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Final
Feasibility Study Report for AOC 9: Weapons Storage Area (WSA) Landfill

October 2004

Prepared for:

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List of Abbreviations and Acronyms

1,1-DCE	1,1-dichloroethene
AFB	Air Force Base
AFFF	aqueous film-forming foam
ALCM	Air Launch Cruise Missiles
AOC	Area of Concern
AOI	Area of Interest
ARAR	Applicable or Relevant and Appropriate Requirements
AS	air sparging
AST	aboveground storage tank
BASH	bird air strike hazard
BGS	below ground surface
BMP	bimetallic particle
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
cis-1,2-DCE	cis-1,2-dichloroethene
COCs	chemicals of concern
COPCs	chemicals of potential concern
CS	Confirmatory Sampling
CTW	constructed treatment wetland

List of Abbreviations and Acronyms (cont.)

DCE	dichloroethane
DOC	dissolved organic carbon
E & E	Ecology and Environment, Inc.
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
ESI	Expanded Site Investigation
ETI	Environmental Technologies, Inc.
Fe	iron
FS	feasibility study
gpd	gallons per day
gpm	gallons per minute
GRA	General Response Action
H_2O_2	hydrogen peroxide
HHRA	Human Health Risk Assessment
ICP	inductively coupled plasma (spectrometry)
IRP	Installation Restoration Program
$KMnO_4$	potassium permanganate
LEL	lowest effect level
MCL	maximum contaminant level
MCLG	maximum contaminant level goals
µg/L	micrograms per liter
mg/L	milligrams per liter
MnO_2	manganese dioxide
NA	natural attenuation
NCP	National Oil and Hazardous Substances Pollution Contingency Plan

List of Abbreviations and Acronyms (cont.)

NYCRR	New York State Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
O&M	operation and maintenance
O&P	overhead and profit
ORP	oxygen-reduction potential
OSWER	Office of Solid Waste and Emergency Response
OTH	Other Miscellaneous Environmental Factors
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
PISCES	passive in situ concentration/extraction sampler
POTW	Publicly Owned Treatment Works
PRB	permeable reactive barrier
PVC	polyvinyl chloride
RAGS	Risk Assessment Guidance for Superfund
RAOs	Remedial Action Objectives
RI	Remedial Investigation
SAC	Strategic Air Command
SDWA	Safe Drinking Water Act
SEL	severe effect level
SI	Supplemental Investigation
SMCL	secondary maximum contaminant level
SPDES	State Pollutant Discharge Elimination System
SRAM	Short Range Attack Missile
SVE	soil vapor extraction

List of Abbreviations and Acronyms (cont.)

TAGM	Technical and Administrative Guidance Memorandum
TBC	To Be Considered
TCE	trichloroethene
TOGS	Technical and Operational Guidance Series
TRPH	total recoverable petroleum hydrocarbon
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USGS	United States Geological Survey
UST	underground storage tank
UV	ultraviolet
VC	vinyl chloride
VOCs	volatile organic compounds
WSA	Weapons Storage Area

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Introduction

Ecology and Environment, Inc. (E & E), under contract to the United States Army Corps of Engineers (USACE), Kansas City District, has prepared this feasibility study (FS) for the AOC 9: Weapons Storage Area (WSA) Landfill groundwater contamination at the former Griffiss Air Force Base (Griffiss AFB) in Rome, New York. The FS is conducted in accordance with the United States Environmental Protection Agency's (EPA) *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 540/G-89/004) (October 1988) and the New York State Department of Environmental Conservation's (NYSDEC) Technical and Administrative Guidance Memorandum (TAGM) No. 4030, *Selection of Remedial Actions at Inactive Hazardous Waste Sites* (New York State Department of Environmental Conservation [NYSDEC] 1990).

1.1 Purpose and Organization of the Feasibility Study

The Area of Concern (AOC) 9 contaminated groundwater plume was discovered while conducting the Group I Confirmatory Sampling (1995 CS) and Expanded Site Investigation (1997 ESI) at what was then Area of Interest 9 (AOI 9). AOI 9 was upgraded to AOC 9 based primarily on the volatile organic compound (VOC) contamination detected in the overburden groundwater. This report focuses on contaminated on-site overburden groundwater.

In accordance with the Federal Facility Agreement and Resolution of Disputes between the United States Air Force (USAF), EPA Region II, and NYSDEC, Supplemental Investigations (SIs) were performed at AOC 9 (E & E August 2001; August 2002). The purpose of the SIs was to evaluate the nature, level, and extent of potential contamination at the site and to perform a baseline risk assessment to evaluate the potential effects of chemicals of potential concern (COPCs) on human health and the environment. The 2000 and 2002 SIs were conducted in locations where the groundwater exceeded screening criteria (identified in previous site investigations) but where the extent of the groundwater plumes was not clearly defined.

As described below (Sections 1.2 and 1.4), on-site groundwater discharges to the surface along drainageways and Six Mile Creek. Therefore, although the focus of this FS will be on contaminated groundwater, surface water and sediments at AOC 9 also will be inherently addressed by these remedial efforts performed on site groundwater.

Detailed site investigation results for AOC 9 are presented in the 2004 Remedial Investigation (RI) Report (E & E May 2004) and are briefly summarized in Section 1.4 of this report. As concluded in the *Final AOC 9 Bedrock Groundwater Study* (E & E December 2002), groundwater contamination observed in the overburden aquifer does not appear to have migrated downward into the underlying bedrock and therefore will not be addressed as part of this FS. From this point forward, on-site groundwater in this report refers to overburden groundwater.

The purpose of this FS is to identify and evaluate technologies that are available to remediate on-site groundwater identified in the 2004 RI as requiring remedial action. The technologies most appropriate for site conditions are then developed into remedial action alternatives that are evaluated based on their environmental benefits and cost.

This FS consists of the following sections:

- **Section 1**: includes information regarding site background, site location, site description, site history, a summary of previous site investigations, site geology/hydrology, and public health and environmental risk.

- **Section 2**: presents the identification of standards, criteria and guidelines and development of remedial action objectives (RAOs).

- **Section 3**: identifies appropriate technologies and the development of alternatives.

- **Section 4**: is the detailed evaluation of the alternatives for remediating the affected media.

- **Section 5**: presents an evaluation of criteria, summarizes the rationale for remedy selection, and presents a preliminary cost estimate for the remedy.

- **Section 6**: presents a comparative analysis of alternatives.

- **Section 7**: provides recommendations.

- **Section 8**: provides references.

1.2 Site Description

AOC 9 is a grass-covered area approximately 1,200 feet long and 650 feet wide located in the southwest side of the inactive WSA, (see Figures 1-1 and 1-2). The site is part of a strip of land that lies between an airplane runway to the southwest and the WSA to the northeast; fences separate these areas from AOC 9. Perimeter Road runs through the site and Six Mile Creek borders the southwest edge. Between the WSA fence and Perimeter Road is a small water-retention pond (the aqueous film-forming foam [AFFF] pond) that was connected to WSA operations. The ground surface at AOC 9 slopes gently downward toward Six Mile Creek. Groundwater flows southwest toward the creek. There are several locations in this area where shallow groundwater discharges to the surface. The northwest end of the site proximate to the creek is generally wet. Three intermittent drainageways that discharge to Six Mile Creek exist on the northwestern portion of the site. One apparently starts just south of the westernmost igloo, another is adjacent to the northwest border of the site, and the third is a continuation of culverted surface water drainage from the WSA north of the site, as shown on Figure 1-2.

AOC 9 is currently inactive and access is restricted by Perimeter Road Gates 4 and 11. There is no evidence that anyone visits the site on a regular basis. This area is expected to remain vacant in the future (USAF 1995; 1999), acting as a buffer zone between the runway and future development in adjacent areas.

Site groundwater currently is not used and it is highly unlikely that the groundwater would be used in the future for residential needs since there is an existing municipal water supply system at the former Griffiss AFB.

1.3 Site History

The area comprising AOC 9 was originally farmland in the 1930s, before base construction. In the 1940s and 1950s, the first landfill

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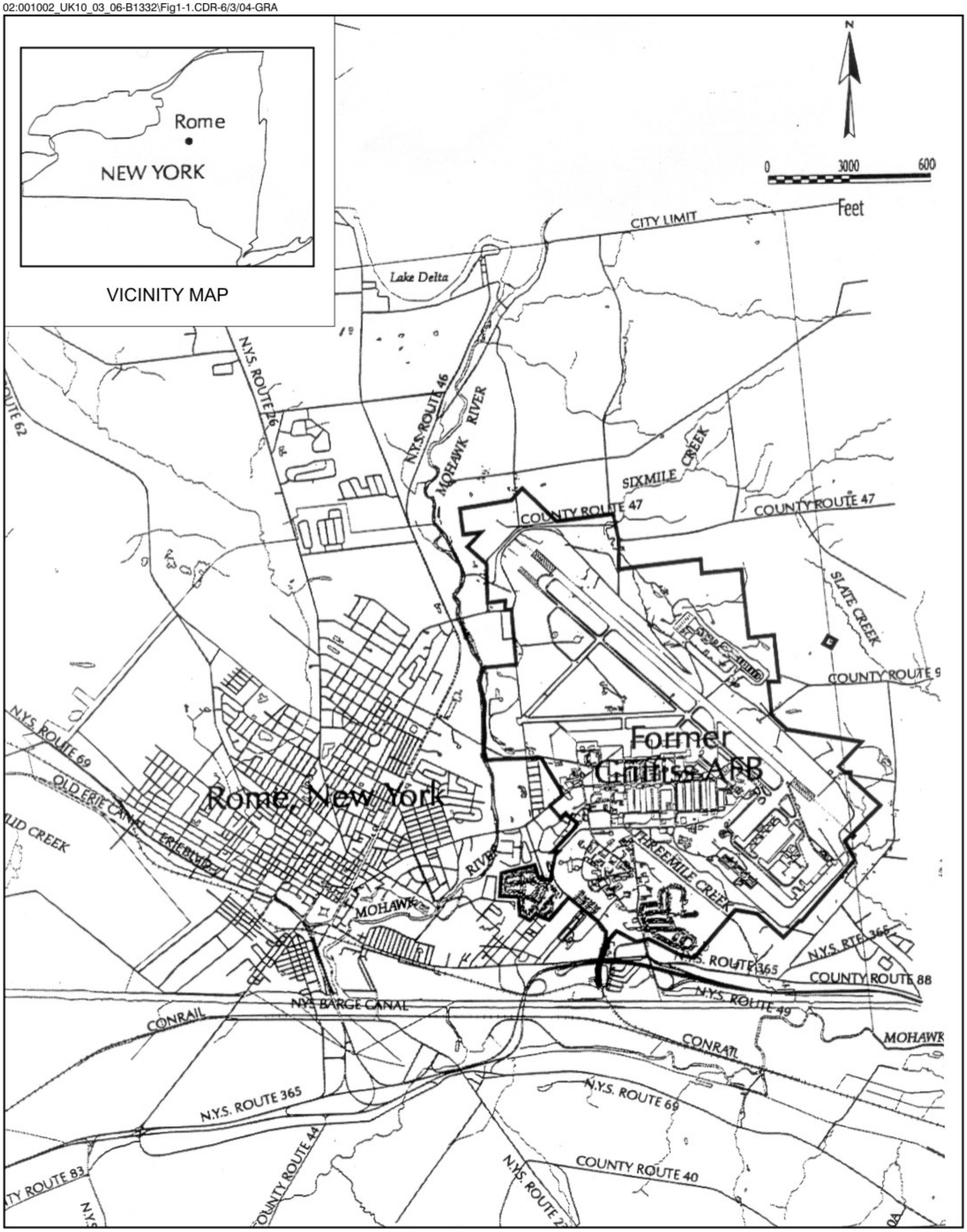

Figure 1-1 **Former Griffiss Air Force Base Site Location Map**

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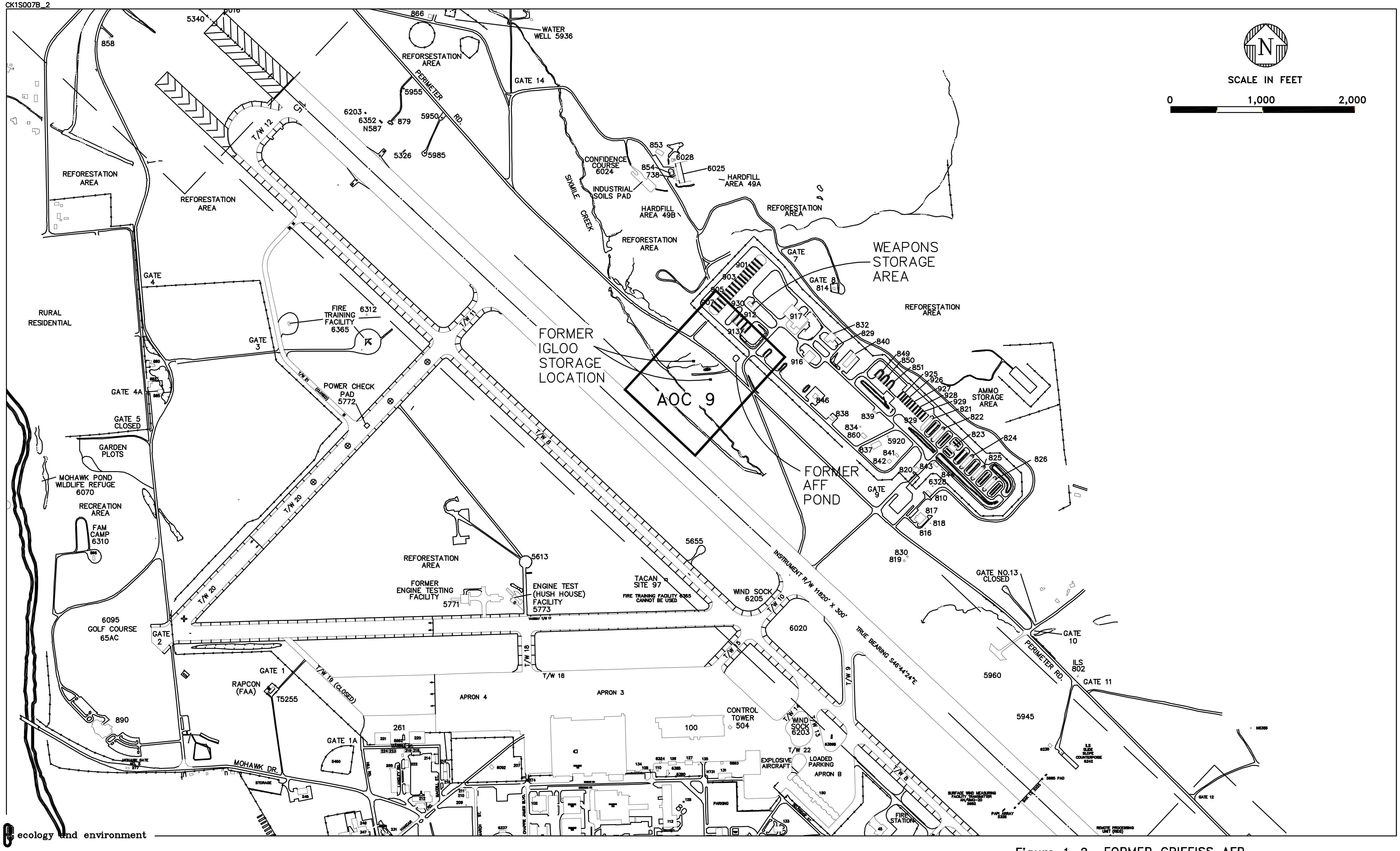


Figure 1-2 FORMER GRIFFISS AFB
AOC9: WEAPONS STORAGE AREA (WSA) LANDFILL
SITE LOCATION MAP

F:/Griffiss/ck1000/bobmeyers/ck1s007b_2.dwg
BUFF plotted: 1/22/04 JJK

for the base (currently known as AOC 9) was located beneath the northern portion of the former WSA and extended south between Perimeter Road and Six Mile Creek. Based on aerial photographs, it was determined that the landfill was used between 1943 and 1957 but no later than 1960. The type of material buried at this site is unknown; however, it is reported that large quantities of the landfill were removed during construction of the WSA. In addition to the WSA, two munitions storage bunkers were erected between Perimeter Road and Six Mile Creek in the early 1950s. One of the bunkers (also referred to as igloos) was removed in the late 1970s or early 1980s (i.e., before 1981), and the other bunker was removed in 1992. Although the bunkers were initially used for munitions storage, they were later used to store hazardous materials (Tetra Tech 1994).

