface soils in the vicinity of the O'Henry dry cleaners due to significant concentrations of PCE detected in adjacent wells.

The site-specific SSLs for BTEX compounds were exceeded at five properties. At the northeast corner of the Curriculum Center, in an area where a sink from the paint shop drain discharged to the ground, BTEX compounds exceeded EPA's SSLs with benzene concentrations up to 2,700 $\mu\text{g/kg}$ and toluene concentrations up to 500,000 $\mu\text{g/kg}$. Benzene and ethylbenzene were detected in the vicinity of the underground storage tank (UST) at the Ramsay Motors property at levels above the EPA SSLs with maximum benzene concentrations of 17 $\mu\text{g/kg}$ and maximum ethylbenzene concentrations of 290 $\mu\text{g/kg}$. At the Texaco Service Station, BTEX compounds were found in the vicinity of the former USTs and at the oil/water separator at concentrations exceeding EPA's SSLs. Results ranged from 69 $\mu\text{g/kg}$ for benzene to 630 $\mu\text{g/kg}$ for ethylbenzene. At the Western Auto facility, all individual BTEX constituents exceeded EPA's SSLs, with maximum results for toluene and ethylbenzene at 16 $\mu\text{g/kg}$ for each and xylene at 34,000 $\mu\text{g/kg}$. A shallow gravel layer underlying the pavement in this area also contained visible stained oil. The impacted soil was located adjacent to an underground storage tank, which was removed in August 1994. At the Esso Tutu Service Station, BTEX compounds exceeded EPA's SSLs near the gasoline pump island, the north oil/water separator, and the former UST excavation. Individual BTEX concentrations above EPA's SSLs ranged from 26 $\mu\text{g/kg}$ of ethylbenzene to 540,000 $\mu\text{g/kg}$ of xylenes.

At the Tillett Gardens property, no CVOCs or BTEX constituents were detected above screening levels in the site soil. However, elevated concentrations (120,000 $\mu\text{g/kg}$) of the polychlorinated biphenyl (PCB) Aroclor 1242 were detected in one surface sample in 1988. Because this sample concentration resulted in unacceptable risks to human health from direct exposure, EPA collected confirmatory samples from the affected area in August 1995 to delineate the extent of impacted soils. PCBs were not detected in any of the confirmatory samples, indicating that PCBs are no longer a concern at this property.

Basis for Taking Action

Exposure to groundwater in the Northern and Southern Plumes was found to pose an unacceptable risk to current and future populations, with CVOCs, particularly PCE, TCE and vinyl chloride being the most significant risk drivers. Concentrations of these contaminants were detected in soils in the four source areas (Curriculum Center, Esso Service Station, Texaco

Service Station and O'Henry) at levels that were not found to pose a risk to human health, but were at levels that indicated they were a source to groundwater contamination. The only unacceptable risk from exposure to site soils was limited to one property (Tillett Gardens) where the noncarcinogenic hazard index for surface soils was exceeded for the residential scenario by metals which were found to be at concentrations consistent with background and were not attributed to the site.

The ecological risk assessment identified unacceptable risk to certain ecological receptors, such as the anole and the red-tailed hawk, based on exposure to soils contaminated primarily with PCE.

Remedial Actions

Remedy Selection

The Record of Decision (ROD) for the site was signed on August 5, 1996. The ROD included remedies for contaminated soils and groundwater.

The following Remedial Action Objectives (RAOs) were established for the Site:

- Remove and/or control the sources of groundwater contamination;
- Remove contamination in groundwater. Restore the aquifer to drinking water standards, except to the extent that such full groundwater restoration proves to be technically impracticable due to the presence of DNAPLs;
- Control the migration of impacted groundwater;
- Prevent human ingestion of groundwater exhibiting excess lifetime cancer risks greater than 1 in 10,000 or a hazard index greater than 1;
- Prevent direct human contact and exposure to contaminated soils that pose excess cancer risks greater than 1 in 10,000 or a hazard index greater than 1; and
- 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.

The groundwater remedy called for area-wide plume/source containment and treatment of contaminated groundwater. The groundwater clean-up goals are the Federal MCLs for drinking water. The groundwater remedy generally includes the following:

- Efforts will be made to have existing domestic and commercial wells within the confines of the groundwater plume decommissioned if these wells are determined to interfere with the operation of the groundwater pump and treat system that will be installed as part of this remedial action. During the remedial design it will be determined which wells would interfere with this remedial action and which wells would continue to operate as they may enhance aquifer restoration, which is a goal of this remedial action. For those wells that are decommissioned, EPA would analyze alternative sources of water for the users of those wells and determine appropriate alternate sources of water for the affected users. These wells could be reestablished at some point in the future, when and if groundwater quality improves to allow extraction and use of untreated groundwater.

- Institutional controls in the form of Governmental controls and/or proprietary controls will be sought to prohibit unauthorized use of groundwater or the installation of new wells. Authorization must be obtained from DPNR and EPA before use of existing wells (i.e., wells that are not decommissioned) or installation of any new wells within the confines of the plume area.
- Implement Source Control Programs (consisting of installation and operation of extraction wells and air strippers) at the Texaco and Esso Service Stations to address impacted groundwater in the immediate vicinity of these facilities.
- Install groundwater recovery wells for hydraulic control of plume migration. The proposed containment program will include the installation of three recovery wells (RW-1, RW-2, and RW-3) strategically placed in an effort to hydraulically contain plume migration.
- Install two groundwater recovery wells (RW-4 and RW-5) for hydraulic control of CVOC contaminant sources. The source containment will provide hydraulic barriers around source areas, allowing the reduction of contaminants in other parts of the aquifer and potentially reducing the time needed to reach MCLs.
- Construct a central groundwater treatment facility with a total flow capacity of 100 gallons per minute (gpm). Water will be treated to surface water criteria for discharge to the storm sewer near the O'Henry Dry Cleaners facility leading to Turpentine Run, or be treated to MCLs for distribution for potable purposes. EPA, in consultation with the Virgin Islands Government, will choose one of these two options during the remedial design phase. If a decision is made to treat the water to surface water criteria (not to MCLs), then water will continue to be supplied to affected residents as it is currently being supplied (i.e., through collection of rain water to cisterns and trucking water by tanker truck).
- Conduct semi-annual groundwater sampling to monitor its quality and contaminant migration. The monitoring program will include the sampling approximately 15 wells at or near the plume boundary for CVOCs, BTEX and semivolatile organic compounds, and would last for the duration of the remedial action and operation and maintenance (O&M) (estimated, for costing purposes, to be approximately 30 years).
- Natural attenuation of low concentration contaminants at the plume edges and downgradient of RW-2 and RW-3.

Various potable use options for with respect to the treated groundwater are as follows:

- connect to the existing Water and Power Authority water main;
- truck the treated water to the impacted residences within the plume area; or
- install a water distribution system from the central treatment facility to the impacted residences within the plume area.

The soil remedy addresses multiple locations containing unsaturated zone BTEX/CVOC source materials. The ROD soil cleanup goals were derived using the EPA SSL methodology for protection of groundwater. The soil remedy generally includes the following for each of the source areas:

- In-situ soil vapor extraction (SVE) treatment of impacted soil with catalytic oxidation for off-gas treatment at the Texaco Service Station;
- In-situ SVE treatment and bioventing of impacted soil with thermal oxidation for off-gas treatment at the Esso Service Station;
- Excavation and off-site disposal of additional soils, if needed (to be determined after confirmatory sampling during remedial design) at Four Winds Plaza/Western Auto;
- At O'Henry dry cleaners, in-situ SVE treatment of impacted soils, or, if such in-situ SVE proves to be ineffective, excavation and ex-situ SVE of impacted soils; in-situ SVE treatment in the unsaturated bedrock; and thermal oxidation for off-gas treatment;
- At the Curriculum Center: excavation of impacted soils, followed by either off-site disposal or ex-situ SVE; in-situ SVE treatment in unsaturated bedrock areas and in soil areas not suitable for excavation; and thermal oxidation for off-gas treatment; and
- Institutional controls in the form of Governmental control and/or proprietary controls to place limitation on property usage and limit disturbance to impacted soils and bedrock.

Buried 4-inch diameter polyvinyl chloride (PVC) piping was identified as a potential source of contamination at the Four Winds Plaza, near the former Western Auto underground storage tank area. The ROD specified that additional investigation be conducted to determine the need for remedial work in the area of Four Winds Plaza. The ROD also specified confirmatory sampling in the area of the underground storage tank removed in 1994 be completed to confirm that no residual contaminated soil above the cleanup levels (SSLs) has been left in-place with excavation and off-site disposed of impacted soils if contamination was found to be present.

Pursuant to a site inspection performed of all properties at the Site in 1995 following Hurricane Marilyn, it was determined that no soil remedial action was required for the Ramsay Motors property at that time. The concrete floor in the area of subsurface soil contamination had been thought to be cracked appeared to be of sound integrity. However, the ROD specified that institutional controls be applied to this property.

Remedy Implementation

EPA funded the remedial designs for the Curriculum Center soil and the site-wide groundwater remedies in September 1997 and the remedial action of these remedies in September 2003. EPA issued separate Unilateral Administrative Orders (UAOs) to Texaco, Esso, and Western Auto/Four Winds Plaza in May of 1998 and to O'Henry in May of 1999, requiring the responsible parties to implement the respective ROD remedies.

O'Henry completed a removal action in March 1995 to address CVOC contaminated soils. Pursuant to the UAO issued in May of 1999, O'Henry completed a pre-design investigation of the unsaturated zone soils and fractured bedrock in November 1999. The results of the pre-design soil delineation investigation and post soil excavation reports did not identify the presence

of unsaturated source materials exceeding the ROD soil cleanup goals/objectives. EPA sent a letter to O'Henry's consultant, IT Corporation, in July 2000 concurring with its recommendation of No further Action for unsaturated zone soil and fractured bedrock at the O'Henry property.