Building 913 is located within the former WSA, along the northeast boundary of AOC 9. Building 913 is an earth-covered munitions storage igloo that was constructed in 1987 for storing Air Launch Cruise Missiles (ALCMs) and Short Range Attack Missiles (SRAMs). Building 913 is not an Installation Restoration Program (IRP) site; no aboveground storage tanks (ASTs) or underground storage tanks (USTs) are associated with Building 913; no Other Miscellaneous Environmental Factors sites (OTHs) are associated with Building 913; and no wastewater-related systems are associated with Building 913 (Tetra Tech 1994). In addition, no drywell is listed for Building 913 in the *Final Screening Table for Drywells, Grease Traps, Silver Recovery Units, and Miscellaneous Waste Water-Related Systems* (E & E December 1997).

Due to the presence of elevated chlorinated solvents (i.e., in excess of NYSDEC Class GA standards and EPA maximum contaminant levels [MCLs]) in groundwater samples collected during the ESI at AOI 9 (E & E July 1998), the status of this site was changed from AOI to AOC. This change was requested by NYSDEC and EPA representatives at the September 23, 1998 ESI meeting. This site is near the main runway and is planned to be retained as part of the airfield (USAF 1995).

1.4 Previous Site Investigations

Several site investigations have been performed at AOC 9 and include:

- 1994 Remedial Investigation (Law 1996);
- Group I AOI Confirmatory Sampling conducted in 1995 (E & E 1996);

- Expanded Site Investigation conducted in 1997 (E & E July 1998),

- Supplemental Investigation sampling conducted in 1997, which included the collection of one passive in situ concentration/ extraction sampler (PISCES) (E & E July 1998b);

- Supplemental Investigation conducted in 2000 (E & E August 2001);

- Supplemental Investigation conducted in 2002 (E & E October 2002);

- Bedrock Groundwater Study conducted in 2002 (E & E December 2002);

- Remedial Investigation (E & E May 2004); and

- Treatability pilot study conducted in 2002 and 2003 (E & E June 2004).

Detailed descriptions of site investigations are presented in the RI (E & E May 2004). A summary of site activities and major findings for each site investigation specific to groundwater activities is presented in Table 1-1.

Hydrology Summary

According to the 2004 RI, groundwater flow beneath AOC 9 is to the southwest and discharge is into the Six Mile Creek drainage basin. The depth of groundwater between the WSA and Perimeter Road is approximately 10 to 12 feet below ground surface (BGS) but is closer to ground surface between Perimeter Road and Six Mile Creek at approximately 7 feet BGS. Bedrock is encountered approximately 11 feet below the top of the water table. In some areas, groundwater discharges to the surface as seeps, and other wet areas. These discharge areas are primarily located south of Perimeter Road, especially at the former storage igloo closest to Perimeter Road, and along the upgradient slope on the northeast side of Six Mile Creek. However, seeps were also noted in the drainageway on the northeast side of Perimeter Road. Three intermittent drainageways also cross the site, one of which drains the WSA.

Table 1-1 Site Investigation Summary, AOC 9 – Former Griffiss AFB, Rome, New York

Site Investigation	Site Activities	Media Sampled (Number of Samples Collected)	Analysis	Major Findings
1994 Remedial Investigation (Law 1996)	■ Surface water and sediment samples collected	■ Surface Water (3) (SMCSW-9, SMCSW-10, SMCSW-11)	■ VOCs, SVOCs, pesticides, dioxins, total metals, glycol, radionuclides, herbicides, and several wet chemistry parameters including TRPH and cyanide	■ One surface water sample (SMCSW-9) from the AFFF pond; two surface water samples (SMCSW-10 and SMCSW-11) from Six Mile Creek in the vicinity of AOC 9 ■ No VOCs detected above screening criteria ■ All samples contained PAHs and metals in exceedence of screening criteria
		■ Sediment (3) (SMCSD-9, SMCSD-10, SMCSD-11)	■ VOCs, SVOCs, pesticides/PCBs, metals, radionuclides, and several wet chemistry parameters	■ Samples co-located with surface water samples. ■ No VOCs or metals detected above screening criteria ■ Several SVOCs detected above screening criteria from SMCSD-11

Table 1-1 Site Investigation Summary, AOC 9 – Former Griffiss AFB, Rome, New York

Site Investigation	Site Activities	Media Sampled (Number of Samples Collected)	Analysis	Major Findings
1995 Group I AOI Confirmatory Sampling (E & E 1996)	■ Drilling of 4 soil borings ■ Installation of temporary wells in each boring	■ Groundwater (4) (G009-LS04 through G009-LS07)	■ TCL VOCs, TCL SVOCs, TAL metals, TRPH	■ No TRPH was detected in the groundwater samples ■ Trichloroethene (TCE), tetrachloroethene (PCE), and chlorobenzene were detected in concentrations that exceeded screening criteria in the groundwater screening sample from G009-LS05 ■ Several metals, including aluminum, iron, and manganese, were detected in concentrations that exceeded groundwater screening criteria in one or more wells
		■ Sediment (4) (G009-SD01 through G009-SD04)	■ TCL VOCs, TCL SVOCs, TAL metals, TRPH, TOC	■ Several metals, including arsenic, cadmium, copper, iron, lead, manganese, nickel, and silver, were detected in concentrations that exceed screening criteria
		■ Surface Water (4) (G009-SW01 through G009-SW04)	■ TCL VOCs , TCL SVOCs, TAL metals, TRPH	■ One sample (G009-SW02) was collected from Six Mile Creek; two of the samples were collected from seeps located at the southeastern portion of the site (G009-SW03 and G009-SW04); and the fourth was collected from a seep located approximately 150 feet north of Six Mile Creek (G009-SW01) ■ G009-SW02 contained chlorobenzene in concentrations exceeding screening criteria ■ Several metals, including aluminum, cadmium, cobalt, copper, iron, lead, mercury, silver, vanadium, and zinc, were detected in concentrations that exceeded screening criteria in one or more samples

Table 1-1 Site Investigation Summary, AOC 9 – Former Griffiss AFB, Rome, New York

Site Investigation	Site Activities	Media Sampled (Number of Samples Collected)	Analysis	Major Findings
1997 Expanded Site Investigation (E & E 1998)	■ Drilling, installation, and sampling of four permanent monitoring wells (G009-MW01 through G009-MW04)	■ Groundwater (4) (G009-MW01 through G009-MW04)	■ TCL VOCs, TCL SVOCs, pesticides/PCBs, TRPH , TAL metals	■ The groundwater sample from G009-MW03 contained benzene, chlorobenzene, 1,2-dichlorobenzene (DCB), 1,3-DCB, 1,4-DCB, PCE, and TCE in concentrations that exceeded screening criteria ■ The groundwater sample from G009-MW04 contained chlorobenzene, 1,2-dichloroethane, and TCE in concentrations that exceeded screening criteria ■ Several metals, including aluminum, iron, manganese, and potassium, were detected in concentrations that exceeded screening criteria in one or more wells
		■ Sediment (4) (G009-SD05 through G009-SD08)	■ TCL VOCs, TCL SVOCs, pesticides/PCBs, TRPH, TOC, TAL metals	■ G009-SD05 contained benzo(a)pyrene in concentrations that exceeded screening criteria ■ G009-SD07 contained chlorobenzene in concentrations that exceeded screening criteria ■ G009-SD08 contained benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, indeno (1,2,3-cd) pyrene, phenanthrene, aldrin, and heptachlor epoxide in concentrations that exceeded screening criteria
		■ Surface Water (4) (G009-SW05 through G009-SW08)	■ TCL VOCs, SVOCs, pesticides/PCBs, TRPH, TAL metals	■ Several metals, including aluminum, chromium, iron, vanadium, and zinc were detected in one or more samples in concentrations that exceeded screening criteria

Table 1-1 Site Investigation Summary, AOC 9 – Former Griffiss AFB, Rome, New York

Site Investigation	Site Activities	Media Sampled (Number of Samples Collected)	Analysis	Major Findings
2000 Supplemental Investigation (E & E 2001)	43 Geoprobe and 2 Hydropunch sampling locations were developed 4 monitoring wells installed 4 monitoring wells from 1997 resampled 12 test pits	■ Groundwater (94) (geoprobe/hydropunch) (AOC9-GP01 through AOC9-GP-43, AOC9-HYD1, AOC9-HYD2) ■ Groundwater (8) (monitoring wells) (G009-MW01 through G009-MW04, AOC9-MW05 through AOC9-MW08)	■ VOCs ■ VOCs, SVOCs, pesticides/PCBs, TAL filtered and unfiltered metals	Geoprobe/Hydropunch ■ Sixteen VOCs were detected at levels that exceed the groundwater screening criteria: benzene; n-butylbenzene; sec-butylbenzene; chlorobenzene; 1,2-DCB; 1,4-DCB; cis-1,2-dichloroethene; ethylbenzene; isopropylbenzene; naphthalene, n-propylbenzene; PCE; TCE; 1,2,4-trimethylbenzene (TMB); 1,3,5-TMB; vinyl chloride ■ AOC9-GP03I, at a depth of 10 to 12 BGS, contained 14.9 µg/L of TCE, 227.2 µg /L of cis-1,2-DCE, 63.7 µg /L of VC, and 647.4 µg /L of chlorobenzene ■ AOC9-GP05D, at a depth of 10 to 12 BGS, contained 66.9 µg /L of TCE, 39.0 µg /L of cis-1,2-DCE, ND concentrations of VC, and 719 µg /L of chlorobenzene ■ AOC9-GP27S, at a depth of 6 to 8 BGS, contained 28.6 µg /L of TCE, 39.8 µg /L of cis-1,2-DCE, ND concentrations of VC, and 2352 µg /L of chlorobenzene ■ AOC9-GP28I, at a depth of 16.5 to 18.5 BGS, contained 27.0 µg /L of TCE, 2.6 µg /L of cis-1,2-DCE, ND concentrations of VC, and 2151.4 µg /L of chlorobenzene Monitoring Wells ■ 14 VOCs and 5 metals were found at concentrations that exceeded screening criteria: benzene; chlorobenzene, 1,2-DCB, 1,4-DCB, cis-1,2-DCE, ethylbenzene, isopropylbenzene, methylene chloride, TCE, 1,2,4-TMB, 1,3,5-TMB, VC,

Table 1-1 Site Investigation Summary, AOC 9 – Former Griffiss AFB, Rome, New York

Site Investigation	Site Activities	Media Sampled (Number of Samples Collected)	Analysis	Major Findings
				m,p-xylene, o-xylene, aluminum, iron, manganese, selenium, and thallium
		■ Sediment (4) (AOC9-SD09 through AOC9-SD12)	■ TCL VOCs, TCL SVOCs, pesticides/PCBs, TAL metals, TOC, and percent solids	■ Chlorobenzene concentration of 157 µg/L exceeded screening criteria at AOC9-SD10
		■ Surface Water (12) (AOC9-SW09 through AOC9-SW20)	■ VOCs, SVOCs, pesticides/PCBs, TAL metals, hardness	■ VOCs were not detected in three of the eight samples (AOC9-SW16, -SW19, and -SW20) ■ Chlorobenzene was detected above screening criteria at AOC9-SW14 (41.3 µg /L) and AOC9-SW15 (10.6 µg /L) ■ VOCs were not detected above screening criteria at AOC9-SW19. However, VOCs were detected at AOC9-SW18, which is slightly downgradient ■ There were some exceedences of cis-1,2-DCE, TCE, PCE, and 1,4-DCB at AOC9-SW14, AOC9-SW15, and AOC9-SW18

Table 1-1 Site Investigation Summary, AOC 9 – Former Griffiss AFB, Rome, New York

Site Investigation	Site Activities	Media Sampled (Number of Samples Collected)	Analysis	Major Findings
2002 Supplemental Investigation (E & E 2002)	■ 14 Geoprobe sampling locations were developed ■ 2 soil borings were advanced ■ 5 test pits excavated	■ Groundwater (56) (geoprobes) (AOC9-GP44 through AOC9-GP57) ■ Groundwater (5) (test pits) (AOC9-GW-TP01, TP03, -TP04, -TP04DUP, TP06)	■ VOCs ■ TCL VOCs, SVOCs, pesticides/PCBs, TPH as diesel, and TPH as gasoline	Geoprobes ■ 15 VOCs exceeded screening criteria: acetone; benzene; chlorobenzene; 1,2-DCB; 1,3-DCB; 1,4-DCB; cis-1,2-dichloroethene; total 1,2-DCE; ethylbenzene; PCE; TCE; vinyl chloride; m,p-xylene; o-xylene; and total xylene ■ AOC9-GP44S2 contained a chlorobenzene concentration of 2,150 µg /L at a depth of 15.9 to 17.9 feet BGS ■ AOC9-GP44I contained 10.3 µg /L of TCE, 70 µg /L of cis-1,2-DCE, 13.1 µg /L of VC, and 1,610 µg /L of chlorobenzene at a depth of 19.3 to 21.3 feet BGS ■ AOC9-GP44D1 contained concentrations of 25.8 µg /L for cis-1,2-DCE, 6.32 µg /L for VC, and 1,630 µg /L for chlorobenzene at a depth of 22.4 to 224.4 feet BGS Test Pits ■ 1,2-DCB, 1,4-DCB, and chlorobenzene were detected at concentrations above screening criteria at AOC9-GW-TP03

Table 1-1 Site Investigation Summary, AOC 9 – Former Griffiss AFB, Rome, New York

Site Investigation	Site Activities	Media Sampled (Number of Samples Collected)	Analysis	Major Findings
		■ Sediment (2) (AFFF-SD01 and AFFF-SD02)	■ TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, mercury, and percent solids	■ 3 pesticides (Heptachlor, 4,4’-DDD, and 4,4’-DDT) were detected in sample AFFF-SD01 at concentrations exceeding screening criteria, and no pesticides were detected in AFFF-SD02. 4.4’-DDT was not detected in duplicate sample AFFF-SD01/D. ■ Copper was detected in AFFF-SD01 at concentrations that exceeded screening criteria, but duplicate sample AFFF-SD01/D detected copper at levels below screening criteria

Table 1-1 Site Investigation Summary, AOC 9 – Former Griffiss AFB, Rome, New York

Site Investigation	Site Activities	Media Sampled (Number of Samples Collected)	Analysis	Major Findings
AOC 9 Bedrock Groundwater Study (E & E 2002)	■ Installation of three bedrock wells. ■ Installation of one overburden borehole.	■ Groundwater Bedrock (3) AOC 9-MW9Br, AOC 9-MW10Br, and AOC 9-MW11Br. ■ Overburden (1) AOC 9-MW11Br-HP.	■ VOCs, methane, ethane, ethene, anions, DOC (bedrock) ■ VOCs (overburden)	■ No analyte exceedences were detected. ■ Groundwater contamination in the overburden does not appear to have migrated into bedrock.
AOC 9 Remedial Investigation (E & E 2004)	■ None, compilation of previous investigations.	■ None, compilation of previous investigations.	■ None, compilation of previous investigations.	■ Results of the year 2000 and 2002 SI activities and analytical data indicate that the groundwater is significantly contaminated, and contamination is discharging into the Six Mile Creek drainage basin. ■ Groundwater contaminants of concern are chlorobenzene and other VOCs.
AOC 9 Pilot Study (E & E 2004)	■ Installation of 88 temporary injection points (44 for each injection event). ■ Two injection events.	■ Groundwater (9) (AOC9-MW8, AOC9-MW12, AOC9-MW13, AOC9-GP44, AOC9-GP47, AOC9-GP48, G009-MW02, G009-MW03, AOC9-MW7).	■ VOCs, DOC, TAL metals, sulfate, ferrous iron	■ Overall, 1,2-DCB decreased 10% to 53%, 1,3-DCB decreased 9% to 50%, 1,4-DCB decreased 14% to 49%, and chlorobenzene decreased 5% to 65% from baseline samples to monitoring samples collected eight weeks after the first injection event. ■ After the second injection event, there was an overall total VOC reduction from baseline conditions (prior to the first injection event) of 99% in wells AOC9-MW12 and -MW13, 86% in AOC9-GP47I, 77% in AOC9-MW8, 38% in AOC0-GP48D1, and 35% in AOC9-GP44S.

Table 1-1 Site Investigation Summary, AOC 9 – Former Griffiss AFB, Rome, New York

Site Investigation	Site Activities	Media Sampled (Number of Samples Collected)	Analysis	Major Findings

Notes:

1 Soil samples were collected during the 1995 Group I AOI Confirmatory Sampling, 1997 Expanded Site Investigation, 2000 Site Investigation, and 2002 Site Investigation. However, these samples are not included in the table for brevity. Refer to RI (E & E 2003) or individual site investigation reports for information on these soil samples and their results.

Key:

DOC = Dissolved Organic Carbon.
ND = Non-Detect.
PCBs = Pesticides/Polychlorinated Biphenyls.
SVOCs = Semivolatile Organic Compounds.
TAL = Target Analyte List.
TCL = Target Compound List.
TOC = Total Organic Carbon.
TPH = Petroleum Hydrocarbon.
TRPH = Total Recoverable Petroleum Hydrocarbon.
VOCs = Volatile Organic Compounds.

The vertical hydraulic gradient is believed to be upward in the vicinity of the Six Mile Creek discharge area. This is supported by upward groundwater discharge causing significant year-round flow of Six Mile Creek in the vicinity of the site. In addition, the presence of the relatively impermeable underlying bedrock results in preferential upward flow of groundwater rather than downward flow because the bedrock serves as a hydraulic boundary.

Overburden observed during soil boring and monitoring well and test pit installation at AOC 9 during the 2004 RI consisted of silty fine to coarse sand with some gravel seams and silt. In addition, cobbles and/or concrete debris were encountered in the area north of Perimeter Road while drilling or attempting to install sampling points.

Hydraulic conductivity (K) values recorded in January 2003 from the overburden wells ranged from 10^{-1} to 10^{-3} cm/s. K values from the upgradient wells (AOC9-MW8, -MW12, and -MW13) located north of Perimeter Road were slightly higher (10^{-1} to 10^{-2} cm/s with an average of 9.87×10^{-2} cm/s or 280 feet per day [ft/day]) than K values from the downgradient wells (G009-MW1, -MW2, and -MW3, and AOC9-MW7) (10^{-2} to 10^{-3} cm/s with an average of 1.61×10^{-2} cm/s or 45.8 ft/day).

To confirm the K values obtained from the slug tests performed in January 2003, a brief pump test was performed on G009-MW02 in July 2003. A submersible pump was installed in the well and the water level was allowed to return to static conditions. The well was pumped at 0.5 gallons per minute (gpm) until the water level stabilized. Data collection was initiated at the time pumping began with an In-Situ, Inc. Hermit 2000 data logger and pressure transducer system as was done during the slug tests. Data transfer software by In-Situ, Inc. was used to download the slug test data to a computer. The raw data were then processed and interpreted using AQTESOLVE software (Duffield 1998). A K value of 1.8×10^{-3} cm/s was obtained using the interpretation methods of Cooper-Jacob (Kruseman and de Ridder 1991), which corresponds to a groundwater velocity of 0.93 ft/day. This value correlates well with typical K values for the silty sands observed on site during drilling activities and provides a more reasonable value than the slug tests, which can produce elevated K values for the area immediately surrounding a well due the effect of the porous sandpack around the wells compared to the relatively small volume of the slug used.

Assuming an average effective porosity (n) of approximately 0.35 (for silty sand and sand) (Roberson 1998), the groundwater velocity north of Perimeter Road is estimated to be 14.4 ft/day (using an average K value of 280 ft/day and a hydraulic gradient of 0.018 ft/ft), and the velocity south of Perimeter Road is estimated to be 8.4 ft/day (using an average K value of 45.8 ft/day and average hydraulic gradient of 0.064 ft/ft). Although the gradient south of Perimeter Road is higher, the lower K values are causing the groundwater velocities to be much lower than the area north of Perimeter Road. This difference in groundwater velocities between the northern and southern portions of the site would be expected to cause the groundwater flowing from the north area to be slowed as it reaches the south area, causing a damming effect, which would explain the reduced hydraulic gradient observed north of Perimeter Road.

1.5 Previous Site Risk Assessments

Human Health Risk Assessment (HHRA) Summary

In 2003, E & E conducted a Human Health Risk Assessment as part of the RI. The HHRA was prepared and organized following the general approach outlined in the EPA’s *Risk Assessment Guidance for Superfund (RAGS)*, *Volume I: Human Health Evaluation Manual (HHEM)*, *Part A* (EPA 1989) and *Part D* (EPA December 2001), and other related EPA guidance.

Data collected from site investigations spanning from July 1992 through July 2002 were reviewed to evaluate human health risks at the site.

AOC 9 is currently inactive and access is restricted by Perimeter Road Gates 4 and 11. Current human receptors include site visitors who visit AOC 9 for recreational purposes, who would come into contact with surface soils or, if wading in the creeks or tributaries, would come into contact with sediment and surface water. There are no direct routes of exposure to in situ groundwater contamination. Inhalation exposures are unlikely under existing conditions. The low levels of VOCs detected in soil gas, surface water, and sediment indicate that vapor releases to ambient air are negligible. The soil at AOC 9 is generally moist and the surface is covered with grass that prevents wind erosion and generation of airborne dust from soil.

Site-related contaminants discharged to Six Mile Creek may be taken up by fish. Recreational fishing is unlikely in the shallow water near AOC 9 but might occur elsewhere along the creek. If fishermen consumed fish from Six Mile Creek, they could potentially be exposed to site-related contaminants. According to a previous HHRA for Six Mile Creek (Law 1996), if recreational visitors were to consume fish from the creek, the potential risks from fish consumption would be unacceptably high, mostly due to polychlorinated biphenyls (PCBs), which are not site-related contaminants.

According to the USAF's plans for disposal and reuse of the airfield property at Griffiss AFB (USAF 1995; 1999), the area along the northeast edge of the runway, which includes AOC 9, will be maintained as open space. Since no development of the site is expected in the foreseeable future, potential exposure pathways for future site visitors are expected to be the same as those of current visitors. However, the frequency of such exposures could increase from current levels if the site were to become more accessible due to land use changes and development in surrounding areas.

Considering that site groundwater is contaminated and there is an existing municipal water supply system, it is highly unlikely that site groundwater would ever be used for household needs.

Two future hypothetical residential and commercial/industrial land uses were explored in the HHRA. Future site residents, who would likely engage in outdoor recreation near their homes, could potentially be exposed to contaminants in surface soil, sediment, and surface water by the same direct contact routes as site visitors. In addition, if there were areas of bare soil as a result of future development, residents might inhale airborne dust raised by wind erosion of the surface soul. If homes were constructed over the plume of VOC contamination that exists in groundwater at AOC 9, vapors could infiltrate upward through the soil and enter the buildings through cracks, exposing residents to contaminant vapors through inhalation of indoor air.

The HHRA concluded that under existing conditions and expected future site conditions, assuming no development of the site, contaminants present in soil, sediment, and surface water at AOC 9 do not appear to pose any significant health risks. However, as stated in previous site investigations, analytes have exceeded applicable federal and state screening criteria.

Ecological Risk Assessment (ERA) Summary

In 2003, E & E conducted an ecological risk assessment as part of the RI. The ERA was consistent with NYSDEC guidance for characterizing threats to fish and wildlife at inactive hazardous waste sites (NYSDEC 1994) and ERA guidance issued by the EPA.

Data collected from site investigations over the past 10 years were reviewed to evaluate ecological risks at the site.

AOC 9 does not represent a high-quality habitat because most of the site is periodically mowed because it is close to the runway. The area immediately surrounding AOC 9 is developed and includes several buildings, paved roads, fences, and mowed lawns. A fence on-site limits wildlife access to the site. Consequently, the value of AOC 9 as a source of food and habitat for wildlife is low. Wildlife species present at AOC 9 are limited to those that have adjusted to using the area with limited and routinely disturbed habitat.

The ERA focused on four assessment points: terrestrial and wetland plant communities; the soil-fauna community; aquatic life in Six Mile Creek and the on-site tributaries to the creek; and bird and mammal populations in the site vicinity. PAHs, several chlorinated pesticides, and several metals exceeded conservative screening benchmarks at selected sampling locations or were predicted to pose a risk to certain wildlife species when exposure was calculated from the maximum chemical concentrations in soils and sediment. These include potential risks to terrestrial and wetland plant communities from selenium and PAHs; risks to soil fauna from manganese and PAHs; risks to aquatic life in the on-site drainageways from several metals in the water; and risks to birds and mammals from organics and metals. Given the conservative nature of the risk estimation process, the overall results suggest that current levels of environmental contamination at AOC 9 are unlikely to adversely affect populations or communities of ecological receptors at the site. However, as stated in previous investigations, analytes have exceeded applicable federal and state screening criteria.

2

Definition of Remedial Action Objectives and Groundwater Cleanup Goals

This section identifies the contaminants of concern and establishes proposed cleanup goals for site groundwater. Through remediation of on-site groundwater, the apparent source of on-site surface water and sediment contamination will also be addressed. Also presented are estimates of areas and volumes of contaminated on-site groundwater.

2.1 Remedial Action Objectives

This section presents the objectives for on-site remedial actions to protect human health and the environment. Groundwater RAOs were developed based on information contained in the 2004 RI, including identified contaminants present in the study area and existing or potential exposure pathways in which the contaminants may affect human health and the environment.

The RAOs for the on-site groundwater are to:

1. Reduce the potential for human risk of exposure to contaminants of potential concern found in on-site groundwater by reducing the potential for ingestion of contaminated groundwater and dermal contact with contaminated groundwater;

2. Reduce further off-site migration of contaminated groundwater to the extent practical; and

3. Achieve proposed cleanup goals for contaminants of concern based on an evaluation of applicable or relevant and appropriate requirements (ARARs) to the extent practical.

Proposed chemical-specific cleanup goals were developed for groundwater. These proposed cleanup goals were developed based on an evaluation of ARARs. These proposed cleanup goals were used to define the area and volume of groundwater that must be addressed to meet the RAOs.

ARARs are used at inactive hazardous waste sites to establish the locations where remedial actions are warranted and to establish cleanup goals. ARARs include state requirements. The following sections present potentially applicable ARARs and other standards and establish proposed cleanup goals for contaminated on-site media.

2.2 ARARs and TBCs

2.2.1 ARARs

Applicable requirements are legally enforceable standards or regulations such as groundwater standards for drinking water that have been promulgated under state law.

Relevant and appropriate requirements include those requirements promulgated under state law that may not be "applicable" to the specific contaminant released or the remedial actions contemplated but are sufficiently similar to site conditions to be considered relevant and appropriate. If a relevant and appropriate requirement is well suited to a site, it carries the same weight as an applicable requirement during the evaluation of remedial alternatives.

2.2.2 TBCs

To be considered (TBC) criteria are non-promulgated advisories or guidance issued by state agencies that may be used to evaluate whether a remedial alternative is protective of human health and the environment in cases where there are no standards or regulations for a particular contaminant or site condition. These criteria may be considered with ARARs in establishing cleanup goals for protection of human health and the environment.