The UAO issued to Western Auto/Four Winds Plaza required that characterization in the area of the buried 4-inch diameter PVC piping be performed and confirmatory sampling of the tank grave area be completed to confirm that no residual contaminated soil above the cleanup levels (SSLs) was present. Investigation work was performed in January and February of 1999. No investigation and confirmation sampling results exceeded the ROD specified cleanup criteria with the exception of ethylbenzene results in samples collected in the vicinity of the buried PVC piping. Western Auto/Four Winds Plaza consultants calculated a revised contaminant specific SSL for ethylbenzene, which was approved by EPA and DPNR. No sample results exceeded the revised criteria. The subsequent No Further Action recommendation was approved by EPA in January of 2000.

Remedy Implementation for Curriculum Center Soils and Site-Wide Groundwater

A pre-design investigation of the Curriculum Center soils and site-wide groundwater was conducted from August 1998 to November 1999 to further define the extent of Curriculum Center soil and site-wide CVOC groundwater contamination and to collect hydrologic and geologic information to be used for the corresponding remedial designs (RDs). The RD for the Curriculum Center soil and site-wide groundwater was completed in September 2001. During the pre-design and remedial design activities, it was determined that soil excavation at the Curriculum Center was not required. Activated carbon was determined to be more feasible than thermal oxidation for off-gas treatment. In addition, it was determined that the SSLs defined in the ROD are not appropriate for evaluating the fractured bedrock. Therefore, shutdown of the SVE system was to be based upon a significant contaminant decrease and asymptotic conditions in the SVE system influent. A number of RD wells and piezometers (PZ) were installed during pre-design and design phases to fine tune the extent of contamination of the site-wide plumes.

Site construction was completed in March 2004, and consisted of the following activities:

- Construction of a groundwater extraction and treatment system at the Curriculum Center (referred to as GWTF #1) to achieve hydraulic control and remove contaminant mass from the saturated-zone source of CVOC groundwater contamination. The treatment system consists of three groundwater extraction wells, an equalization tank and transfer pumping system, bag filters, a low-profile air stripper and an off-gas treatment system (granular activated carbon [GAC] adsorption followed by potassium permanganate oxidation). Chemical feed systems were also included for sequesterant/biocide injection and pH adjustment. RW-7 and RW-9 were screened across the shallow, productive portion of the aquifer, and RW-6 was screened across the deeper, non-productive portion of the aquifer.
- Construction of a groundwater extraction and treatment system downgradient of the Northern Plume (referred to as GWTF #2) to achieve hydraulic control and remove contaminant mass. The treatment system, located on the Grace Gospel Church property, consists of two groundwater extraction wells, an equalization tank and transfer pumping system, bag filters, and a low-profile air stripper. Chemical feed systems were also

included for sequesterant/biocide injection and pH adjustment. RW-1 is screened in the deep zone and RW-1S and is screened across the shallower, more productive zone.

- Construction of an SVE system at the Curriculum Center to remediate the unsaturated zone source of the CVOC groundwater contamination. The system includes two SVE wells (SVE-1 and SVE-7), a moisture knockout tank, and a blower and utilized the same offgas treatment system as the groundwater treatment system. The location of SVE-7 coincides with RW-7, which was constructed as a dual-phase extraction well.
- Construction of injection and monitoring wells at the Curriculum Center to support the performance of an enhanced anaerobic bioremediation (EAB) pilot study, which was performed following treatment system startup. Based on the results of initial phase of the pilot study, no additional pilot testing or bioremediation was performed.

An initial testing program (ITP) for the facilities was completed between March 19 to April 16, 2004 to confirm achievement of the treatment system performance requirements, and to obtain data for supporting decisions regarding system treatment system operation and optimization. The result of the ITP indicated that the facilities were operating as intended. Both facilities discharge to surface water in accordance with the Territorial Pollutant Discharge Elimination System (TPDES) permit equivalent.

The Operation and Maintenance (O&M)), which consists of operation, maintenance and monitoring activities, is ongoing. The facilities are operated and maintained in accordance with the site documents, manufacturer's specifications with the U.S. Virgin Islands DPNR TPDES permit equivalency and Air Pollution Control permit equivalency. Process monitoring is performed to verify permit equivalency compliance and to support decisions regarding treatment system operation and optimization. Water process sampling/monitoring includes monthly influent and effluent samples for CVOC analysis, weekly effluent samples for total organic carbon (TOC) and total suspended solids analysis, and pH is monitoring continuous via a pH meter. Offgas samples are currently collected from the discharge stack on a monthly basis for CVOC analysis at GWTF #1, and air emissions at GWTF#2 are calculated based on the facilities influent groundwater concentrations assuming 100 percent VOC removal in the air-stripper.

Extraction wells RW-7, RW-9 and RW-1S are operated to maintain a set groundwater elevation in the extraction well. At GWTF #1, extraction well RW-7 is operated on a continuous basis and extraction well RW-9 operates as required to maintain the required set groundwater elevation, typically during heavy rain events. Since startup, the average and maximum flow rate at GWTF #1 was 24 and 58 gpm, respectively. In addition, extraction well RW-6 is operated once per week for approximately 1 hour at a flow rate of 2 gpm, until the extraction well pump shuts down due to low water conditions in the well. At GWTF#2, extraction well RW-1S operates on a continuous basis with an average and maximum flow rates of 18 and 38 gpm, respectively, since start-up. Extraction well RW-1 which was installed during the pre-design investigation, has not been in operation since the ITP because sampling performed after installation and during startup testing indicated that the contamination in the zone in which this well is screened was more diluted than expected.

Groundwater monitoring is routinely performed at site-wide groundwater monitoring wells to assess remedial action RA progress. Groundwater sampling was performed on a quarterly basis from system start-up until April 2007 and annual groundwater sampling has been performed

thereafter. Samples are collected from 30 groundwater monitoring wells and residential wells at each groundwater sampling event. Samples from all monitoring wells are analyzed for VOCs. In addition samples from five groundwater monitoring wells located in the southern plume area are analyzed for nitrate, sulfate, chloride, TOC and ethane/ethene to assess monitored natural attenuation in this area. Groundwater monitoring levels are collected on a monthly basis from 36 monitoring wells.

The Curriculum Center SVE system was operated for approximately two years. Due to a significant decrease in SVE influent concentrations since system startup and achievement of asymptotic conditions, it was determined that the SVE system was no longer cost-effective and the system was shutdown in April 2006. A pulsing period was initiated prior to system shutdown to confirm that the CVOC soil vapor concentrations would not significantly rebound after initial shutdown. While in operation vacuum measurements were collected from 12 soil gas vapor probe (SGVP) locations at the Curriculum Center with each probe location consisting of multiple probes screened at different depth intervals. Annual soil gas samples were collected for VOC analysis from 12 SGVP locations at the Curriculum Center. The soil vapor results showed significant reductions in soil vapor concentrations since system startup, with the most significant reductions occurring in the vicinity of extraction wells SVE-1 and SVE-7, which reductions of greater than 99 and 96 percent, respectively.

The off-gas treatment system was also shut down in April 2006 because it was no longer required to meet the Air Pollution Control permit equivalency requirements. One GAC and one potassium permanganate unit remain onsite on standby and the other GAC and potassium permanganate units have been removed from the site.

Remedy Implementation for the Texaco Service Station

Texaco completed a remedial design for groundwater and soil treatment system in 1995. Construction of an on-site SVE and groundwater treatment system (Texaco gas station) and a downgradient groundwater treatment system was completed in early 1998. The Texaco plant consisted of two groundwater extraction wells (TEW-1 and TEW-1D), three soil vapor extraction wells (VE-1, VE-2 and VE-3), a bag-filter, an air-stripper for removal of hydrocarbons from extracted groundwater, chemical feed systems for scale inhibitor and pH adjustment, and a catalytic oxidizer for treating vapor for the air stripper and soil vapor extraction wells prior to discharge to the atmosphere. One shallow (TEW-1) and one deep (TEW-1D) extraction well was installed. In addition, 11 soil vapor probes were constructed for monitoring of the site soil gas. The downgradient groundwater treatment system consists of two groundwater extraction wells and an air stripper for removing hydrocarbons from extracted groundwater. One shallow (TEW-2) and one deep (TEW-2D) extraction well was installed. Treated water from both the Texaco Service Station and the Vitelco Plant discharged to catch basins located within the storm drainage system in the Turpentine Run in accordance with the facility's TPDES permit.

Groundwater start-up testing for the Texaco Service Station was performed in January 1998. The results of the start-up testing indicated that the system was operating as intended. The facility initially operated at a flow rate of 50 gpm but the flow rate was reduced to 30 gpm in April 1998 because it was determined that the groundwater capture was more than what was needed for controlling the plume emanating from the Texaco Service Station. Deep extraction well TEW-1D was shut down in June of 1998 to prevent potential onsite migration of chlorinated

hydrocarbons that were documented from the upgradient properties. Baseline sampling performed prior to start-up activities indicated that the benzene plume did not extend to the downgradient groundwater treatment system. This plant was, therefore, not started on a continuous basis, and has been operated only on an as-needed basis to treat sample purge water prior to discharge to the catch basin.

Operation of the SVE system at the Texaco Service Station was initiated in April 1998 at high vacuum of approximately 80 inches water column from SVE wells VE-1 through VE-3. Start-up testing indicated that the radii of influence for the SVE wells adequately influenced the area of concern.

The Texaco Service Station treatment facility operated from 1998 to 2003. Wells VE-1 through VE-3 were eventually operated as dual phase extraction (DPE) wells with the catox off-gas treatment system treating all hydrocarbon vapors extracted by the DPE system and emitted by the groundwater treatment system. The catox system was decommissioned in June 2002. Oxygen release compound (ORC) socks were historically installed in MW-5 and TT-2 to add oxygen to the groundwater to facilitate aerobic biodegradation.

After conducting a pulsing period, the SVE and groundwater treatment system at the Texaco plant were shut down in July 2003. Monitored natural attenuation (MNA) activities have been conducted at the Texaco site since system shut down and remain on-going. Initially groundwater monitoring was performed on a quarterly basis and the frequency of the sampling events was reduced to semi-annually starting in 2004. Groundwater samples are typically collected from four to nine monitoring wells, and samples are analyzed for BTEX and methyl tertiary butyl ether (MTBE). Removal and replacement of three underground storage tanks and associated fuel lines was performed in December 2006. In January 2007, an enhanced bioremediation application was conducted at the site to further reduce the source area groundwater concentrations.