The following subsections present the three categories of ARARs:

- **Chemical-specific ARARs** are usually health- or risk-based numerical values or methodologies that establish an acceptable amount or concentration of a chemical in the ambient environment. They are used to assess the extent of remedial action required and to establish cleanup goals for a site. Chemical-specific ARARs may be directly used as actual cleanup goals or as a basis for establishing appropriate cleanup goals for the contaminants of concern at a site.

- **Action-specific ARARs** are usually administrative or activity-based requirements that guide how remedial actions are conducted. These may include record-keeping and reporting requirements, design and performance standards for remedial actions, and permitting requirements.

- **Location-specific ARARs** are restrictions placed on the concentration of hazardous substances or the conduct of activity solely because they occur in special locations. Location-specific ARARs are commonly associated with features such as wetlands, floodplains, or historic buildings that are located on or near the site.

Site-appropriate chemical-, action-, and location-specific ARARs are discussed in this section and when evaluating individual alternative criteria in Sections 5 and 6.

Proposed Cleanup Goals

Proposed cleanup goals are developed by evaluating the available ARARs for each contaminant. In general, this process uses standards as proposed cleanup goals. If no standards exist for a given contaminant, the most conservative criterion or guidance value is selected as a proposed cleanup goal. Where appropriate, the proposed cleanup goals then are compared to site-specific background values for naturally occurring analytes to confirm that no proposed cleanup goal is set below site background concentrations. If the site-specific background concentration is higher than the ARAR-based proposed cleanup goal, then the background concentration is selected as the proposed cleanup goal. These proposed cleanup goals then are compared to site data to identify which contaminants may require cleanup. These contaminants are then considered with regard to other factors influencing the need for cleanup, including comparison with regional background levels and an evaluation of contamination. The cleanup goals proposed by this process then are compared again to site data in order to identify areas that must be addressed in the FS.

The sections below describe the details of this process and present the extent of contamination in groundwater.

2.3 Metals Data Usability

Both filtered and unfiltered groundwater samples were collected from monitoring wells during the 1995 CS, 1997 ESI, and 2000 SI. Although some of the groundwater samples collected at the site were unfiltered, usability of the data was not affected, provided that the samples contained low levels of suspended solids. If the samples were turbid and contained elevated levels of suspended solids, their metals concentrations, especially common metals such as aluminum, iron, and manganese, increased. The metals content of the silt and clay particles that create the turbidity does not represent a credible threat to human health because they do not migrate through the aquifer. Any water well installed in the aquifer would be developed, by pumping out turbid water, until nonturbid water was produced.

Based on the results of the 1995 CS, 1997 ESI, and 2000 SI (monitoring well samples only), on-site groundwater contains exceedances of iron, manganese, selenium, and thallium concentrations above proposed cleanup goals. Table 2-1 illustrates the number of detections of iron, manganese, selenium, and thallium above proposed cleanup goals during each site investigation.

Table 2-1 Number of Inorganic Exceedances in Monitoring Wells (for Iron, Manganese, Selenium, and Thallium)

	Site Investigation					
	1995 CS		1997 ESI		2000 SI	
Inorganic	F	U	F	U	F	U
Iron	1	1	0	1	3	3
Manganese	2	1	3	3	7	7
Selenium	0	0	0	0	7	2
Thallium	0	0	0	0	1	1

Key:

F - Filtered groundwater samples.
U - Unfiltered groundwater samples.

A review of the available data regarding metals detected in the groundwater at AOC 9, basewide analytical results, and historic use of AOC 9 has indicated the following:

- The presence of high concentrations of iron and manganese suggests the presence of suspended particulates due to the high turbidity of the aquifer at the Former Griffiss AFB. The fact that elevated concentrations of metals were found at many of the wells installed across the Former Griffiss AFB since the 1994 RI that are not located downgradient of any known AOC on the base suggests that the elevated concentrations of iron and manganese are naturally occurring and result from suspended particulate matter in the groundwater.

- The comparison of filtered and unfiltered groundwater samples collected during the 2000 SI with respect to selenium indicates that the filtered result is greater than the unfiltered for all seven wells in which this analyte was detected. The data was thoroughly reviewed and it was determined that it was reported correctly. It is believed that the selenium results are attributable to analytical interferences, sampling artifacts, or site background. Regarding analytical interferences, samples were analyzed by EPA Method 6010B inductively coupled plasma (ICP) spectrometry, an analytical technique that measures atomic emissions of metals. Selenium has a low wavelength of atomic emissions; therefore, it is not detected strongly by the ICP method. A review of the raw data for these samples indicates that the method is highly variable for selenium at low levels due to matrix and spectral interference. Thus, there could be some bias due to the analytical method, which could result in false positives. The risk to public health and the environment is minimal even if these low-level detections are not false positives.

- Thallium was detected at levels above criteria in one downgradient well (AOC9-MW07) during the 2000 SI and at upgradient wells (MW08 and MW13) at AOC 9 during treatability study baseline sampling, but it was not detected during the second round of sampling.
- No historical uses of thallium or selenium on base have been discovered.
- The sporadic nature of the exceedances of selenium and thallium indicate that a “plume” of these metals is not present at AOC 9.

Iron, manganese, selenium, and thallium detected at elevated levels in the groundwater at AOC 9 have also been detected sporadically at concentrations exceeding proposed cleanup goals at numerous locations across the base in both groundwater and soil. Considering the above, iron, manganese, selenium, and thallium are considered naturally occurring metals at AOC 9.

2.4 Organic Data Usability

Water samples collected for organics analyses were not filtered. If the samples were turbid and if analytes with a strong tendency to sorb to soil were in the soil surrounding the well, those analytes may have been recorded at levels exceeding their solubility or their dissolved level in the aquifer and are not representative of water quality. Such analytes include SVOCs and pesticides in groundwater. However, for purposes of this evaluation, all organic data reported as detected in the 2004 RI were accepted as being present. The presence of any organics in groundwater is assumed to indicate anthropogenic materials, not naturally occurring materials.

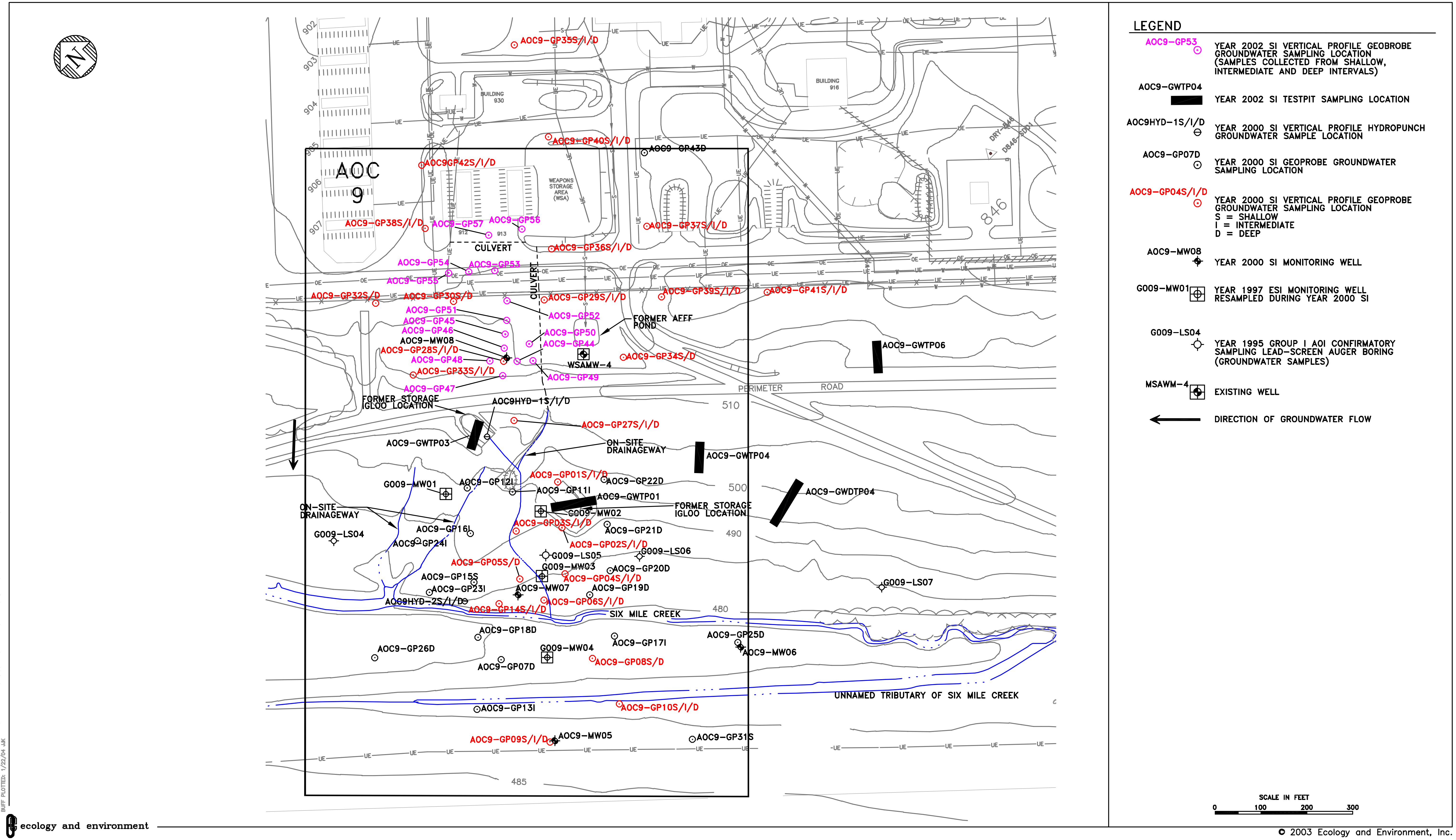
Historical data show that low levels of some organic compounds, for example, pesticides, are typically found in wells that are unaffected by any known release or source and that are not found on a reproducible basis.

These findings indicate that low-level, isolated instances of organics exceeding ARARs are not always candidates for remediation. In cases where SVOCs were detected, levels were very low (typically below the quantitation limit), isolated, and often ephemeral; thus, the groundwater may not be deemed a candidate for consideration of remedial alternatives for the specific analyte, despite exceeding a ARAR at least once. Rather, they are present in a water quality pattern observed throughout the region and are not a result of contamination from the base.

2.5 Groundwater

Four temporary wells were advanced on-site during the 1995 CS to evaluate the possible presence of contamination within the soil and groundwater. During the 1997 ESI, four permanent overburden groundwater monitoring wells were installed and sampled. Four additional overburden groundwater monitoring wells were installed and sampled during the 2000 SI and four groundwater monitoring wells installed in 1997 were resampled. Also during the 2000 SI, 94 Geoprobe/Hydropunch samples were collected from the shallow, intermediate, and deep aquifer zones. The results of the 1995, 1997, and 2000 site investigations indicated the presence primarily of VOCs.

In 2002, fifty-six groundwater samples were collected from Geoprobes as part of the SI to more clearly define the source area of the VOC contamination detected during previous site investigations. Groundwater samples were also collected from five excavated test pits during the 2002 SI. These Geoprobe samples were collected from the shallow, intermediate, and deep aquifer zones in the overburden. The highest concentrations of VOCs (chlorobenzene and trichloroethene [TCE]) were situated in the middle of the aquifer between the top of the water table and the top of bedrock. Further information regarding these samples, including locations, analyses performed, and a summary of major findings can be found in Figure 2-1 and Table 1-1.



LEGEND

AOC9-GP53 ⊙	YEAR 2002 SI VERTICAL PROFILE GEOBROBE GROUNDWATER SAMPLING LOCATION (SAMPLES COLLECTED FROM SHALLOW, INTERMEDIATE AND DEEP INTERVALS)
AOC9-GWTP04 ▬	YEAR 2002 SI TESTPIT SAMPLING LOCATION
AOC9HYD-1S/I/D ⊖	YEAR 2000 SI VERTICAL PROFILE HYDROPUNCH GROUNDWATER SAMPLE LOCATION
AOC9-GP07D ⊙	YEAR 2000 SI GEOPROBE GROUNDWATER SAMPLING LOCATION
AOC9-GP04S/I/D ⊙	YEAR 2000 SI VERTICAL PROFILE GEOPROBE GROUNDWATER SAMPLING LOCATION S = SHALLOW I = INTERMEDIATE D = DEEP
AOC9-MW08 ⯌	YEAR 2000 SI MONITORING WELL
G009-MW01 ⊞	YEAR 1997 ESI MONITORING WELL RESAMPLED DURING YEAR 2000 SI
G009-LS04 ⌖	YEAR 1995 GROUP I AOI CONFIRMATORY SAMPLING LEAD-SCREEN AUGER BORING (GROUNDWATER SAMPLES)
MSAWM-4 ⊞	EXISTING WELL
←	DIRECTION OF GROUNDWATER FLOW

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FIGURE 2-1 GROUNDWATER SAMPLING LOCATIONS
AOC9 FORMER GRIFFISS AFB
ROME, NEW YORK

2.5.1 Selection of Groundwater Cleanup Goals

Standards

Standards identified for groundwater at AOC 9 are the NYSDEC Class GA maximum contaminant levels (MCLs) from NYSDEC's Division of Water *Technical and Operational Guidance Series (TOGS) (1.1.1) Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations* (NYSDEC June 1998; 2000), indicating the potential use of this groundwater as a drinking water source. All New York State groundwater is considered Class GA by NYSDEC.

Guidance

The NYSDEC Class GA water guidance values were also obtained from TOGS 1.1.1. These guidance values were used for analytes for which NYSDEC Class GA Standards have not been established.

Selection Process

Applicable ARARs for the contaminants detected in groundwater are presented in Table 2-2. Groundwater data was screened using Geoprobe, Hydropunch, and monitoring well data from the 1995 CS, 1997 ESI, 2000 SI, and 2002 SI. The following describes the methodology used in selecting the proposed cleanup goals for on-site groundwater:

- The NYSDEC Class GA standard, if it existed, was selected as the proposed cleanup value.
- If a groundwater standard did not exist for an analyte, the NYSDEC Class GA guidance value, if it existed, was used.
- If a standard or guidance value did not exist for an analyte, no proposed cleanup value was selected.
- The proposed cleanup values were then compared to the maximum observed concentrations of each analyte to determine which analytes may require cleanup.
- Finally, the analytes identified for cleanup were reviewed to determine whether they are site-related and whether cleanup actually is warranted.

As shown in Table 2-2, several analytes exceeded proposed cleanup goals. Potential contaminants of concern in groundwater include:

- 21 VOCs (1,2-dichlorobenzene, 1,2-dichloroethane, 1,3-dichlorobenzene, 1,3,5-trimethylbenzene, 1,4-dichlorobenzene, acetone, benzene, chlorobenzene, cis-1,2-dichloroethene, ethylbenzene, isopropylbenzene, methylene chloride, n-butylbenzene, n-propylbenzene, naphthalene, sec-butylbenzene, tert-butylbenzene, tetrachloroethene, TCE, vinyl chloride, and xylene (total);
- one SVOC (bis (2-ethylhexyl)phthalate);
- two pesticides (aldrin and dieldrin); and
- four metals (iron, manganese, selenium, and thallium).

Table 2-2 Proposed Cleanup Goal Screening Process for Groundwater (µg/L) AOC 9 – Former Griffiss AFB, Rome, New York

Analyte	NYSDEC Class GA Groundwater Standard	NYSDEC Class GA Groundwater Guidance	Maximum Concentration	Proposed Cleanup Goal
VOCs				
1,2-Dichlorobenzene	3	—	513 J	3
1,2-Dichloroethane	0.6	—	71	0.6
1,3-Dichlorobenzene	5	10	11.4	5
1,3,4- Trimethylbenzene	5	—	3.2	—
1,3,5- Trimethylbenzene	5	—	34.4	5
1,4-Dichlorobenzene	5	10	227	5
Acetone	—	50	352	50
Benzene	1	—	13	1
Chlorobenzene	5	—	2,352	5
Chloroform	7	—	1.3 J	—
Cis-1,2-Dichloroethene	5	—	240	5
Ethylbenzene	5	—	60	5
Isopropylbenzene	5	—	23	5
Methylene Chloride	5	—	73	5
n-Butylbenzene	5	—	250	5
n-Propylbenzene	5	—	14	5
Naphthalene	—	10	51	10
p-Cymene (p-Isopropyltoluene)	5	—	2.9	—
Sec-Butylbenzene	5	—	10	5
Tert-Butylbenzene	5	—	5.4	5
Tetrachloroethene	5	—	173	5
Toluene	5	—	5	—
trans-1,2-Dichloroethene	5	—	3.8	—
Trichloroethene	5	—	67	5
Vinyl Chloride	2	—	64	2

Table 2-2 Proposed Cleanup Goal Screening Process for Groundwater (µg/L)
AOC 9 – Former Griffiss AFB, Rome, New York

Analyte	NYSDEC Class GA Groundwater Standard	NYSDEC Class GA Groundwater Guidance	Maximum Concentration	Proposed Cleanup Goal
Xylene (total)	5	—	218	5
Pesticides				
Aldrin	ND	—	0.573 J	ND
Dieldrin	0.004	—	0.327 J	0.004
SVOCs				
2-Methylnaphthalene	—	—	0.6 J	—
Bis(2-ethylhexyl)adipate	20	—	1.2 J	—
Bis(2-ethylhexyl)phthalate	5	—	8.4	5
Butylbenzylphthalate	—	50	0.7 J	—
Di-n-butylphthalate	50	—	15 J	—
Diethylphthalate	—	50	4.8 J	—
Phenanthrene	—	50	0.7 J	—
Metals				
Aluminum	—	—	7,300 J	—
Arsenic	25	—	5	—
Barium	1,000	—	158	—
Beryllium	—	3	0.2 J	—
Cadmium	5	—	5	—
Calcium	—	—	101,000	—
Chromium	50	—	21	—
Cobalt	—	—	3.7 J	—
Copper	200	—	27	—
Iron	300[a]	—	14,000 J	300
Lead	25	—	11	—
Magnesium	—	35,000	14,000	—
Manganese	300[a]	—	6,810	300
Nickel	100	—	26	—
Potassium	—	—	6,000	—
Selenium	10	—	23	10
Silver	50	—	4.6 J	—
Sodium	20,000	—	15,000	—
Thallium	—	0.5	7.5 J	0.5
Vanadium	—	—	6.4 J	—
Zinc	—	2,000	61	—

Source: NYSDEC, June 1998, Ambient Water Quality Standard and Guidance Values, Class GA Groundwater.

[a] Iron and manganese groundwater standard is 500 µg/L combined.

Key:

— = No standard/guidance value available/applicable.
J = Estimated value.
µg/L = Micrograms per liter.
NYSDEC = New York State Department of Environmental Conservation.
SVOCs = Semi-volatile organic compounds.
VOCs = Volatile organic compounds.

The following section discusses whether cleanup of these contaminants of concern is warranted at AOC 9.

2.5.2 Selection of Groundwater Contaminants of Concern

Based on the above analysis, it was determined that on-site groundwater along a linear, northeast-southwest area (extending throughout the aquifer) in the northwestern portion of the site is contaminated primarily with chlorobenzene. Several other VOCs, one SVOC, two pesticides, and four inorganics were detected in groundwater samples (1995 CS, 1997 ESI, 2000 SI, 2002 SI) above proposed cleanup goals. However, for the purpose of delineating groundwater contamination the focus is on remediation of VOCs. Remedial efforts conducted to either extract or treat chlorobenzene contaminated groundwater are expected to remediate other VOCs.

The following presents the rationale for selecting VOCs as the focus of groundwater remediation in this FS:

- Maximum chlorobenzene concentrations were found during the 2000 SI at a level of 2,352 µg/L in AOC9-GP27, located just south of Perimeter Road in the northwestern portion of the site. Other concentrations of chlorobenzene exceeding cleanup goals in 2000 and 2002 SI were found at AOC9-GP44 and AOC9-GP14 at concentrations of 2,150 µg/L and 1,147 µg/L, respectively. These exceedances follow a northeast-southwest direction parallel to the groundwater flow direction to the creek. One sediment exceedance of chlorobenzene at AOC9-SD10 is located along Six Mile Creek in-line with the flowpath of the suspected groundwater plume, indicating chlorobenzene contamination is flowing via groundwater to the creek.

  The daughter products of chlorobenzene (1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, and benzene) were also found at levels exceeding proposed cleanup goals. Therefore chlorobenzene and its daughter products in groundwater will be further addressed in this FS.

- The highest concentration of TCE detected between the 2000 and 2002 SI was 66.9 µg/L, located at AOC9-GP05, less than 100 feet from Six Mile Creek. Based on the groundwater flow direction, TCE is flowing into Six Mile Creek. However, surface water and sediment samples show no TCE concentrations exceeding cleanup goals on-site and along the creek, and this indicates TCE is attenuating by natural processes such as volitalization. Analytical data from G009-MW04, located south of Six Mile Creek in line with the plume, detected TCE at 17.7 µg/L, exceeding cleanup goals. TCE concentrations in groundwater samples collected from AOC9-MW05 (farther south of Six Mile Creek in line with the plume) and AOC9-MW06 (in Six Mile Creek downstream of the plume) were undetected during the 2000 SI. This data indicates that TCE contamination is flowing via groundwater to the creek.

The parent and daughter products of TCE (tetrachloroethene, cis-1,2-dichloroethene, and vinyl chloride) were also found at levels exceeding proposed cleanup goals. Therefore TCE and its parent and daughter products in groundwater will be further addressed in this FS.

- Other VOCs detected with concentrations exceeding cleanup goals include: 1,2-dichloroethane, 1,3,5-trimethylbenzene, acetone, ethylbenzene, isopropylbenzene, methylene chloride, n-butylbenzene, n-propylbenzene, naphthalene, sec-butylbenzene, tert-butylbenzene, and xylene (total). These VOCs in groundwater will be further addressed in this FS.

- Elevated concentrations of inorganics, including aluminum, iron, manganese, and potassium, were found throughout the site in varying concentrations in multiple site investigations. However, these inorganics are naturally occurring and will therefore not be addressed further in this FS.

- Selenium and thallium were detected at elevated levels in monitoring wells sampled during the 2000 SI. In some cases (G009-MW01, -MW02, -MW03, -MW04), selenium was detected in filtered samples but had not been detected in either filtered or unfiltered 1997 ESI samples. In other cases, (AOC9-MW05, -MW06, and -MW07) selenium was detected at higher levels in the filtered sample as opposed to the unfiltered sample. These results are questionable because detected metals concentrations are typically lower in filtered samples than in unfiltered samples. Therefore, although selenium was detected in groundwater, the levels detected are questionable and will not be addressed further in this FS.

  Thallium was detected in only one sample (AOC9-MW07) during one site investigation. An on-site source of thallium is unknown and there is evidence of sporadic and inconsistent detections of thallium basewide. Therefore, although thallium was detected above proposed cleanup goals, there is reason to believe thallium is not a contaminant of concern in groundwater at this site and will not be further addressed in this FS.

- Concentrations of two pesticides, aldrin and dieldrin, were found in one of the five groundwater test pit samples (AOC9-GW-TP03) collected during the 2002 SI. Pesticides have been found at levels exceeding ARARs due to general use basewide. Since pesticides were detected in only one groundwater sample on-site and there is historical use of pesticides basewide, an on-site source is unlikely. Therefore, remediation of these analytes is not warranted in groundwater and will not be further addressed at this site.

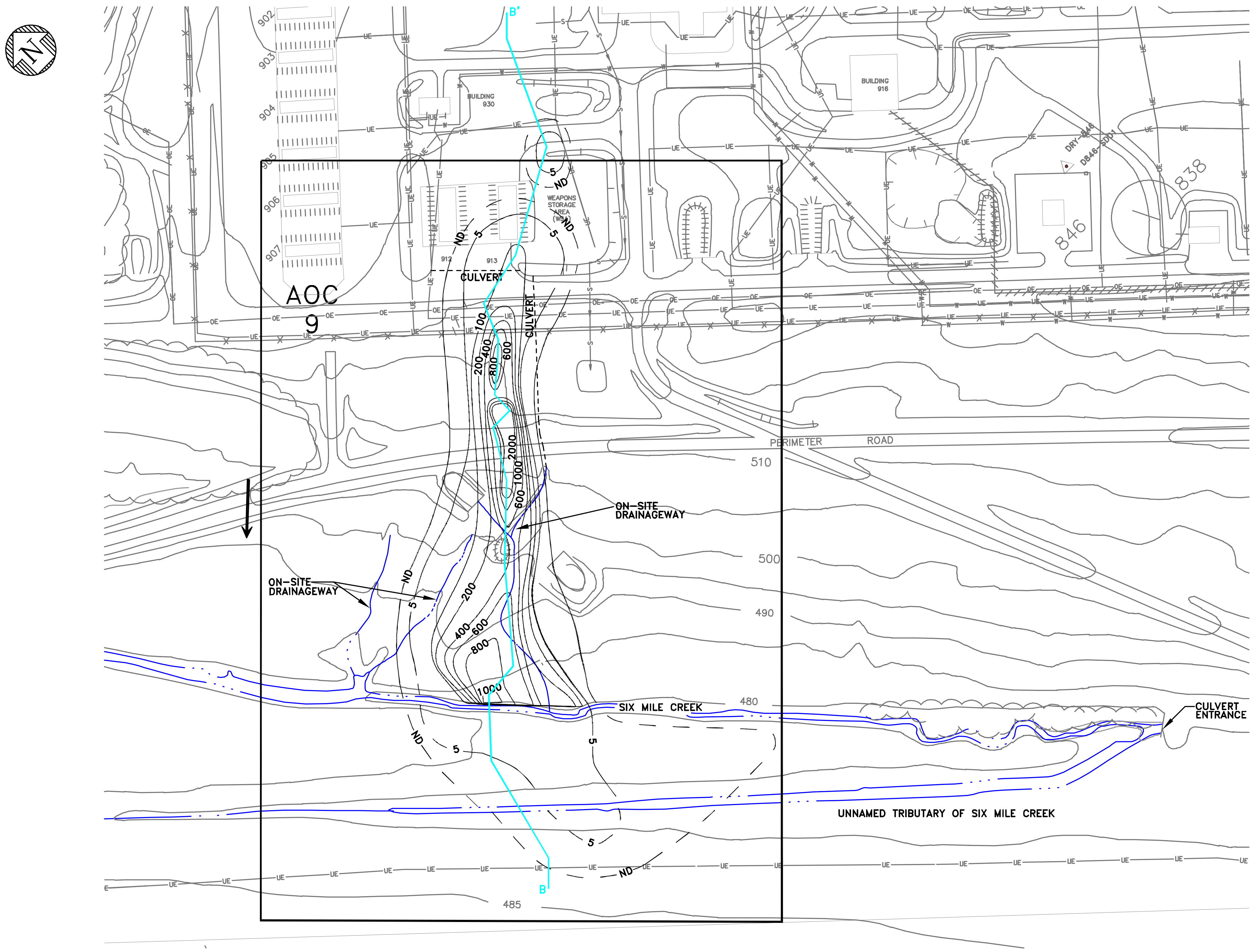
- Bis(2-ethylhexyl)phthalate is a common sample contaminant due to its presence in the gloves typically used by field and laboratory personnel. It is suspected that the detection of this analyte is from this source and is not site-related. Therefore bis(2-ethylhexyl)phthalate in groundwater will not be further addressed in this FS.

2.6 Determination of Contaminated Groundwater Volume

In this section, contamination of the on-site plume is evaluated considering the ARAR-based proposed cleanup goals identified in Section 2.5. This evaluation defines the extent of the plume in the areas where remedial action should be considered.

To determine the extent of groundwater contamination, the maximum concentrations of the shallow, intermediate, and deep samples from the 2000 and 2002 Geoprobe/Hydropunch data were utilized to develop 2-dimensional concentration contours that illustrate the extent of the plume. Groundwater concentration contours were developed using Surfer™ software and plotted for chlorobenzene/1,2-dichlorobenzene, TCE, and dichloroethene (DCE)/VC (see Figures 4-1, 4-2, and 4-3 in the 2003 RI). Chlorobenzene was found in varying concentrations along the entire plume, while the majority of TCE contamination was found within 100 feet of Six Mile Creek. DCE concentrations extended between the area around AOC9-MW8 to Six Mile Creek. The concentration contour plot for chlorobenzene captured the majority of the other VOC contaminant contours and was therefore used to estimate the area of the contaminated plume. This chlorobenzene plot illustrates the lateral extent of contamination and is included as Figure 2-2. The vertical extent of contamination is included as Figure 2-3.