Remedy Implementation and System Operations, Maintenance, and Monitoring Programs for the Esso Service Station

Esso groundwater and soil treatment system construction was completed in February 1999. The system consisted of SVE and bioventing systems with catalytic oxidation to remediate the site soils, total fluids extraction system with treatment via oil/water separator, air-stripping and granular activated carbon. The extraction system consisted of four shallow extraction wells (G1 through G4), four deep groundwater extraction wells (G5 through G8), five vapor extraction wells (V1 through V5), and bioventing extraction wells (BE-1 through BE-5).

System start-up testing was performed in March 1999. Initially only the deep extraction wells were operated because the shallow wells were not scheduled to be brought on line until the LNAPL was to be removed, to the extent possible, from the perched groundwater zone. The groundwater system operated intermittently during March through May as a result of power outages and fouling of the bag filters and GAC canisters with a calcium precipitate. The initial sequestering agent was replaced, and as a result of this modification, bag filter and GAC fouling was eliminated and the groundwater treatment system operated continuously through September 1999 at a flow rate of approximately 5 gpm. Treated water from the Esso Service Station discharged to a catch basin within the storm drainage system in the Turpentine Run in

accordance with the facility's TPDES permit. In addition, recovery of free product was conducted concurrently with groundwater extraction through manual hand bailing and pumping of selected wells, and absorbent socks were installed in wells containing measureable thickness of free product.

Start-up of the SVE system was performed in June 1999. Soil vapors were extraction from SVE wells V1 through V5 as well as bioventing extraction wells BE1 through BE5 to increase the radius of influence of the SVE system. The bioventing system was not initially operated. The system operated at a flow rate of approximately 150 standard cubic feet per minute (scfm).

Although hydraulic capture was achieved by the groundwater remediation system, both the soil and groundwater remediation systems did not produce substantial rates of source mass removal. As a result, a modified source control program was implemented, which incorporated soil excavation and off-site treatment via bio-piles; installation of a groundwater "hot-spot" remediation system, and natural attenuation of distal plume areas. The objective of the soils excavation was to excavate soils with concentrations above the site-specific SSLs for benzene, toluene, ethylbenzene, and xylene compounds as defined in the ROD and remediation goals for gasoline range and diesel range total petroleum hydrocarbons of 100 ppm and 5,000 ppm, respectively, as required by DPNR. Soils were excavated from November 2001 to April 2002. Evidence of oil-impacted soils was encountered over the majority of the area at depth of approximately 10 feet, corresponding to the depth of the perched water zone. Gasoline-impacted soils were encountered in the northeast portion of the site, proximal to the former and existing pump islands at approximately five to 10 feet in depth. Contaminated soils were segregated based on photo-ionization detector (PID) reading collected and visual staining of the soils. Soils were transported to the bio-cell treatment cells or temporarily staged on-site and subsequently characterized as clean fill materials. Excavation limits were initially determined based on field screening and visual observations, and subsequently confirmed based on post-excavation sample results. With the exception of two samples that slightly exceeded the SSL for benzene, all post-excavation soil samples results were below the SSLs. Approximately 2,600 cubic yards (CY) of petroleum-impacted soils were excavated from the service station property and transported to the biocells. Soils deposited in the bio-cells were turned over in April and October 2002 to homogenize nutrients and aerate the soils and grab samples were collected at each maintenance event biased to visibly stained soils. For each event, all soil sample results were below the SSLs. In addition, water samples were collected in the January and October 2002 from the cells and no sample results exceeded applicable Federal or DPNR groundwater standards. Esso subsequently petitioned EPA/DPNR to terminate the biocell treatment program and dispose of all soils at the Bovoni Landfill, and EPA/DPNR approved the request on May 14, 2003.

Construction of the of the "hot-spot" remediation system was performed in 2002. The hotspot remediation system consisted of one extraction well PW-1 that was installed within the 1,000 BTEX iso-contour. System start-up was performed in October 2002, where groundwater was extracted from well PW-1 and treated by air stripping with polishing by two granular activated carbon treatment drums arranged in series. Phase-separated hydrocarbons were not encountered in any on-site or off-site monitoring wells. The results of initial operations indicated that pumping PW-1 at an average sustained rate of 0.7 gpm has resulted in hydraulic capture of the residual source zone beneath the Esso Service Station. Operation of the groundwater "hot-spot" remediation system was conducted until April 2005.

MNA activities have been conducted at the site since May 2005 and remain on-going. The existing groundwater treatment system remains on site and operable should it be concluded that natural attenuation along is not sufficient to maintain plume stability. Groundwater monitoring was initially performed quarterly and the frequency of monitoring was reduced to annually beginning in 2006. Typically five to seven groundwater monitoring wells are analyzed for BTEX and both gasoline range and diesel range total petroleum hydrocarbons (TPH-GRO and TPH-DRO) and five wells are analyzed for a suite of biological indicator parameters (nitrite, nitrate, sulfate, sulfide, chloride, total iron, TOC, alkalinity, hardness, and methane).

System Operations/Operation and Maintenance

GWTF #1 and #2 for the site-wide groundwater remedy continued to operate as designed during the review period. The facilities consistently met the TPDES and Air Pollution Control permit discharge criteria. No significant operational problems were encountered, other than continued frequent shutdowns attributed to power outages in the Water and Power Authority (WAPA) service. In addition, frequent replacement of equipment is typically necessary due to the corrosive environment that exists on the island.

No major operational changes were made during the review period. Both facilities continued to operate in by-pass mode except during operation of RW-6, when the water is diverted to the equalization tank/transfer pumps to dilute flow from RW-6 with the influent from RW-7, minimizing the high VOC loading to the air-stripper. The SVE and off-gas systems continued to remain off-line. These systems were shut down after the first two years of operations because it was determined they were no longer needed.

Prior to transfer of the facilities to the USVI Government (GVI) in April 2013, a series of final inspections were performed to ensure the facility components were in good working order. Repairs were performed as necessary to transfer the facilities in an acceptable condition.

Site-wide monitoring wells have been periodically inspected and repaired. Monitoring wells RD-8 and RD-10 were damaged during the review period due to construction activities performed by others. Both well casings have subsequently been repaired and resurveyed.

Progress Since Last Five-Year Review

The first five-year review for the site was signed on April 17, 2009. The five-year review found that:

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 issues identified in the table below needed to be resolved.

Following is a list of recommendations included in the previous five-year review and the status of the actions to address these recommendations:

Issue	Recommendations and Follow-up Actions	Party Responsible	Progress
Source area ICs not fully implemented	Post completion sampling and appropriate proprietary controls implemented	EPA/PRP/DPNR	Ongoing. Groundwater data have been evaluated to determine where potential delineation may be needed. Monitoring will continue so that the groundwater plume can be further evaluated. Identified as a recommendation in this five-year review.
	Bring out-of-compliance wells back to compliance	DPNR/EPA	Ongoing. The remedy will continue to operate in order to bring out of compliance wells back into compliance. This has already happened for some wells, such as PW-1 in the BTEX Total Petroleum Station.
Full remediation of groundwater uncertain	Evaluate increase flow rate of extraction well near GWTF. #1	EPA	Complete. This was evaluated and it was determined that the current flow rates were appropriate. The system will continue to be monitored.

Issue	Recommendations and Follow-up Actions	Party Responsible	Progress
Full remediation of groundwater uncertain (continued)	Consider additional piezometers, extraction well and in-situ technologies near GWTF #1	DPNR/EPA	Ongoing. Additional wells, piezometers and technologies were considered prior to the transfer of the groundwater pump and treat to the GVI; however, the current remedy demonstrated continued decrease in contaminant concentrations throughout the plume areas and the decision was made to continue monitoring the existing remedy. Identified as an issue in this five-year review.
	Re-assess effectiveness of cleanups to meet remedial action objectives	DPNR/EPA	Ongoing. Groundwater data are evaluated regularly. Groundwater concentrations continue to show overall decreasing trends throughout the plume. Although certain wells may exhibit temporal uptrends, these wells are within the capture zone. Wells will continue to be monitored.
Some monitoring wells are damaged	Repair wells and caps as necessary	EPA	Completed. Repairs were completed prior to the transfer of the groundwater pump and treat to the GVI.

Since the last five-year review, changes have been made to operation, maintenance and monitoring requirements. Changes made to the sampling program include shipment of unpreserved VOC samples rather than preserved samples due to issues with effervescence at the site. In addition, five vials were collected instead of three vials to improve the chance a vial would reach the laboratory without air bubbles. Due to abnormally high sample results observed in several wells during the April 2009 annual sampling event, a semi-annual sampling event was conducted in October 2009 and included sampling of monitoring wells MW-2, MW-8, MW-15, RD-13, and TT-6. The high concentrations encountered in April 2009 were not observed during the October 2009 sampling event. The cause for the abnormally high results is unknown. During the May 2013 sampling event, the Mathias supply well as added to the sampling schedule, and the Laplace, Smith, and Mathias supply wells were also tested for microbial parameters to assess whether the wells were able to be placed into service for potable use. The wells were determined to be unsuitable for drinking because one or more parameters exceeded the drinking water criteria. Also during the May 2013 sampling event, the pump at supply well Eglin-3 was not functioning, so no sample could be collected from this well. During the site inspection on August 6-7, 2014, it was confirmed that the Eglin-3 well was still out of service.

As noted above, that the operation and maintenance of the groundwater remedy was transferred to the GVI in April 2013. Although appropriate training of the operation of the groundwater treatment plant had been conducted with the contractor identified by the GVI, the necessary administrative procedures that the GVI needed to complete were not in place at the time of the transfer, and the groundwater treatment system was shut down for a period of approximately one week. Once all administrative and contractual issues had been resolved, the facility was put back on line and has been in operation continuously, with no break in service.

Additionally, all the residences have been connected to public water.

Five-Year Review Process

Administrative Components

The five-year review team included Caroline Kwan (EPA-RPM), Katherine Mishkin (EPA-Geologist), Julie McPherson (EPA-Human Health Risk Assessor), Mindy Pensak (EPA-Ecological Risk Assessor) and Geoff Garrison (EPA-Community Involvement Coordinator). This is a Fund-lead site.