Data from previous site investigations show groundwater contamination extends to bedrock in the saturated aquifer. For the contaminated groundwater volume calculation, the 5 µg/L contour for chlorobenzene established a conservative boundary for capturing on-site groundwater contamination. Depth to groundwater was approximated in the 2004 RI to be 11 feet BGS north of Perimeter Road, while south of Perimeter Road it was approximated to be 3.5 feet BGS. Bedrock was assumed to be encountered approximately 15 feet below the top of the water table at the site (i.e., 26 feet BGS north of Perimeter Road and 18.5 feet BGS south of Perimeter Road). Based on this information, E & E estimated approximately 1.1×10^6 cubic feet (8.1×10^6 gallons) of groundwater would require remediation. This volume was calculated based on contour interval area take-offs (from Figure 2-2) and assuming a saturated depth of 15 feet. Proposed groundwater remedial actions assume multiple groundwater flushes of the plume over the assumed remedial period. Supporting calculations are provided in Appendix A.



LEGEND

←	DIRECTION OF GROUNDWATER FLOW
—200—	MAXIMUM CHLOROBENZENE ISOCONCENTRATION CONTOUR IN µG/L (DASHED WHEN INFERRED)
B——B'	CROSS SECTION LINE

NOTE

THE CONCENTRATION CONTOUR PLOT FOR CHLOROBENZENE SHOWN IN THIS FIGURE CAPTURES THE AERIAL EXTENT OF OTHER VOC CONTAMINANT CONTOURS INDENTIFIED IN THE 2003 RI

SOURCE: AOC9: WEAPONS STORAGE AREA (WSA) LANDFILL, DRAFT 2002 REMEDIAL INVESTIGATION REPORT, FORMER GRIFFISS AIR FORCE BASE, ROME, NEW YORK (E & E 2003)

SCALE IN FEET
0 100 200 300

F:\GRIFFISS\CK1000\BOB MEYERS\POINT 8-2002\dwg\april report 2003\11 x 17\May Rev\ck1s033d-5-2003_Figure 2-3.dwg
BUFF PLOTTED: 1/22/04 JJK

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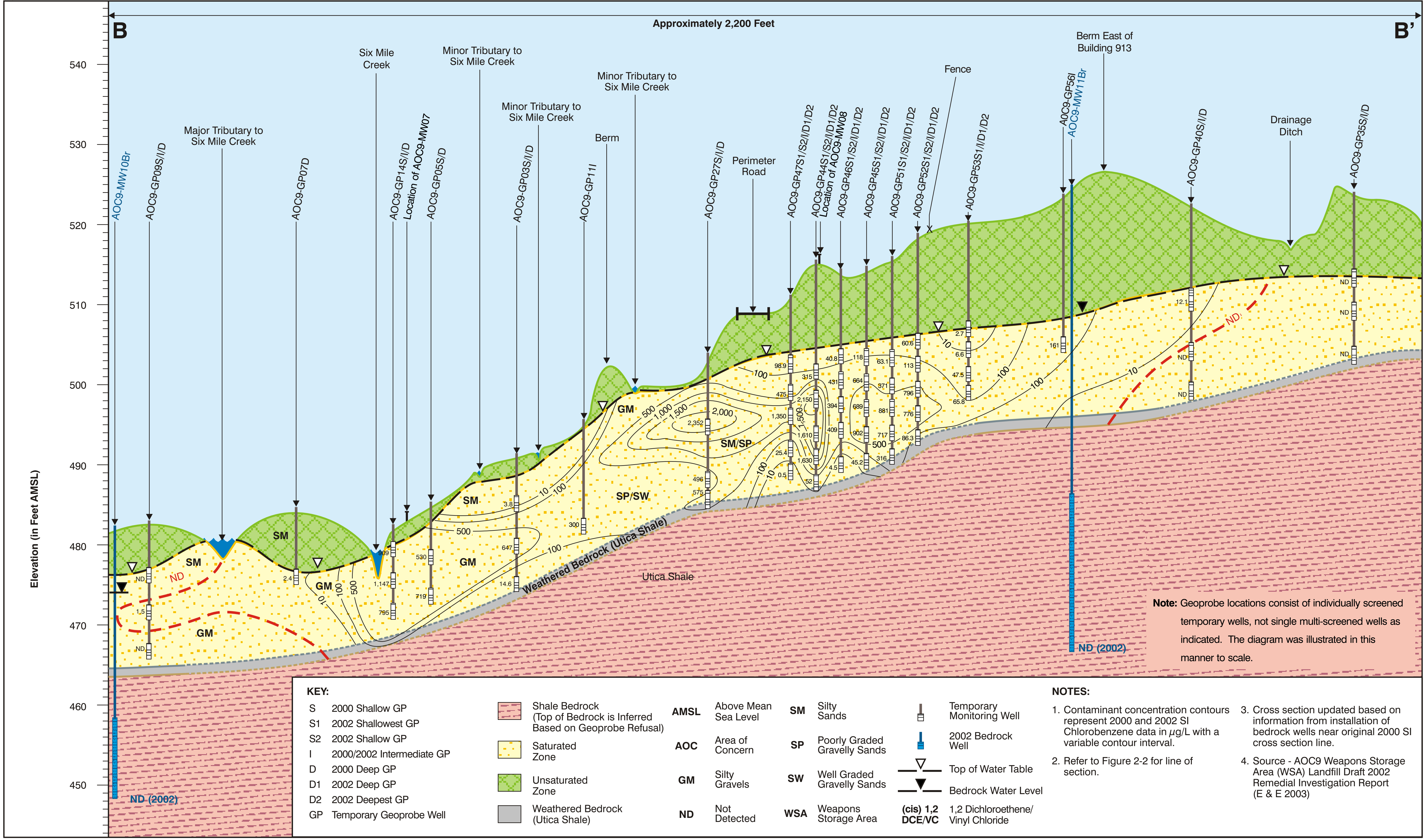
FIGURE 2-2 CHLORBENZENE CONCENTRATION MAP
AOC9 FORMER GRIFFISS AFB
ROME, NEW YORK



Note: Geoprobe locations consist of individually screened temporary wells, not single multi-screened wells as indicated. The diagram was illustrated in this manner to scale.

KEY:

S	2000 Shallow GP
S1	2002 Shallowest GP
S2	2002 Shallow GP
I	2000/2002 Intermediate GP
D	2000 Deep GP
D1	2002 Deep GP
D2	2002 Deepest GP
GP	Temporary Geoprobe Well

▨	Shale Bedrock (Top of Bedrock is Inferred Based on Geoprobe Refusal)
▨	Saturated Zone
🟩	Unsaturated Zone
▨	Weathered Bedrock (Utica Shale)

AMSL	Above Mean Sea Level
AOC	Area of Concern
GM	Silty Gravels
ND	Not Detected

SM	Silty Sands
SP	Poorly Graded Gravelly Sands
SW	Well Graded Gravelly Sands
WSA	Weapons Storage Area

	Temporary Monitoring Well
	2002 Bedrock Well
▽	Top of Water Table
▼	Bedrock Water Level
(cis) 1,2 DCE/VC	1,2 Dichloroethene/ Vinyl Chloride

NOTES:

1. Contaminant concentration contours represent 2000 and 2002 SI Chlorobenzene data in μg/L with a variable contour interval.
2. Refer to Figure 2-2 for line of section.
3. Cross section updated based on information from installation of bedrock wells near original 2000 SI cross section line.
4. Source - AOC9 Weapons Storage Area (WSA) Landfill Draft 2002 Remedial Investigation Report (E & E 2003)

SOURCE: Ecology and Environment, Inc. 2003

Figure 2-3 Year 2000 and 2002 Supplemental Investigation (SI), AOC 9: Weapons Storage Area (WSA) Landfill, Cross Section B-B' Chlorobenzene Concentrations

3

Identification and Screening of Remedial Technologies

3.1 General Response Actions

This section identifies general response actions (GRAs), or classes of responses, to contaminated areas. GRAs describe classes of technologies that can be used to meet the remedial action objectives for groundwater at AOC 9. Applicable classes of remedial technologies were identified and initially screened based on their effectiveness, implementability, and cost effectiveness, taking into consideration the site-specific conditions and contaminant characteristics. Past performance (i.e., demonstrated technology) and operating reliability were also considered in identifying and screening applicable technologies. Technologies that were not initially considered effective and/or technically or administratively feasible were eliminated from further considerations.

Six types of general response actions were identified for on-site contaminated groundwater:

- No action;
- Natural attenuation;
- Institutional controls;
- Capture and control;
- In situ treatment; and
- Ex situ treatment.

3.2 Groundwater Treatment Technologies

3.2.1 Limiting Considerations

The range of potential treatment technologies for use at the AOC 9 contaminated groundwater plume is limited because inapplicable or inappropriate technologies, such as those involving fractured bedrock, nonaqueous-phase liquids, or high concentrations of dissolved contaminants, were not considered. Response technologies that could be appropriate for the general conditions that exist at the site are discussed below.

3.2.2 No-action

A no-action response must be evaluated during the course of the FS. The no-action alternative involves taking no further action to remediate groundwater conditions at the site and is used as the basis of comparison with the other alternatives. As prescribed by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), no action is an acceptable alternative only when it does not result in an unacceptable risk to human health and the environment.

3.2.3 Natural Attenuation

Natural attenuation uses ongoing natural processes to reduce the concentrations of contaminants within an aquifer. There are often aerobic and anaerobic processes occurring within a plume that may eventually reduce contaminant concentrations to proposed cleanup levels. The natural attenuation response action includes documentation of how these processes are occurring and how they will or will not remediate groundwater before potential receptors are exposed.

Natural attenuation uses naturally occurring treatment mechanisms to reduce the concentration of contaminants in an aquifer, including physical processes such as dispersion, volatilization, and adsorption, but more importantly relies on the destructive mechanisms of anaerobic biological reduction. Under the right conditions, anaerobic microorganisms can reductively dechlorinate organic solvents, ultimately producing ethene and chloride end products. Alternatively, this mechanism can produce less chlorinated compounds that are amenable to mineralization through aerobic biological treatment mechanisms. The reductive dechlorination reaction requires anaerobic conditions as well as sufficient electron donors to supply reducing power. Typically, electron donors include hydrocarbon contamination that may be co-located with the solvent contamination, or carbohydrate or organic acid material that may be present either naturally or from the disposal of nonhazardous material.

A protocol was developed by the EPA to document the natural attenuation process, the methods used to verify their natural attenuation is occurring, and the conditions under which it can be applied. This technology can be used to clean up a site if the existing processes are suitable for treating contaminants as fast as they are released and if the plume would not migrate to potential future receptors.

Natural attenuation is not applicable as a stand-alone remedial technology at AOC 9 for two reasons. First, natural attenuation parameters were collected as part of the 2000 SI and data indicated that primarily aerobic conditions existed at the site, although there was some indication that anaerobic conditions may exist as well. It is well documented that PCE and TCE readily attenuate in anaerobic conditions; DCE and VC readily attenuate in aerobic conditions. Chlorinated benzenes can evaporate when exposed to air, but with respect to chlorobenzene, specifically, there is no clear documentation indicating whether chlorobenzene attenuates more readily in aerobic versus anaerobic conditions. Therefore, it is unclear as to the rates and processes at which natural attenuation is occurring on-site.

Secondly, groundwater contamination is currently discharging to Six Mile Creek. By allowing natural attenuation to occur, groundwater contamination will continue to flow to the creek, as evidenced by analysis of groundwater samples collected between the 1997 ESI and the 2000 SI, which showed an increase in chlorobenzene and TCE concentrations from AOC9-MW04 (located south of Six Mile Creek, in line with the plume). Due to attenuation uncertainties and evidence of groundwater contamination discharging to the creek, natural attenuation is not considered a viable remedial technology as a stand-alone technology. Natural attenuation will, however, be evaluated in combination with other remedial technologies to provide a complete remedial action.

3.2.4 Institutional Controls

Institutional controls are not technologies. Rather, they are legal or social actions or practices that reduce or prevent exposure of the human population to the contaminated groundwater (e.g., deed restrictions, fencing/signs, health advisories). Long-term groundwater monitoring can also be included in institutional controls to detect contaminant migration toward potential receptors. Long-term monitoring is distinct from natural attenuation in that it does not attempt to demonstrate that the contaminants are being degraded and/or that they will be attenuated before reaching a receptor.

Institutional controls can be used as a stand-alone alternative or can be used in conjunction with other technologies to achieve RAOs. The Record of Decision (ROD) for Six Mile Creek (E & E December 2003) states that sources of contamination to the creek will be remediated and potential sources, such as AOC 9, may be remediated if recommended by this FS. Since the 2003 RI indicates a portion of AOC 9 groundwater discharges to Six Mile Creek, institutional controls should not be used as a stand-alone alternative at this site. Because groundwater in the vicinity of AOC 9 is currently not used and not anticipated to be used as a drinking water source, this technology is effective in preventing exposure to groundwater contaminants, and institutional controls are readily implemented. Therefore, institutional controls will be retained for further consideration in conjunction with other technologies.

3.2.5 Capture and Control

Subsurface Barriers

Subsurface barriers are typically used to divert the flow of groundwater from a contaminated area or to direct the flow of contaminated groundwater into a capture or treatment system. Typical barriers include slurry walls, sheet piling, and grouting.

Slurry walls are usually constructed by excavating a trench while simultaneously replacing the excavated soil with a slurry of soil mixed with bentonite clay or cement mixed with bentonite clay. Slurry walls can also be created by augering a series of intersecting vertical boreholes and mixing the slurry in the boreholes. The overlapping, filled boreholes comprise a slurry wall. The excavation of slurry walls in dense, hard, fractured rock is difficult and often precludes implementation under these conditions.

Sheet piling with interlocking joints can be driven or vibrated into the ground in granular material to form an effective barrier to groundwater flow. Several materials can be used for sheet pilings, including wood, plastic, precast concrete, and steel, but steel is used most often.

Subsurface barriers are most effective and their success often depends upon their completion within the upper portion of a natural layer of low hydraulic conductivity such as an aquiclude. Where areas of low hydraulic conductivity exist, subsurface barriers capture and control groundwater flow quite effectively, and all three barrier types are equally implementable. Because the plume at AOC 9 is relatively shallow (approximate maximum of 26 feet BGS to bedrock), a subsurface barrier may be cost-effective and may be effective in combination with a collection or in situ treatment technology. Therefore, subsurface barriers will be retained to possibly be combined with another treatment technology.

Groundwater Collection

Groundwater is captured and controlled by pumping it out of the ground and creating hydraulic gradients toward the capture point. The capture methods considered include trenching (with or without barriers to enhance control) and pumping wells.

Collection Trenches. Groundwater collection trenches can be constructed inexpensively. They can be filled to prevent sidewall collapse or left open with sloping walls to create an open ditch. A perforated pipe is usually placed near the bottom of a filled trench and surrounded by granular material of high hydraulic conductivity such as sand or gravel. The pipe functions as a horizontal well and drains water to a sump for removal. An open ditch performs the same function and it requires no pipe but involves the removal of more soil.