Community Involvement

An announcement of the five-year review process was published on the EPA Tutu Wellfield website in July 2014. Once the five-year review is completed, the results will be made available at the local site repository, which is at the USEPA, Virgin Islands Field Office, Tunick Building, Suite 102, 1336 Beltjen Road, St. Thomas, VI 00801 and posted on the EPA's website. In addition, efforts will be made to reach out to local public officials to inform them of the results.

Document Review

The documents, data and information which were reviewed in completing this five-year review are summarized in Table 2.

Data Review

One of the remedial action objectives at the Site calls for restoration of the Tutu aquifer to MCLs. Therefore, it is necessary to evaluate trends in contaminant concentrations in groundwater over the period that the remedy is in effect, and particularly over this five-year review period (2009-2013). The previous five-year review conducted at this Site, indicated that overall total CVOCs have decreased compared to baseline levels measured in March 2004. Fluctuations in concentrations were attributed to periodic changes in groundwater flow regime in response to recharge and groundwater extraction activities.

There are two CVOC groundwater contaminant plumes associated with the Site. Contaminants in the Northern Plume migrate southwest from north of the Curriculum Center. This plume extends vertically from 15-30 feet bgs to about 80 feet bgs. Contaminants in the Southern Plume migrate southeast from O'Henry and along Turpentine Run. The two groundwater plumes were previously co-mingled, but may now be two separate plumes (Figure 10).

CVOC Northern Plume:

Former Source Area

Within the area of GWTF #1, shallow wells near the source area are two open hole extraction wells, RW-7 and RW-9. Influent concentrations for both shallow extraction wells have been under 200 µg/L for total CVOCs and less than 100 µg/L for individual CVOCs. Concentrations in deep well RD-9 range from non-detects in October 2009 to 478,500 µg/L in April 2011, substantially higher than baseline concentrations of 152,020 µg/L, or those ever observed in this well (Figure 3). Concentrations more recently have dropped to below baseline levels, with a concentration of 2,909 µg/L reported in May 2013. The previous five-year review noted an increase in concentrations compared to baseline levels and since this well is screened within the low yield zone that is suspected to contain free product, this increase was attributed to the pumping of extraction wells (RW-7 and RW-9), which may have caused contaminant mobilization in the vicinity of RD-9. RD-9, as shown in Figures 3 and 4, has historically shown some of the highest concentrations of total CVOCs at the Site. This spike in concentration in April 2011 is likely indicative that free-product remains in the vicinity of RD-9 and is influenced by nearby pumping wells.

The only other data available in the vicinity of and at depths consistent with the screen of RD-9 is influent data from recovery wells. Consistent with RD-9 data, the majority of mass appears to reside in the deeper bedrock zones. Influent concentrations in shallow recovery wells, RW-7 and RW-9, were under 200 µg/L for total CVOCs and less than 100 µg/L for individual constituents (e.g. PCE, TCE, 1-2,DCE and vinyl chloride) in 2012. Influent concentrations in deep recovery well RW-6 showed concentrations on the order of 10,000 and 100,000 µg/L for total CVOCs in 2012.

Downgradient

MW-1D, MW-14, RD-13 form a transect that is about 300 feet downgradient of RD-9. MW-1D (70-90 feet bgs) and RD-13 (100-125 feet bgs) are located within the centerline of the plume in the deep bedrock. MW-14 (25.2-45.2 feet bgs) is at the edge of the higher concentration plume. With the exception of a spike in April 2011, concentrations found in MW-1D are generally lower than those detected during the March 2004 baseline sampling event (see Figure 5). Total CVOCs found in RD-13 are similar to the baseline sampling concentration of 780 µg/L (see Figure 5). RD-13 is screened about 30 feet deeper than MW-1D and shows higher concentrations compared to MW-1D showing that contaminant mass increases with depth. The lateral extent of deep contamination is unclear since there is no monitoring in this zone further downgradient of RD-13.

Total CVOCs in shallow well MW 14 are slightly above the baseline sampling concentration of 11 µg/L. Although significantly lower in concentration than the deeper bedrock wells, persistent contamination in shallow well may be attributed to some residual mass remaining in the shallow fractured bedrock.

Further downgradient, average CVOC concentrations in the shallow screened well, MW-15, are slightly greater during this five-year review period (50 µg/L) as compared to the previous review period (37 µg/L), which could be indicative of contaminant migration from the source area. Although slightly higher, concentrations over the last five years remain below those detected during the baseline sampling event (55 µg/L). Total CVOC concentrations in shallow well RD-5

(33-43 feet bgs) have also shown a slight overall increase in CVOCs during this review period (Figure 6), with concentrations ranging from about 70 µg/L in 2009 to approximately 100 µg/L in 2013, but have remained below baseline level concentrations (204 µg/L).

With the exception of a spike in concentration in MW-2 (90 µg/L in April 2009), periphery wells (MW-2, MW-13D) have consistently shown low contaminant levels.

Further downgradient from the Curriculum Center, total CVOC concentrations have decreased since the baseline sampling event (Figure 7). Despite a spike in TT-6 CVOCs (161 µg/L) in 2009, concentrations have been relatively stable in these downgradient wells. A moderate increasing trend is evident in the Tillett well, while stable and moderate decreasing trends are evident in MW-7 and TT-6, respectively.

In the April 2012 Annual Remedial Action Progress Report, it was speculated that consistent contaminant concentrations in the shallow aquifer downgradient of the facility may be indicative of material from the highly contaminated deep zone migrating to shallower zones (CDM, 2012). As stated, concentrations remain either relatively consistent or in a slight upward trend.

Historically, the conceptual site model has depicted the downgradient extent of the Northern plume to be co-mingled with the Southern plume in the vicinity of MW-21D and the Laplace well. However, both wells have shown a gradual reducing trend in concentrations with average concentrations of CVOCs during this review period of 22.9 µg/L and 5.5 µg/L, respectively. Additionally, with the exception of a peak concentration in MW-8 occurring in April 2009 (47 µg/L), MW-8 and MW-10 show low-level concentrations (< 5µg/L) of total CVOCs during this review period. These data suggest that the plumes are no longer co-mingled and that the downgradient extent of the Northern Plume is more accurately in the vicinity of MW-8 and MW-10.

Hydraulic capture

Extraction wells for GWTF #1 include: RW-6, RW-7, RW-9 and for GWTF #2 are RW-1S and RW-1. RW-7 (shallow open hole) and RW-1S (shallow open hole) serve as the primary extraction wells for operation at GWTF #1 and GWTF #2, respectively. RW-6 (deep open hole) operates on a weekly basis to enhance CVOC mass removal from the deep zone, RW-9 (shallow open hole) is operated intermittently to maintain water level elevations during wetter conditions, and RW-1 (deep open hole) is on standby and has never been operated. In 2011, a Remedial Systems Evaluation (RSE) was conducted with the objective of optimizing the effectiveness and protectiveness of the remedy. This report suggested that hydraulic capture associated with the GWTF #1 area is incomplete and recommended that the current extraction system is enhanced with more extraction wells. It was also suggested that GWTF #2 provides minimal benefit to controlling the plume and that this system be discontinued, which would increase the effectiveness of capture from the GWTF #1. However, due to the lack of monitoring points between the source area at GWTF #2 and downgradient monitoring wells (MW-14, MW-1D, RD-13), the limits of hydraulic capture are difficult to ascertain. Additionally, hydraulic capture in a fractured rock setting is complicated and complete capture may be difficult even with additional wells, especially considering the non-productive zone.

The data presented above suggests that conditions in the shallow aquifer have improved, but there may be still be a concern for vertical migration from the deep highly contaminated fractured bedrock aquifer to the shallow aquifer, perhaps due to pumping activities and lateral migration of the deep CVOC plume. The majority of contaminant mass remains at high concentrations in the source area near GWTF #1, likely in the form of product, in the deep fractured bedrock where hydraulic capture would be difficult regardless of the capture system. Although this zone has a low productivity, it is likely acting as a slow and continuous source to downgradient areas and potentially to the shallow aquifer as suggested above. Enhancing the extraction network may lead to spreading the extent of contaminated material in the low-productive zone rather than improving the conditions at that depth, thus, other strategies may need to be assessed.

CVOC Southern Plume:

Total CVOC concentrations in the vicinity of GWTF #2 have, with the exception of Eglin-3, decreased since baseline monitoring. Baseline levels in Eglin-3 were 33 µg/L while during this review period they fluctuated and were as high as 48 µg/L. Until recently, this well was pumping and potentially drawing contamination.

The southern extent of the plume continues south of O'Henry. The monitoring wells in this area include Steele, MW-21D, Laplace, Smith, RD-14, RD-6, Delegard, PZ-4, RD-2, and RD-3. Generally, CVOC concentrations in monitoring wells in this area have decreased since baseline sampling in March 2004, but Steele has shown an upward trend over this review period with concentrations nearing the baseline concentration level of 169 µg/L. This is likely indicative of a low concentration residual source in this area and may be attributed to minimal pumping from Steele and a redistribution of material. However, overall, concentrations in Steele have decreased since baseline monitoring, as shown in Figure 8.

BTEX Texaco:

Groundwater analytical results from monitoring wells in the vicinity of the PUMA facility (formerly Texaco) indicate an overall reduction of dissolved phase BTEX concentrations, by at least an order of magnitude since monitoring activities were initiated in 1998. Groundwater monitoring wells in this area include: VE-1, TT-1, TT-5, TT-6, MW-3, MW-4, MW-5, MW-6R, and MW-7; however, after several rounds of low detection results, TT-6, MW-4, MW-6R, and MW-7 were removed from the sampling program. Most recently groundwater sampling results from the August 2013 groundwater monitoring event indicate that concentrations exceeded the benzene MCL of 5 µg/L in monitoring wells VE-1 and TT-1, with benzene concentrations of 190 µg/L and 220 µg/L, respectively and these are the only wells with BTEX concentrations above the MCLs. Over the review period, BTEX concentrations have fluctuated with total BTEX concentrations exceeding 600 µg/L (TT-1) and 1,000 µg/L (VE-1) for several monitoring events, as shown in Figure 9. Maximum BTEX concentrations are found in wells VE-1 and TT-1 and although concentrations appear to fluctuate most likely due to changes in the water table elevation and mobilization of residual source material in the unsaturated zone, a slight statistical decrease in concentrations is noted (Figure 9).

BTEX Esso:

Groundwater monitoring wells in the vicinity of the Total Petroleum Station (formerly Esso) include: SW-1R, SW-2R, SW-8R, SW-9, SW-10, PW-1, MW-8, MW-9, MW-9S, MW-10, MW-10D, MW-25, CHT-1, CHT-3, CHT-4, CHT-7D, DW-1, G6, and G8; however, after several rounds of low detection results, SW-8R, SW-9, SW-10, MW-9S, MW-10D, MW-25, CHT-1, CHT-4, CHT-7D, DW-1, G6, and G8 were removed from the sampling program. Groundwater analytical results in this area indicate that the dissolved phase BTEX concentrations in both on-site and off-site monitoring wells at this station have exhibited decreasing trends since the start of the “hot-spot” groundwater remediation system in 2002, with total BTEX concentrations decreasing in the onsite well PW-1 from approximately 1,300 µg/L in 1994 to approximately 250 µg/L in 2006. During the previous five-year review benzene was consistently detected in PW-1 at concentrations exceeding the MCL; however, with the exception of a benzene detection of 150 µg/L in December 2009, benzene and all other BTEX constituents in PW-1 have been below MCLs during this review period. Concentrations in all other monitoring wells have exhibited non-detect levels for all BTEX constituents with the exception of downgradient well, CHT-3 with just one benzene detection of 1.2 µg/L in December 2009. In summary, the decreasing trend in BTEX concentrations that has previously been exhibited has continued since the previous five-year review and suggests that the BTEX plume has substantially decreased in size and may have achieved MCLs throughout the plume, based on the non-detects and the very low levels encountered during this period. However, in order to confirm this, samples need to be collected during periods of low groundwater elevation when less dilution is occurring. This was made as a previous suggestion since all previous sampling events occurred during the rainy season.

The SVE system operated for about 2 years and after significant decreases in SVE influence concentrations and having achieved asymptotic conditions, it was shutdown in April 2006. During operation, soil gas samples were collected from 12 soil gas vapor probe locations and showed significant reductions (96-99 percent). However, the last five-year review recommends (page 9) that soil samples should be taken to confirm that residential use standards have been met for both surface and subsurface soils. No confirmatory data was collected.

Site Inspection

The inspection of the site was conducted on August 6 -7, 2014 by Geoff Garrison, the community involvement coordinator (CIC). The purpose of the inspection was to assess the condition and performance of the remedy. The site was inspected to ensure that all well covers remained in place, extraction wells were in good condition and no issues were identified that would question the performance or protectiveness of the remedy. It was confirmed during the site inspection that the Elgin-3 well was not operational, and hasn't been for over one year. The data review assesses the data that reflects that this well is not in service.

Interviews

During the review process, interviews were conducted with William Buskirk, the representative of Arrowhead, the contractor to the GVI operating the groundwater treatment plant. He stated that the plants are operating with no deficiencies. Interviews were also conducted with several residents who had private wells that were hooked up to public water, and the deputy superintendent of a nearby school. The purpose of the interviews was to document any perceived

problems or successes with the remedy that has been implemented to date. Interviews were conducted on August 6 – 7, 2014. Interviews are summarized below.

On August 6th, the CIC met with the residents of the Lucyleta Smith and Ura Jones properties which had been hooked up to WAPA water mains during the October 2013 work, Mr. Alvin Brown, who is the son of (and represents) Ms. Smith, and with Ms. Cenna Mathias who represents the Jones property. At the Smith property, Mr. Brown explained that he was using the well water for irrigation and to run the toilets. He had no issues with the WAPA hookup performed by EPA contractors for his family for the rental units on the property.

The Department of Education Deputy Superintendent for the St. Thomas/St. John District, Mr. Joseph Sibley, was on vacation during the CIC visit but did communicate to the CIC via telephone in reference to the its remediation efforts. Mr. Sibley had no concerns with the ongoing remediation.

Institutional Controls Verification

Institutional controls

The ROD includes requirements for institutional controls. Supply wells used for human consumption and that interfere with the pump and treat operations have been decommissioned. The majority of residents have been placed onto the public water supply and potable water is delivered to the one resident who is still to be connected to public water; this resident is scheduled to be connected to public water by the end of 2014. Authorization must be obtained from DPNR before use of any existing wells or installation of any new wells within the confines of the plume area.

Technical Assessment

Question A: Is the remedy functioning as intended by the decision documents?

The remedy for the Tutu Wellfield Site is not functioning as intended by the decision documents. Overall, the extraction and treatment systems have been effective at removing some CVOC mass and data suggest that CVOC and BTEX contaminant plumes have diminished in size, most likely due to a combination of groundwater extraction activities and natural attenuation of contaminant constituents. The cumulative removal of CVOCs since the start of up both extraction systems has been 162 pounds of mass. Residual source material still appears to be present in the Southern Plume due to the increasing concentrations observed in monitoring well Steele, but these concentrations do not appear to be impacting downgradient wells. However, hydraulic capture of the plumes has been called into question, particularly by the RSE report, due to the limited monitoring well network between the extraction wells and monitoring wells and the nature of the complex fractured bedrock environment the extent of hydraulic capture is difficult to establish. However, it appears that the Steele well is within the area of capture. Considering the lateral extents of both plumes, the peripheral wells and downgradient wells have shown low-level detections of CVOCs, suggesting that if there were any concern with hydraulic containment it would be with regard to the vertical component of the Northern Plume.

Of particular concern is the amount of mass that appears to be present in the source area of the Northern Plume. DNAPL remains in the fractured bedrock and although its presence is in a hydraulically low yielding zone, it has the potential to serve as a slow residual contaminant source to the dissolved phase plume over time. Groundwater monitoring of the DNAPL is limited since the nearest downgradient wells are 300 feet from RD-9 and just one well is screened at a similar depth (RD-13). This well has shown a decreasing trend in CVOC concentrations over this review period, but the next downgradient well (RD-5) screened at a similar depth has shown an increasing trend and there is no monitoring at this depth further downgradient. The cause of the increasing trend is unclear, but may be from downward vertical migration of the plume from upper bedrock zones or lateral transport from the source area.

Given the RAO to restore the groundwater to drinking water standards, the current groundwater extraction remedy will be ineffective at removing the DNAPL material from the low-yielding fractured bedrock. If restoration is going to be achieved, alternative remediation technologies should be considered.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy still valid?

The risk assessment process has changed somewhat since the original risk assessment was performed in 1995. Chemical-specific toxicity values have changed since the original risk assessment was conducted. The risk assessment addressed exposure to the surface soil, subsurface soil and groundwater. This review will include an evaluation of the cleanup goals and objectives for each medium that was evaluated in the risk assessment.

Soil cleanup goals were based on impact to groundwater concerns, since unacceptable risks from direct contact were not identified. The soil remedy was reviewed to address the protectiveness of the remedy presented in the ROD. The remedy for the soils varied from excavation to SVE at the different source area properties of the site. In order to determine if the remedy is currently protective of human health, the cleanup goals established for the chemicals of concern, BTEX and CVOCs, were compared to EPA's Industrial Soil Preliminary Remediation Goals (PRG) to determine if the remedy is currently protective of human health and were found to be within or below the acceptable risk range for direct contact. Since the cleanup goals were developed to be protective for impacts to groundwater, and these values are more stringent than concentrations for direct contact.

The groundwater remedy was reviewed to address the protectiveness of the remedy presented in the ROD. The remedy for groundwater is restoration, and the remedial goals are MCLs, which are promulgated standards that apply to public water systems and are intended to protect human health by limiting the levels of contaminants in drinking water. The MCLs continue to remain protective. Although MCLs have not been achieved, the exposure pathway has been interrupted since there are institutional controls preventing the use of groundwater as a potable water source in the area, and residents have either been hooked up to public water or trucked potable water are being provided until the hook up can be completed. Groundwater use is not expected to change in this area within the next five years, the period of time considered in this review.

Soil vapor intrusion was not evaluated as a potential future exposure pathway during the RI. The evaluation of this pathway is based on the conservative (health protective) assumption that buildings are located above the maximum detected concentration of the contaminants of concern in the groundwater and accumulating vapors migrating up through the vadose zone may impact inhabitants. Considering the high concentrations of volatiles in the groundwater, it was recommended that the vapor intrusion pathway be evaluated, and this was initiated in 2008. Although concentrations of site-related contaminants are above the screening criteria in the subslab, the vapor intrusion pathway was determined to not be a concern at this site considering the relatively low concentrations of site-related contaminants found in the indoor air. Considering the screening criteria have changed since the initial review in 2008, a review of the data collected in 2008 to EPA's current screening criteria for site-related contaminants was conducted for the purpose of this five-year review. This comparison confirmed that the vapor intrusion pathway is currently not a concern at the site.

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

No additional information has come to light that could call into question the protectiveness of the remedy. The information discussed above has been available and demonstrates that the remedy is short-term protective.

Technical Assessment Summary

The soil remedies that had been implemented at the site for source removal purposes and have been completed.

Groundwater data at the site indicates contamination the deeper aquifer of the Northern Plume is not decreasing, which suggests the presence of source material, potentially DNAPL. In the Southern Plume, concentrations are decreasing. Concentrations in the Steele well are slightly increasing during this review period, although this well is within the capture zone and is not migrating. However, data from the most downgradient wells show CVOC exceedances and indicate that the downgradient edge of the plume may not be fully delineated.

There are no known exposures to groundwater. Residents are hooked up to public water or are being supplied trucked water.

Vapor intrusion concerns have been addressed by sampling in 2008, where the subslab results exceeded screening values, but the indoor air concentrations were negligible and well below risk-based concentrations. A review of the data for this five-year review reached the same conclusions.