Collection trenches are generally effective and readily implemented for shallower plumes. Because the plume on-site is relatively shallow, a trench collection system could be used to collect and convey contaminated groundwater. Therefore, collection trenches will be retained as an applicable technology.

Extraction Wells. Extraction wells are constructed with a well screen that opens to the aquifer along that part of the well length placed within the contaminated portion of the aquifer. This is surrounded by a material of high hydraulic conductivity, such as sand or gravel, and a pump is usually inserted in the screened internal well. Shallow wells may have pumps at the surface, with only a production pipe extending below the water table. Well screens and casings, pumps, and pipes are often constructed of polyvinyl chloride (PVC), steel, or stainless steel, depending on the expected corrosivity or aggressiveness of the water and the expected life of the well. The diameter of the well, its anticipated pumping capacity, and the size of the pump are determined based on aquifer properties and the capture zone required.

Extraction wells are both effective and implementable and will be considered further.

3.2.6 In situ Treatment

In situ groundwater treatment is performed without extracting the groundwater from the aquifer. The following paragraphs discuss the biological, chemical, and physical processes that may be used to remediate groundwater.

Biological In situ Treatment

The biological treatment processes described in the section on natural attenuation (see Section 3.2.3) are a form of in situ reduction of chlorinated solvent plumes. In cases where this process is not occurring naturally or occurring very slowly, it can be promoted by artificially providing the required conditions. The most common reason natural oxidation/reductive dechlorination does not take place is a lack of electron acceptors/donors to power the processes. Addition of electron acceptors/donors can cause the biological processes to occur that otherwise would not.

Additives such as organic acids, oils, and proprietary time-release compounds have been used to supply electron donors needed to enhance degradation of chlorinated solvents such as TCE. The success of this technology depends on the successful introduction of the donors into the full extent of the plume or source, the maintenance of anaerobic conditions, and the maintenance of adequate donor supply throughout the period of treatment. This technology is still in the development stage. However, the fundamental science of the process is identical to the more established natural attenuation treatments.

Minimal information has demonstrated successful biological treatment of chlorobenzene. Although biological treatment has been demonstrated to successfully degrade chlorinated solvents under proper site conditions (Nishino 1992), the degradation of chlorobenzene is uncertain and further studies would be required to demonstrate that degradation of the contaminants of concern will occur at the site. Since biological treatment of one of the contaminants of concern is not well demonstrated and the other is in development, in situ biological treatment of groundwater does not appear to be effective or readily implementable for this site. Therefore, in situ biological treatment will not be retained as an applicable technology.

Chemical In situ Treatment

In situ Oxidation. In situ chemical oxidation is a process by which strong oxidizing agents are introduced to the contaminated media so that contaminants are either completely oxidized into CO_2 and water or converted to nontoxic compounds commonly found in nature. Chemical oxidants that have been shown to effectively oxidize organic compounds include hydrogen peroxide (H_2O_2), potassium permanganate ($KMnO_4$), and ozone. Typically these oxidizing agents are injected into the ground through a series of injection wells that cover the plume area.

The use of H_2O_2 with soluble iron (Fe^{2+}) to oxidize organic compounds is based on Fenton's chemistry, where H_2O_2 is decomposed by Fe^{2+} to form hydroxyl radicals. The hydroxyl radicals act as strong oxidants capable of attacking the carbon-hydrogen bond and converting complex organic compounds into carbon dioxide and water. Generally, a low pH environment (2 to 4 pH) is needed to promote the generation of hydroxyl radicals, although some vendors have reportedly developed ways to apply this technology at pHs closer to neutral. Using H_2O_2 has two main advantages: no organic by-products are formed during the oxidation process and iron and hydrogen peroxide are abundant and low cost. A major concern with using H_2O_2 is handling large quantities of chemicals and introducing acidic solutions into the environment. In addition, special measures may be required during injection of H_2O_2 into the ground because it can readily break down into water vapor and oxygen (O_2).

Potassium permanganate is also an effective oxidizing agent for some, but not all, organic contaminants. Reaction of $KMnO_4$ with organic compounds produces manganese dioxide (MnO_2) and CO_2 or an intermediate organic compound. Since MnO_2 is naturally present in soils, the introduction of permanganate to the environment is generally not a concern. However, the production of MnO_2 particles may result in reduction of the general permeability of the affected aquifer in the treated area.

Ozone, like $KMnO_4$ and H_2O_2, is also an effective oxidant for organic contaminants. One advantage of using ozone is the ability to generate it on-site, which eases transportation and storage problems.

In situ oxidation technologies have recently gained more attention as a feasible alternative to remediate sites contaminated with chlorinated and non-chlorinated organic compounds. One of the primary concerns and key to successful implementation of in situ oxidation technologies is delivering the aqueous chemical oxidants to the contaminated region. In general, implementation of in situ oxidation proceeds in three phases: laboratory bench-scale study, on-site pilot program, and full-scale treatment. The bench-scale study determines the effectiveness of oxidation on the site's contaminants and the optimum treatment dosage. Upon successful completion of the laboratory study, an on-site pilot-scale study is conducted, for which a series of well points are installed in a representative area of the plume (typically the highest area of contamination) to further evaluate the treatment potential of the contaminants. Specific system monitoring and sampling procedures are performed during the two to three-month long pilot program to evaluate reaction efficiency and environmental response. If the pilot program is successful, full-scale treatment is performed using procedures similar to the pilot program, and a chemical delivery system is designed to cover the plume area.

Bench-scale tests and an on-site pilot study were performed on contaminated groundwater at AOC 9 (E & E June 2004). Bench-scale test results from the Fenton-based test on the site groundwater indicated a 99.9% destruction of VOCs, while potassium permanganate showed no VOC reduction. The pilot study was located in the vicinity of AOC9-MW08 and exhibited a general decrease of pilot study-established COCs: chlorobenzene, 1,2-DCB, 1,3-DCB, and 1,4-DCB (see Section 4.3 and 5.3 for further discussion). Therefore in situ chemical oxidation will be retained as an applicable technology.

In situ Zero-valent Iron Reactive Walls. In situ reactive walls containing zero-valent iron is a passive-type technology used to degrade chlorinated organic compounds in groundwater as they pass through the “wall.” The oxidation of the zero-valent iron by water provides a source of electrons for reductive dehalogenation of the chlorinated organic compounds. The simultaneous oxidation of iron and degradation of the chlorinated organic compounds proceeds spontaneously without the addition of catalysts or a source of energy. The products of this reaction are chloride and non-toxic hydrocarbons.

The two most common configurations of in situ iron reactive walls are the funnel and gate and the continuous permeable wall systems. In the funnel and gate system, impermeable funnel sections are installed to direct groundwater to the reactive permeable gate sections that contain the zero-valent iron. With the continuous permeable wall system, a reactive wall section is placed to intersect the entire plume. These continuous walls can be anchored to an impermeable layer or hung from the surface. The appropriate configuration is usually based on site characteristics, prevention of groundwater from escaping below or around the reactive wall, and providing the optimal residence time (contact time) for reducing the contaminant concentrations to proposed cleanup levels as they naturally flow through the wall.

Several studies have evaluated the potential use of zero-valent metals to degrade halogenated organic compounds dissolved in water. The in situ chemical treatment wall using iron was initially developed at the University of Waterloo in 1992. EnviroMetal Technologies, Inc., subsequently commercialized this treatment method, which is now referred to as EnviroMetal Process^{TM}. Since this technology was commercialized, 32 pilot-scale and 28 full-scale systems have been implemented at a number of sites in the United States. Pilot-scale studies indicated treatment efficiencies of more than 95% for VOCs. Discussions with a technology-specific vendor indicated that using the zero-valent iron wall to degrade chlorinated benzenes has been unsuccessful. An additional technology such as activated carbon (in situ or ex situ) would be required to remediate the site contaminants identified in Section 2.5.2.

Other media evaluated for the treatment of VOCs were zero valent zinc, palladized zinc, palladized iron, iron/magnesium/, iron/sulfur and hydrogen activation systems with palladium catalyst. Of these media, only the hydrogen activation system with palladium catalyst was tested specifically for chlorobenzene in an in situ pilot study. However, anaerobic degradation of the chlorbenzene was not proven (EPA January 2002).

The process of implementing a site-specific reactive wall technology proceeds in a phased approach. Bench-scale testing is conducted first to determine the rate of degradation and residence time required to achieve the required proposed cleanup levels. An on-site, pilot-scale study is then conducted to collect the required data and design parameters that would be required for full-scale implementation. Finally, a full-scale system is designed using the data collected during the pilot study.

In situ reactive walls have been shown to be most technically effective and cost-effective for depths less than 45 feet and are potentially applicable at this site. The additional capital and operation/maintenance costs for an additional technology to treat site contaminants (chlorobenzene and other VOCs) makes this technology more difficult to implement. Therefore, the in situ zero-valent iron reactive wall technology may not be as cost effective when compared to other available treatment technologies and will not be retained for further consideration.

In situ Nano-scale Bimetallic Particles Treatment. Nano-scale bimetallic particle (BMP) treatment is a developing technology that uses the same chemistry as the zero-valent reactive iron walls. To implement this technology, iron (doped with some deposits of palladium catalyst to increase reaction rates) is introduced into the aquifer via injection wells as nano-scale subcolloidal-size particles rather than placed as a monolithic wall in an excavated trench. This reduces cost by requiring less iron (BMP has much greater specific surface area for promoting the reduction reaction) and obviating the need for trench construction. However, it requires the injection of the BMP into the aquifer, which in turn would require that all of the aquifer be effectively accessible through an injection program. An injection program would require that the injected BMP travel from the injection spot to a sufficient radius of influence but also would eventually adsorb to the aquifer matrix to provide a resident dechlorination power within the aquifer matrix itself. The plumes considered in this FS are all situated in relatively slow-moving groundwater that would minimize the effect of continued BMP migration following injection.

Similar to the permeable zero-valent iron reactive wall, BMP treatment may be applicable at AOC 9. BMP treatment will result in a cost savings over in situ zero-valent iron reactive wall technology because a trench and/or containment barriers would not have to be excavated. However, because this technology has been demonstrated less often than permeable reactive barriers and because of the uncertainties of contaminant remediation, BMP treatment will not be retained for further consideration.

Physical In situ Treatment

Air Sparging/Soil Vapor Extraction. Air sparging (AS) is remedial technology that reduces concentrations of VOCs that are adsorbed to soils and dissolved in groundwater. This technology, which is also known as “in situ air stripping” and “in situ volatilization,” involves the injection of contaminant-free air into the subsurface saturated zone under pressure, enabling a phase transfer of VOCs from a dissolved state to a vapor phase. The air and vapor phase VOCs are then vented through the unsaturated zone.

Air sparging is most often used together with soil vapor extraction (SVE), but it can also be used with other remedial technologies. When air sparging is combined with SVE, the SVE system creates a negative pressure in the unsaturated zone through a series of extraction wells to control the vapor plume migration. This combined system is called AS/SVE. Implementing a site-specific AS/SVE system proceeds in a phased approach. An on-site, pilot-scale study is conducted to collect the required data and design parameters that would be required for full-scale implementation. Then a full-scale system is designed using the data collected during the pilot study.

Due to the relatively high volatility of site contaminants, chlorinated solvents and benzenes, the physical removal through AS/SVE is a viable technology for this site. Therefore in situ AS/SVE will be retained as an applicable technology.

3.2.7 Ex situ Treatment

Ex situ treatment requires contaminated groundwater to be captured and removed from the aquifer before treatment. Groundwater is captured using a groundwater recovery system such as recovery wells or trenches. Ex situ treatment allows for greater flexibility in controlling the physical, chemical, or biological conditions, or any combination of these conditions, that are required to remove or destroy the contaminants.

Physical/Chemical Treatment

The six technologies below have been considered for physical/chemical treatment of extracted groundwater.

Precipitation/Coagulation/Flocculation. This process removes metals and colloidal and dissolved solids from wastewater. Precipitation is a chemical (or electrochemical) process by which soluble metallic ions and certain anions are converted to an insoluble form for subsequent removal from the wastewater stream. Various coagulants and coagulant aids such as alum, ferric chloride, sodium sulfide, organic polymers, and sodium hydroxide are selected, depending on the specific waste material to be removed, and rapidly mixed with the wastewater to cause the colloidal particles to agglomerate into a floc large enough to be removed by a subsequent clarification process. The performance of the process is affected by chemical interactions, temperature, pH, solubility variances, and mixing effects. These will be considered as viable technologies potentially needed as a pretreatment step to be used with other treatments such as air stripping/sparging.

Filtration. Filtration is a well-established unit operation for achieving supplemental removal of residual suspended solids from wastewater. Filtration may be employed prior to ex situ air stripping/sparging or activated carbon adsorption to reduce the potential for biological growth, clogging, and the suspended solid loads on these units. Filtration could also be used as part of a polishing unit to remove residual floc from the effluent of a precipitation, flocculation, and sedimentation process. This technology will be retained for further consideration.

Sedimentation. Sedimentation is designed to let water flow slowly and quiescently, permitting solids more dense than water to settle to the bottom and materials less dense than water (including oil and grease) to flow to the surface. Polymers may be added to the wastewater to enhance liquid-solid separation. Settled solids form a sludge at the bottom of the clarifier, which is pumped out either continuously or intermittently. Oil and grease and other floating materials may be skimmed off the surface. Filtration is more appropriate than sedimentation for the low-flow applications considered in this study. Thus, this technology will not be retained for further consideration.

Activated Carbon Adsorption. Activated carbon adsorption removes organics from aqueous waste streams by adsorbing the compounds onto the large internal pore surface area of activated carbon. This process has been demonstrated on a variety of organics, particularly those exhibiting low solubility and high molecular weight. It is an effective and reliable means of removing low solubility organics over a broad range of concentrations. Activated carbon can be used in a treatment column or by adding powdered activated carbon directly to contaminated water. In column applications, adsorption involves the passage of contaminated water through a bed of activated carbon that adsorbs the contaminants. When the activated carbon has been utilized to its maximum adsorptive capacity (i.e., spent), it is then removed for disposal, destruction, or regeneration.

Carbon adsorption can be readily implemented at hazardous waste sites and can remove dissolved organics from aqueous wastes to levels below 1 μg/L. This process will be retained for further consideration.

Air Stripping/Steam Stripping. This includes mass transfer processes in which volatile organic contaminants in water are transferred to gas. Stripping processes maximize contact between contaminated aqueous solutions and air and transfer volatile organics to the air to form a gaseous effluent.