Issues, Recommendations and Follow-Up Actions

OU #	Issue	Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness? (Y/N)	
						Current	Future
OU 1	Potential DNAPL in the deep aquifer of the Northern Plume	Additional evaluation of the potential DNAPL will be conducted under a separate operable unit	EPA	EPA	9/1/2018	No	Yes
OU 1	Downgradient plume capture in the Southern Plume is not fully characterized	Additional evaluation of the southern plume to ensure complete capture of the downgradient plume will be conducted	EPA	EPA	9/1/2018	No	Yes

Protectiveness Statement

Protectiveness Statement(s)		
<i>Operable Unit:</i> OU 1	<i>Protectiveness Determination:</i> Short-term Protective	<i>Addendum Due Date (if applicable):</i> Click here to enter a date.
<i>Protectiveness Statement:</i> The remedy at Tutu Wellfield currently protects human health and the environment because the groundwater extraction and treatment systems are capturing the contaminated groundwater in the plumes and the source areas in the soils have been addressed. In order for the remedy to be protective in the long-term, additional evaluation of potential DNAPL in the Northern Plume is needed and further evaluation of groundwater capture in the Southern Plume is needed to be documented for the remedy to be protective.		
Sitewide Protectiveness Statement		
<i>Protectiveness Determination:</i> Short-term Protective	<i>Addendum Due Date (if applicable):</i> Clickate.	
<i>Protectiveness Statement:</i> The remedy at Tutu Wellfield currently protects human health and the environment because the groundwater extraction and treatment systems are capturing the contaminated groundwater in the plumes and the source areas in the soils have been addressed. In order for the remedy to be protective in the long-term, additional evaluation of potential DNAPL in the Northern Plume is needed to identify if this is a source of contamination to the groundwater, and further delineation of the Southern Plume needs to be documented.		

Next Review

The next five-year review report for the Tutu Wells Superfund site is required five years from the completion date of this review.

Tables

<i>Table 1: Chronology of Site Events</i>	
Event	Date(s)
Investigation at the Site begins pursuant to complaints from local residents of an odor emanating from groundwater supply wells	1987
Unilateral Administrative Orders (UAO) 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	1988 - 1990
Hazard Ranking System package prepared, and Site is proposed for addition to the NPL	February 1992
PA issues Administrative Order of Consent (AOC) to Texaco and Esso to implement an RI/FS	February 1992
Various RI/FS activities	1992 - 1995
Western Auto removes underground storage tank and paves the area with a concrete cap	August 1994
EPA issues Consent Order to O'Henry for soil cleanup. Pursuant to the Order O'Henry performs soil removal.	March 1995
Site is added to the NPL	September 1995
ROD signed	August 1996
Construction completed for the Texaco Service Station groundwater and soil treatment system and Vitelco groundwater treatment system. Texaco Service Station system is placed into operation.	1998
EPA issues UAOs to Texaco, Esso, and Western Auto /Four Winds Plaza for RDs/RAs to address site contamination	May 1998
Pre-design investigation performed for Curriculum Center soils and site-wide groundwater	August 1998 - November 1999
Esso groundwater and soil treatment system construction completed and system is placed into operation	1999
Pre-design investigation performed at Western Auto/Four Winds Plaza	January - February 1999

<i>Table 1: Chronology of Site Events</i>	
EPA issues UAO to O'Henry for RDs/RAs to address site contamination	May 1999
O'Henry Dry Cleaners performs pre-design soil delineation investigation	November 1999
EPA approves No Further Action recommendation regarding ROD specified soil contamination for Western Auto Mart/Four Winds Plaza	January 2000
EPA approves No Further Action recommendation for O'Henry Dry Cleaners	July 2001
EPA completes the design for the Curriculum Center groundwater treatment and SVE, and side-wide groundwater treatment	September 2001
Soil excavation of contaminated soils at Esso Service Station and treatment of soils in bio-cells. Construction of Esso "Hot-Spot" remediation system.	2001 - 2002
Operation of Esso Service Station "Hot-Spot" remediation system	2002 - 2005
Texaco Service Station groundwater and SVE systems shutdown after a pulsing period is conducted	July 2003
MNA activities for Texaco Service Station	July 2003 – present
Site construction completed for Curriculum Center soils and site-wide groundwater. System is placed into operation.	March 2004
Operation, maintenance, and monitoring activities for Curriculum Center SVE and off-gas systems	March 2004 – March 2004
Operation, maintenance, and monitoring activities performed for site-wide groundwater	March 2004 - April 2013
MNA activities for Esso Service Station	2005 - present
Removal and replacement of three underground storage tanks and associated fuel lines performed at the Texaco Service Station	December 2006
Enhanced bioremediation application performed at the Texaco Service Station	January 2007
Previous Five Year Review report	April 2009
EPA transfer LTRA to Virgin Islands Government	April 2013

<i>Table 2: Documents, Data and Information Reviewed in Completing the Five-Year Review</i>	
Document Title, Author	Submittal Date
US Environmental Protection Agency Record of Decision, Tutu Wellfield	August 5, 1996
Forensic Environmental Services, Inc. -Remedial Action Progress Reports - Esso Tutu Service Station	Various Dates
MACTEC Engineering and Consulting, Inc.- Remedial Action Progress Report - Chevron/Texaco Tutu Service Station -	Various Dates
CDM Federal Programs Corporation, Inc.- Annual Remedial Action Progress Reports	April 2009 to August 2013
First EPA Five Year Review Report	April 2009
EPA's Remediation System Evaluation Report	August 2011
Lockheed Martin- Tutu Wellfield Work Assignment 0-154- Air Sampling Trip Report	February 2012

Figures

Figure 1: Site Location Map

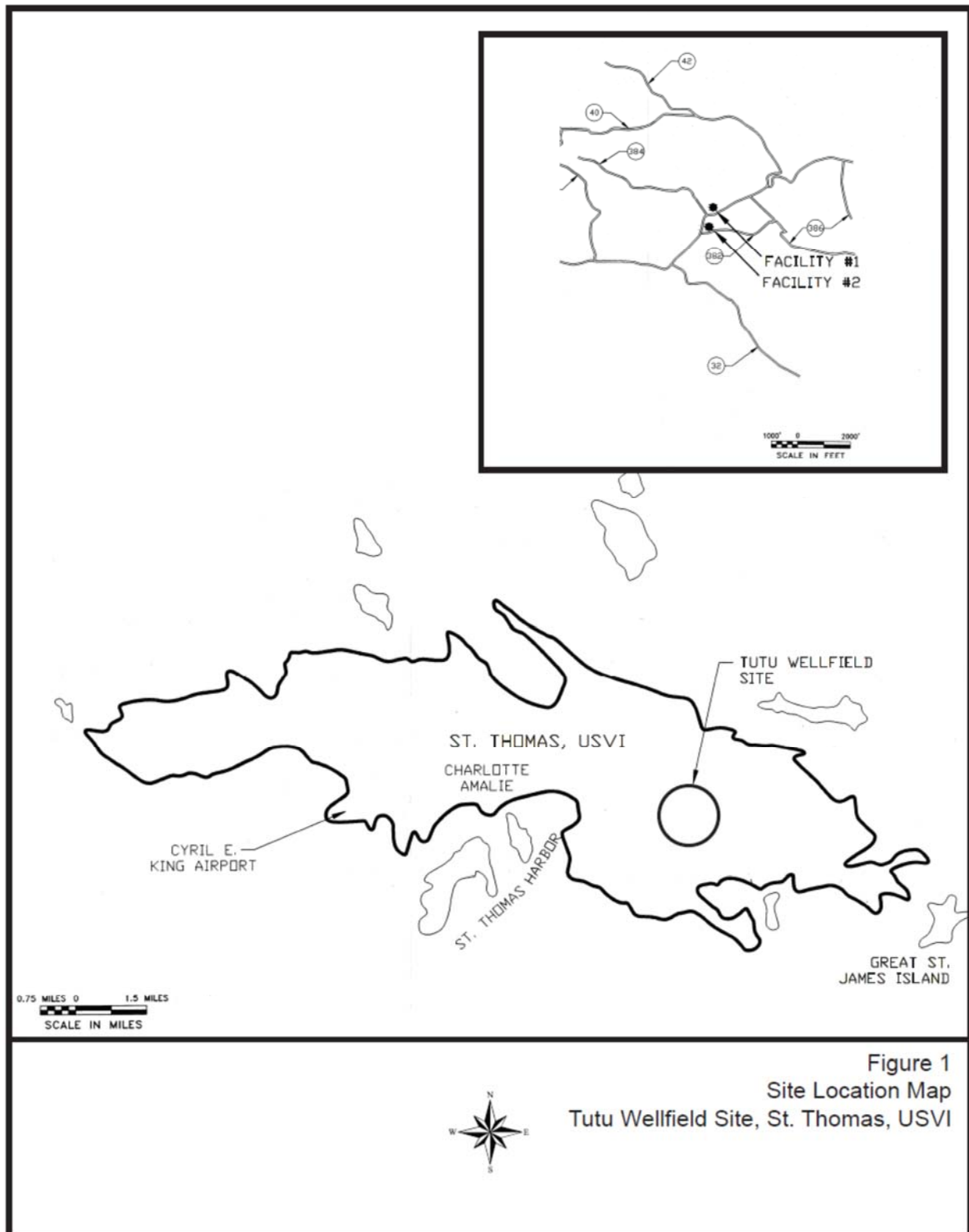


Figure 2: Topographic Site Map

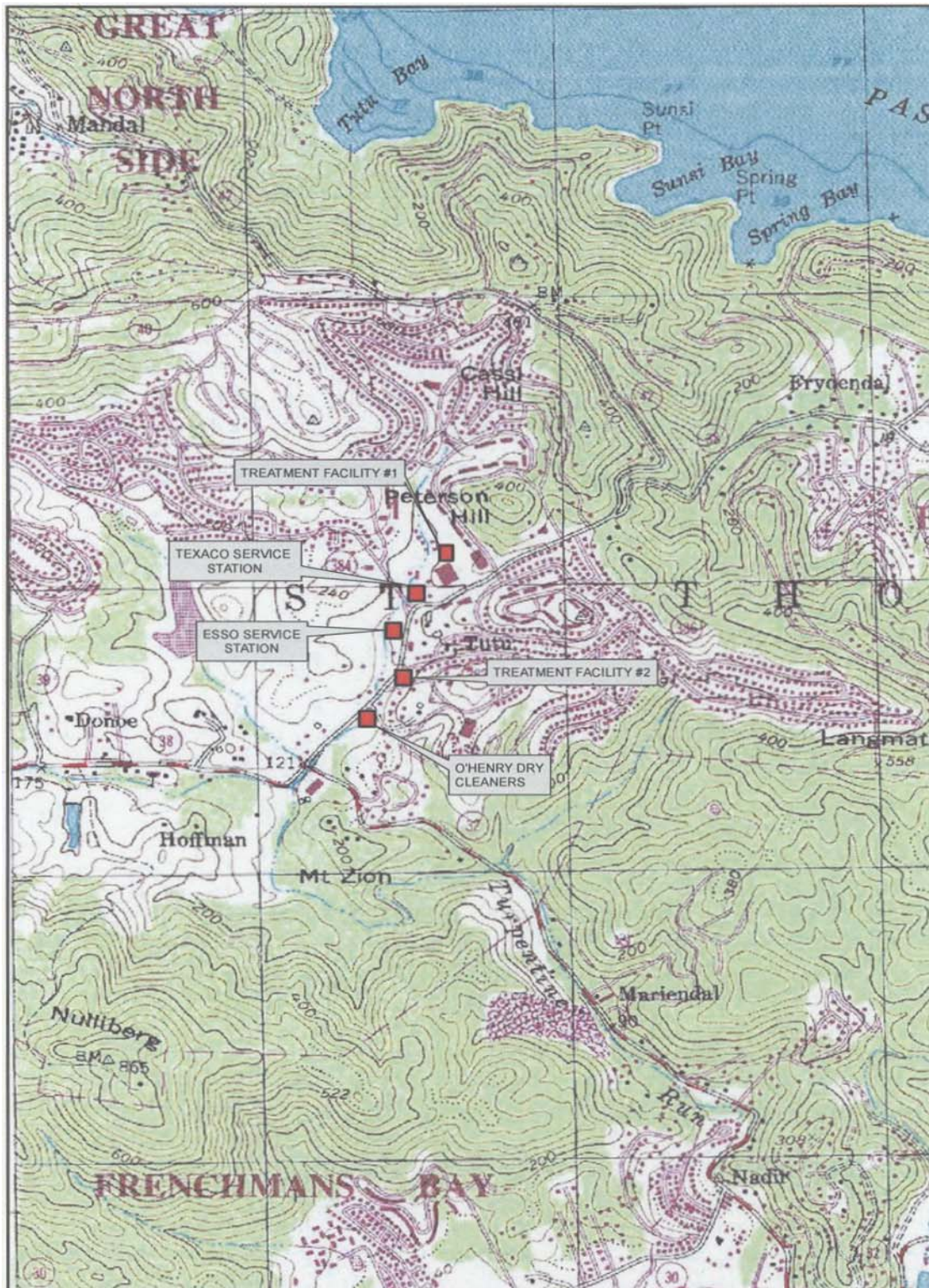


Figure 2
Topographic Site Map
Tutu Wellfield Site, St. Thomas, USVI

Figure 3: Total CVOC concentrations in RD-9 over five-year review period. Concentrations ranged from 0 µg/L to 478,500 µg/L over this time period.

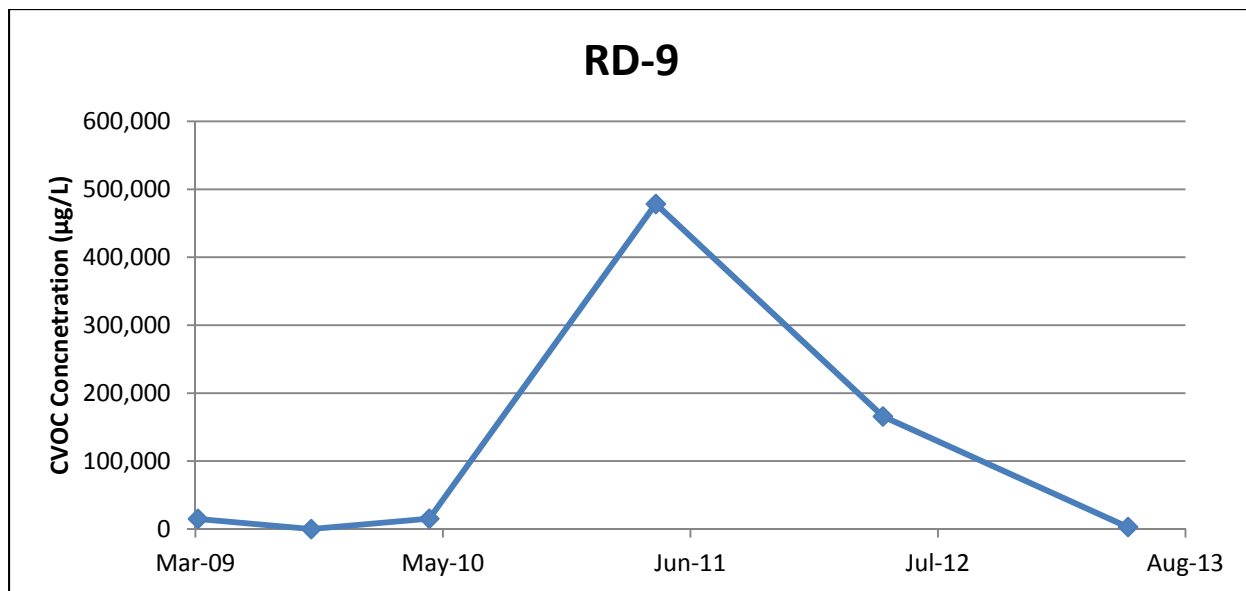


Figure 4: Concentrations in RD-9 from baseline sampling in March 2004 to present-day.

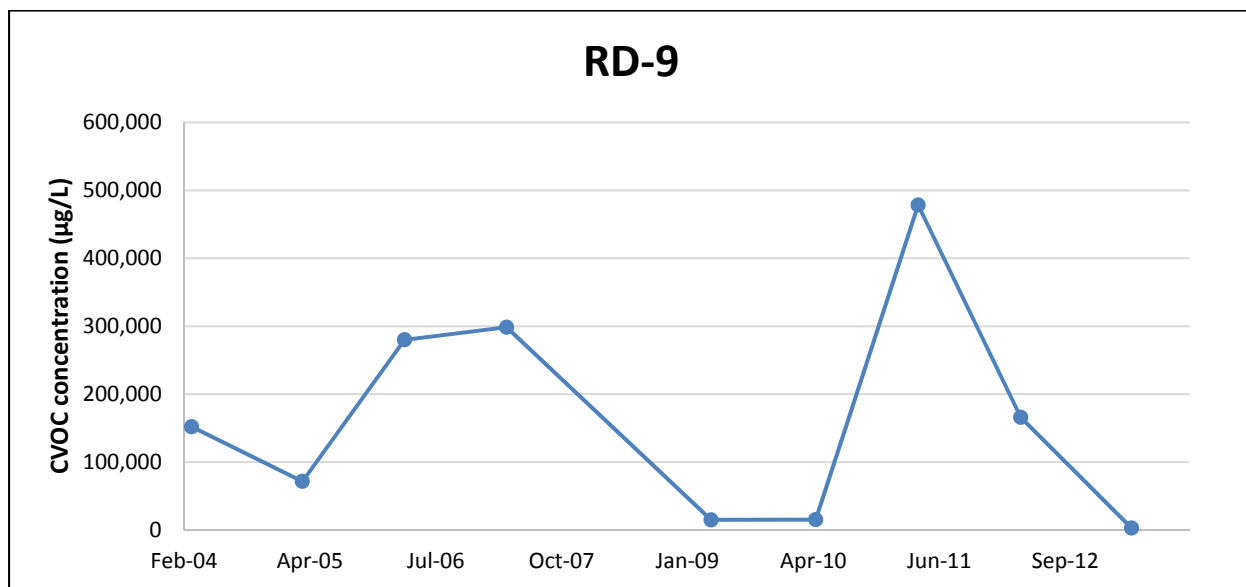


Figure 5: Total CVOC concentrations in transect downgradient of RD-9. Wells included are MW-1D, RD-13, and MW-14

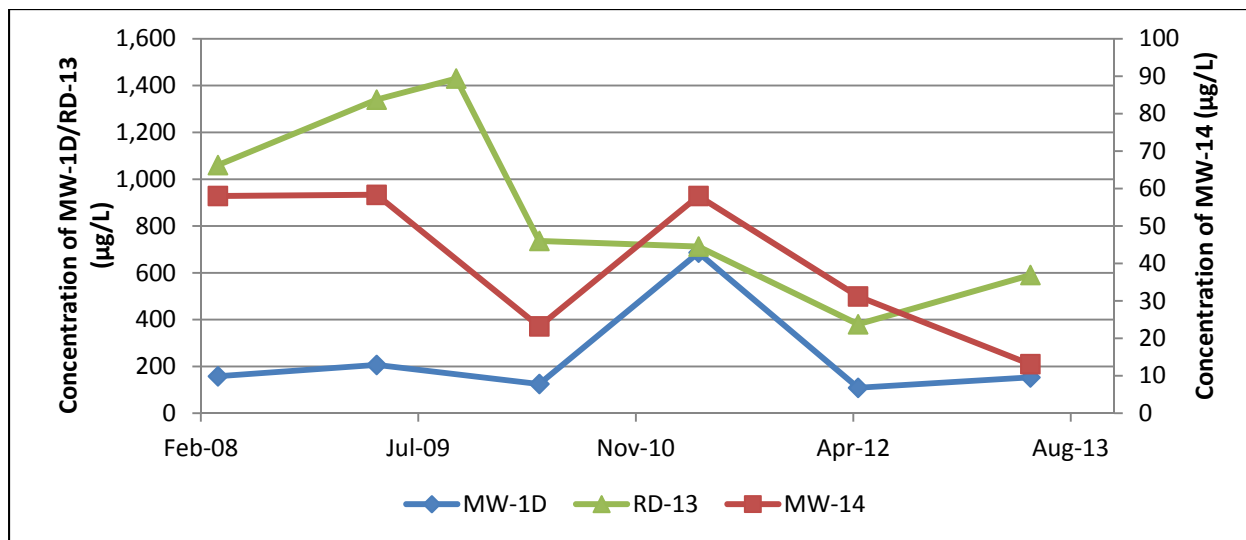


Figure 6: Total CVOC concentrations in RD-5 over five-year review period.

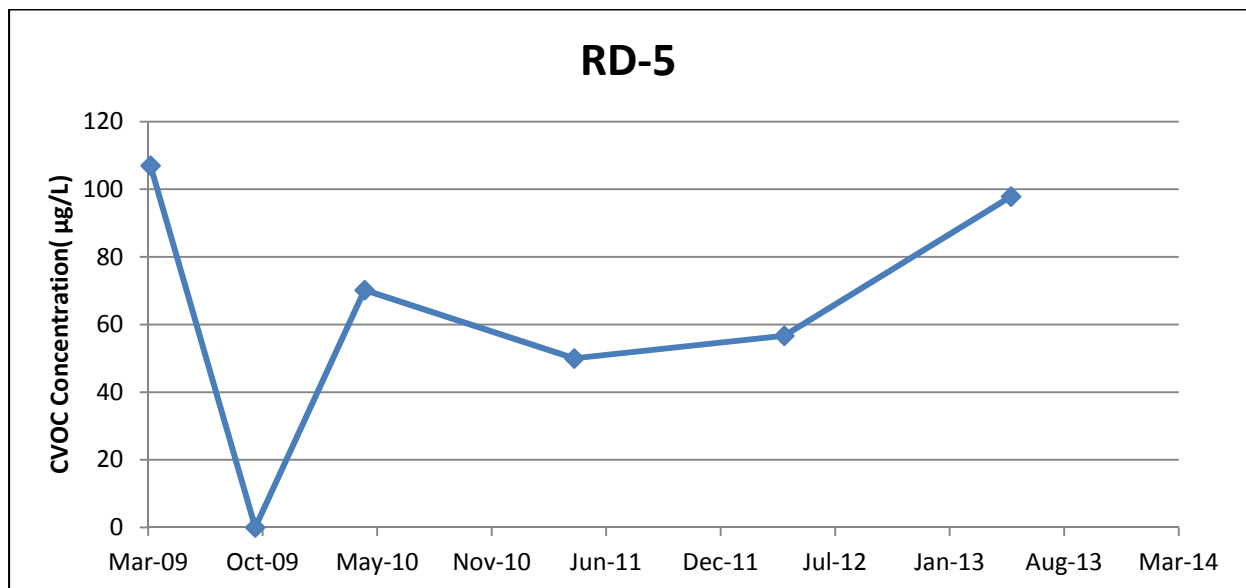


Figure 7: Total CVOC Concentrations further downgradient from the Curriculum Center. Trends are shown for MW-7, TT-6, and Tillett monitoring wells.

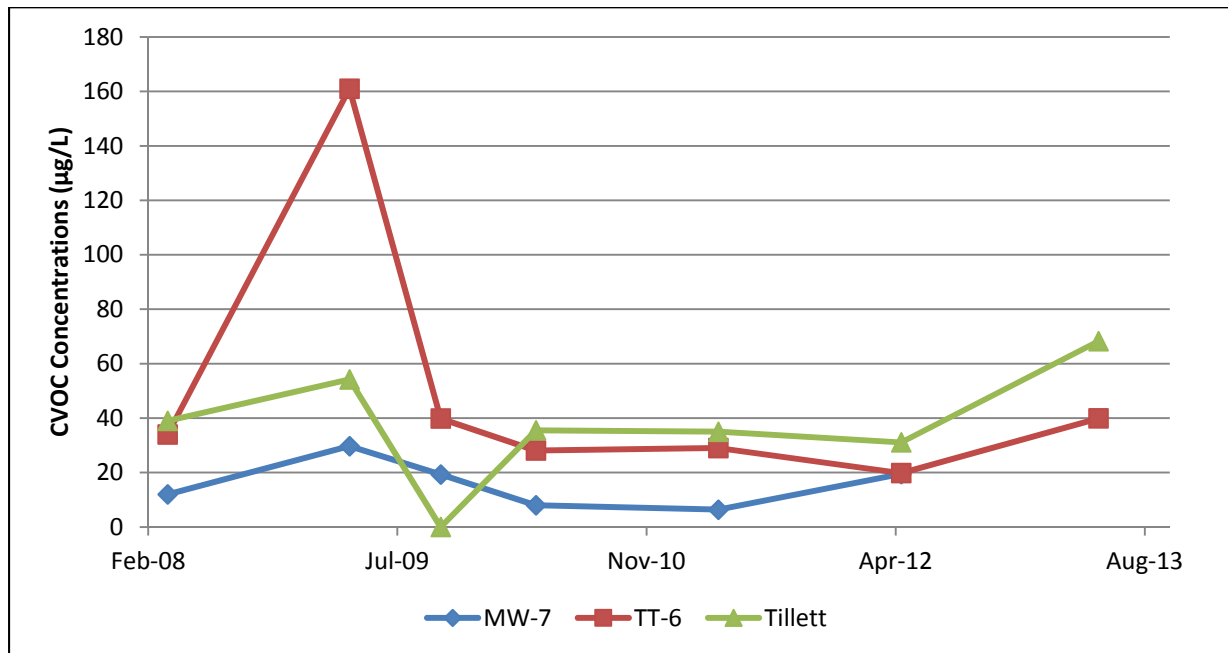


Figure 8: Monitoring well Steele is situated in the source area of the Southern plume and shows an increasing trend during this five-year review period. It should be noted, however, that overall concentrations have decreased since baseline monitoring was conducted in 2004.

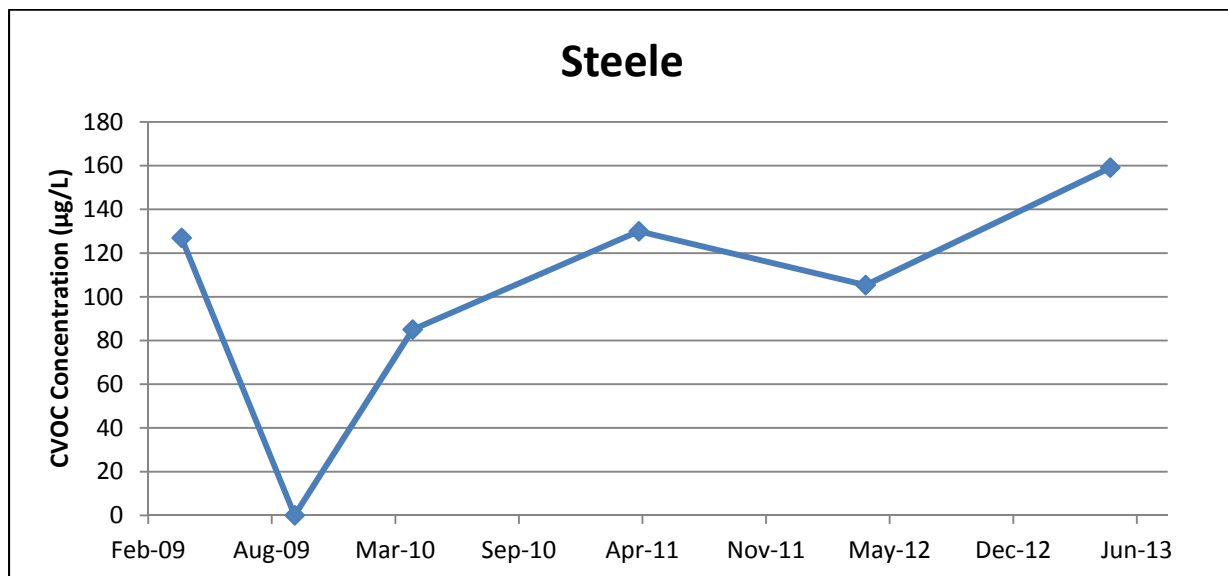


Figure 9: BTEX concentrations in VE-1 and TT-1 over this five-year review period. Concentrations fluctuate over the review period, but a slight statistical decreasing trend is noted. These are the only wells with BTEX concentrations well above the MCLs.

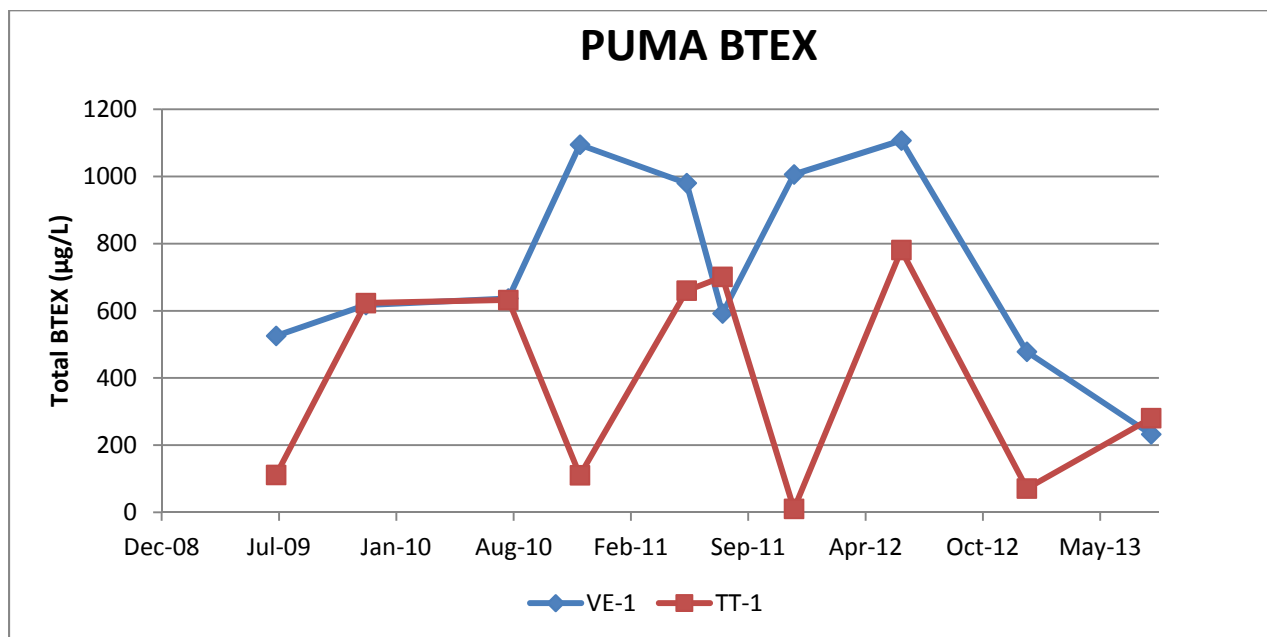


Figure 10: Site Illustration.