Air stripping is effective for diluting waste streams that contain highly volatile organics. Steam stripping and elevated-temperature air stripping are effective for more concentrated waste streams containing less volatile organics. Steam stripping is a variation of distillation that uses steam as both the heating medium and the driving force for the removal of volatile materials. Steam is introduced into the bottom of a tower, and as it passes through the wastewater, the steam vaporizes, removes volatile materials from the waste, and exits via the top of the tower. Although commonly employed as an in-plant technology for solvent recovery, steam stripping is also used as a wastewater treatment process. Air stripping and steam stripping will be further considered as viable in combination with other remedial technologies.

Ultraviolet Oxidation. The ultraviolet (UV)-light chemical oxidation process is applicable to the removal or destruction of organic contaminants in groundwater. Using hydrogen peroxide or ozone as a reagent, this process reduces the contaminants to acceptable levels or destroys them completely. UV light catalyzes the chemical oxidation of organics in groundwater. The process involves extracting the contaminated groundwater and passing it through an oxidation chamber (the mixture flows past the UV lamps, which are housed in quartz tubes). The contaminants absorb the UV light, and this light energy activates the contaminant so that it is more readily oxidized by the hydrogen peroxide or ozone. This technology will be retained as a viable pre/post-treatment step to be combined with other remedial technologies.

Constructed Treatment Wetland

Constructed treatment wetlands (CTWs) are manmade wetlands that are designed to reduce pollutants to acceptable levels. They can be constructed as surface- or subsurface-flow wetlands. Most often, they treat surface water, but they can also receive and treat groundwater. Today, there are more than 300 systems operating in North America that treat contaminants at rates greater than 50,000 gallons per day for a wide range of pollutants in domestic wastewater, refinery effluents, drainage from mining sites, and waters from hazardous waste sites (EPA 1996). All wetlands (both manmade and natural) contain interdependent physical, biological, and biogeochemical processes that can effectively remove pollutants. These processes (mixing, adsorption, precipitation, volatilization, phytoremediation, and microbial degradation) act singly or together to remove different types of organic and/or inorganic contaminants. Inorganic compounds cannot be degraded; hence, they are stored in a wetland. Wetland processes can help transfer them from one medium to another and make them insoluble. Organic compounds such as petroleum hydrocarbons and some chlorinated organics actually can be degraded and, therefore, permanently remediated through wetland processes.

Wetlands exhibit both aerobic and anaerobic conditions. Aerobic conditions persist in the surface water column and, to a lesser degree, in the thin layer of surface sediment and within the layer of respirating roots. Anaerobic conditions dominate in the underlying zone of detritus and peat, although there are pockets of aerobic conditions within respirating roots. The presence and proximity of both aerobic and anaerobic environments in wetlands ensure that multiple microbial degradation reactions can occur and can degrade many chlorinated hydrocarbons such as PCE and TCE, which degrade anaerobically, and petroleum hydrocarbons daughter products of TCE, which degrade aerobically. Microorganisms within the wetland gain energy for growth and reproduction by performing oxidation-reduction reactions. During these reactions, organic compounds are degraded by serving either as the electron donor that becomes oxidized or as an electron acceptor that becomes reduced.

There is evidence of CTWs successfully remediating contaminated groundwater with chlorinated ethenes. In a recent study performed by the United States Geological Survey (USGS) at the Aberdeen Proving Grounds, the half-lives of chlorinated solvents such as TCE in a wetland were reported in the range of 2 to 7 days (USGS 1998). This half-life is much lower than what has been previously measured through laboratory studies. Since 1998, E & E has been performing a full-scale pilot study to remediate a groundwater plume contaminated with TCE, DCE, and VC. The CTW has been constructed directly into the groundwater plume so the system is entirely passive: no pumps or electricity are necessary. The CTW, which is four acres in size, treats an average of 40,000 gallons per day (gpd) with average removal rates in the range of 95%. With recent improvements the treatment wetland has actually been operating at removal rates of 99%, resulting in contaminant concentrations exiting the wetland below MCLs.

There is limited evidence of successful treatment of chlorinated benzenes in CTWs. Some say that chlorobenzenes are not usually metabolized by natural communities (van der Meer 1998). However, bench-scale studies performed to evaluate the biodegradability of chlorobenzene show that it is possible for chlorobenzene to degrade under methanogenic conditions (Means and Hinchee 2000). There is potential that the biodegradation process could be enhanced in a CTW because microbial populations are higher than would be recognized in groundwater. Higher microbial populations should result in higher rates of breakdown of site contaminants.

Implementation of a CTW would proceed in two phases: a small-scale laboratory pilot study followed by development of a full-scale CTW. A pilot study performed in a laboratory would assist in confirming evidence of biodegradation processes, examine transformation patterns using anaerobic and aerobic microcosms, and estimate degradation rates of primary contaminants of concern. Data from a pilot study would be collected for at least six months. In addition to determining degradation processes and rates, the pilot study would be able to assist in sizing a CTW and then deciding if a CTW would be economical compared with other remedial technologies.

A CTW at AOC 9 is considered a viable technology for the following reasons:

- Groundwater is near or at the surface at certain portions of the site; hence, the plume may be captured passively by excavating a basin in it.
- It is documented that TCE and its daughter products can be remediated in CTWs via aerobic and anaerobic processes; evidence from bench scale tests suggests that chlorobenzene and its parent and daughter products degrade anaerobically and are expected to perform similarly in the field.
- There is adequate room to construct a CTW in the site area without any significant issues to the environs of the site area.
- This technology is easily implementable and capital and operation and maintenance (O&M) costs would be minimal.

Therefore, a CTW will be retained as a viable treatment technology.

Table 3-1 summarizes the applicability of each of the technologies presented and indicates if they will be further addressed in this report.

Table 3-1 Summary of Groundwater Treatment Technologies

Section Reference	Technology	Applicable to AOC 9	Further Considered
3.2.2	No Action	Yes	Yes
3.2.3	Natural Attenuation	Yes, combined with other technology	Yes
3.2.4	Institutional Controls	Yes	Yes
Capture and Control			
3.2.5	Subsurface Barriers	Yes, combined with other technology	No
3.2.5	Collection Trenches	Yes	Yes
3.2.5	Extraction Wells	Yes	Yes
In Situ Treatment			
3.2.6	Biological In situ	No	No

Table 3-1 Summary of Groundwater Treatment Technologies

Section Reference	Technology	Applicable to AOC 9	Further Considered
3.2.6	Chemical In situ	Yes	Yes
3.2.6	In situ Zero-valent Iron Reactive Walls	No	No
3.2.6	In situ Nano-scale Bimetallic Particles	No	No
3.2.6	Air Sparging/ Soil Vapor Extraction	Yes	Yes
Ex Situ Treatment			
3.2.7	Precipitation/ Coagulation/ Flocculation	Yes, combined with other technology	No
3.2.7	Filtration	Yes	No
3.2.7	Sedimentation	No	No
3.2.7	Activated Carbon Adsorption	Yes	Yes
3.2.7	Air Stripping/ Steam Stripping	Yes, combined with other technology	No
3.2.7	Ultraviolet Oxidation	Yes, combined with other technology	No
3.2.7	Constructed Treatment Wetland	Yes	Yes

3.3 Disposal

Once groundwater is treated, it must be disposed of. This is the case for many technologies described in Section 3.2; common disposal methods will be described below.

Disposal is the discharge of treated groundwater to surface water or back into the subsurface. A special case of disposal is discharge to a publicly owned treatment works (POTW), either directly or through a sanitary sewer. Off-site disposal to a POTW typically results in additional treatment at that facility prior to discharge from that facility. Disposal to surface water is typically direct, but it can be disposed of indirectly through a storm drain or a ditch.

Discharge to POTW

Extracted groundwater may be discharged to a POTW or a sanitary sewer leading to a POTW. This requires the consent of the POTW after assessment of its own State Pollutant Discharge Elimination System (SPDES) permit conditions. The Former Griffiss AFB has a system of sanitary sewer pipes that discharges to the City of Rome POTW. The POTW must verify that it will continue to meet its permitted discharge levels while receiving the groundwater captured from the site. Discharge to a POTW via trucking is the only option because the nearest sanitary sewer line/manhole is on the opposite side of the runway (southwest of AOC9) and installing a new line is not feasible. Considering that there are other more feasible disposal options, discharge to a POTW will not be further considered.

Reinjection Into the Aquifer

Treated groundwater can be returned to the aquifer through the use of injection wells once it meets NYSDEC Class GA groundwater standards. Changes in the chemistry of the water during treatment, particularly increased dissolved oxygen, may make this impractical if reactions with untreated groundwater cause the precipitation of iron or manganese oxides or growth of bacteria. Therefore, this technology will not be considered further.

Surface Water Discharge

Discharge to surface water may be direct or indirect by discharge to a storm drain. In either case, discharge permit equivalency would be required or the existing permit would have to be reviewed to ensure that the discharge complies with the permit specifications. This technology will be considered further.

4 Development of Alternatives

The technologies that have been retained for consideration have been grouped into alternatives appropriate for the groundwater plume at AOC 9. Consideration of the ROD for Six Mile Creek (E & E December 2003) was given in developing these alternatives. In general, the ROD states sources of contamination to the creek will be remediated and potential sources, such as AOC 9, may be remediated if recommended by this FS. In collaboration with the Former Griffiss AFB and USACE representatives, six alternatives addressing groundwater contamination were identified. A description of each alternative is provided in this section. A detailed evaluation of the alternatives is presented in Section 5. The six alternatives are:

- Alternative 1: No Action
- Alternative 2: Institutional Controls / Long-term Monitoring
- Alternative 3: In situ Chemical Oxidation
- Alternative 4: In situ Air Sparging/Soil Vapor Extraction (AS/SVE)
- Alternative 5: Extraction, Treatment, and Disposal
- Alternative 6: Constructed Treatment Wetland

4.1 Alternative 1: No Action

The No Action alternative was carried through the FS for comparison purposes as required by the NCP. This alternative would be acceptable only if it is demonstrated that the contamination at the site is below the remedial action objectives or that natural processes will reduce the contamination to acceptable levels. This alternative does not include institutional controls or monitoring.

4.2 Alternative 2: Institutional Controls/Long-term Monitoring

To prevent future exposure to contaminated groundwater, this alternative calls for implementing restrictions on the use of and access to groundwater at the AOC 9 area. Groundwater use restrictions would include deed restrictions to prevent future use of the groundwater. Deed restrictions would be filed to control future use/activities at the site. This alternative will not actively reduce contaminant concentrations. However, because groundwater in the vicinity of the site is not used as a drinking water source, this alternative is effective in preventing exposure to groundwater contaminants.

4.3 Alternative 3: In situ Chemical Oxidation

Bench-scale tests and a pilot study were performed at this site in 2002 and 2003 using in situ chemical oxidation technology, with results indicating effective reduction of the mass of site contamination. This alternative consists of installation of temporary injection wells strategically placed in and/or near the highest concentrations of contaminants found along the plume in an effort to reduce contaminant mass. Long-term monitoring would also be performed to monitor site contaminant levels. This alternative actively provides contaminant reduction through in situ treatment of site-contaminated groundwater.

4.4 Alternative 4: In situ Air Sparging/Soil Vapor Extraction (AS/SVE)

Because effective treatment of contaminants by air sparging relies greatly on site-specific conditions, an on-site pilot study would be performed before full-scale implementation of this technology at AOC 9. Based on favorable site conditions for this technology resulting from the pilot study, this alternative would consist of the installation of air sparging injection wells and vapor extraction wells. Both types of wells will be placed along the plume at locations in and/or near the highest concentrations of contaminants in an effort to reduce contaminant mass. As site contaminants volatilize from the saturated to the unsaturated zone, vapors would be collected through the vapor extraction wells, filtered through a carbon treatment system, and then discharged to the ambient air. An air pollution control system will be included as part of the treatment system to ensure that air emissions meet regulatory criteria before discharge to the atmosphere. Long-term monitoring would also be performed to monitor site contaminant levels. This alternative is effective in preventing exposure to groundwater contaminants as well as actively providing contaminant reduction through treatment of contaminated groundwater.

4.5 Alternative 5: Extraction, Treatment, and Disposal

This alternative consists of the installation of a collection trench perpendicular to the flow of the plume to allow for the extraction of site-contaminated groundwater. The groundwater will then be treated by a carbon treatment system and discharged to the nearby Six Mile Creek. Long-term monitoring would also be included in this alternative to monitor site contaminant levels. This alternative actively provides contaminant reduction through treatment of contaminated groundwater.

4.6 Alternative 6: Constructed Treatment Wetland

A bench scale pilot study would be performed before full-scale implementation of a constructed treatment wetland at AOC 9. If positive results are obtained, implementation of this alternative would consist of the construction of a treatment wetland in the downgradient portion of the plume, along Six Mile Creek. Aerobic and anaerobic processes within the wetland are expected to degrade site contaminants. Institutional controls and long-term monitoring would also be included in this alternative to control access to the wetland and monitor site contaminant levels. This alternative is effective in preventing exposure to groundwater contaminants as well as in actively providing contaminant reduction through the treatment of contaminated groundwater.

5

Detailed Analysis of Alternatives

5.1 Alternative 1: No Action

5.1.1 Description

This No Action alternative is presented in accordance with the NCP as a baseline for comparison with other alternatives. This alternative does not include remedial action, institutional or engineering controls, or long-term monitoring.

5.1.2 Evaluation of Criteria

Overall Protection of Human Health and the Environment

This alternative is not protective of human health or the environment. Under existing site conditions, there are currently no on-site human or environmental receptors in direct contact with overburden groundwater contamination. However, site groundwater discharges to the surface in certain areas and to Six Mile Creek, allowing the potential for exposure to site contaminants by site visitors. By not performing remedial actions or providing protection to human health and the environment, groundwater contamination exceeding regulatory standards will remain in place and be available for potential future exposure.

Compliance with Applicable Standards, Criteria, and Guidelines

Because no action will be taken, this alternative does not comply with ARARs for site COCs, and RAOs would not be achieved. Contaminated groundwater and/or vapors from volatile groundwater contaminants can diffuse to the surface, where they may be released to ambient air.

Long-term Effectiveness and Performance

Because this alternative does not involve the removal or treatment of contaminated groundwater, the contamination, the risks associated with potential groundwater use, and the migration of contaminants in groundwater will remain essentially the same. This alternative is therefore not effective in the long-term.

Reduction in Toxicity, Mobility, or Volume through Treatment

This alternative does not involve removal or treatment of contaminated groundwater, and therefore the toxicity, mobility, and volume of contamination will not be reduced.

Short-term Effectiveness

No short-term impacts are anticipated during implementation of this alternative since no groundwater removal or treatment activities are involved with the alternative.

Implementability

There are no actions to implement under this alternative.

Costs

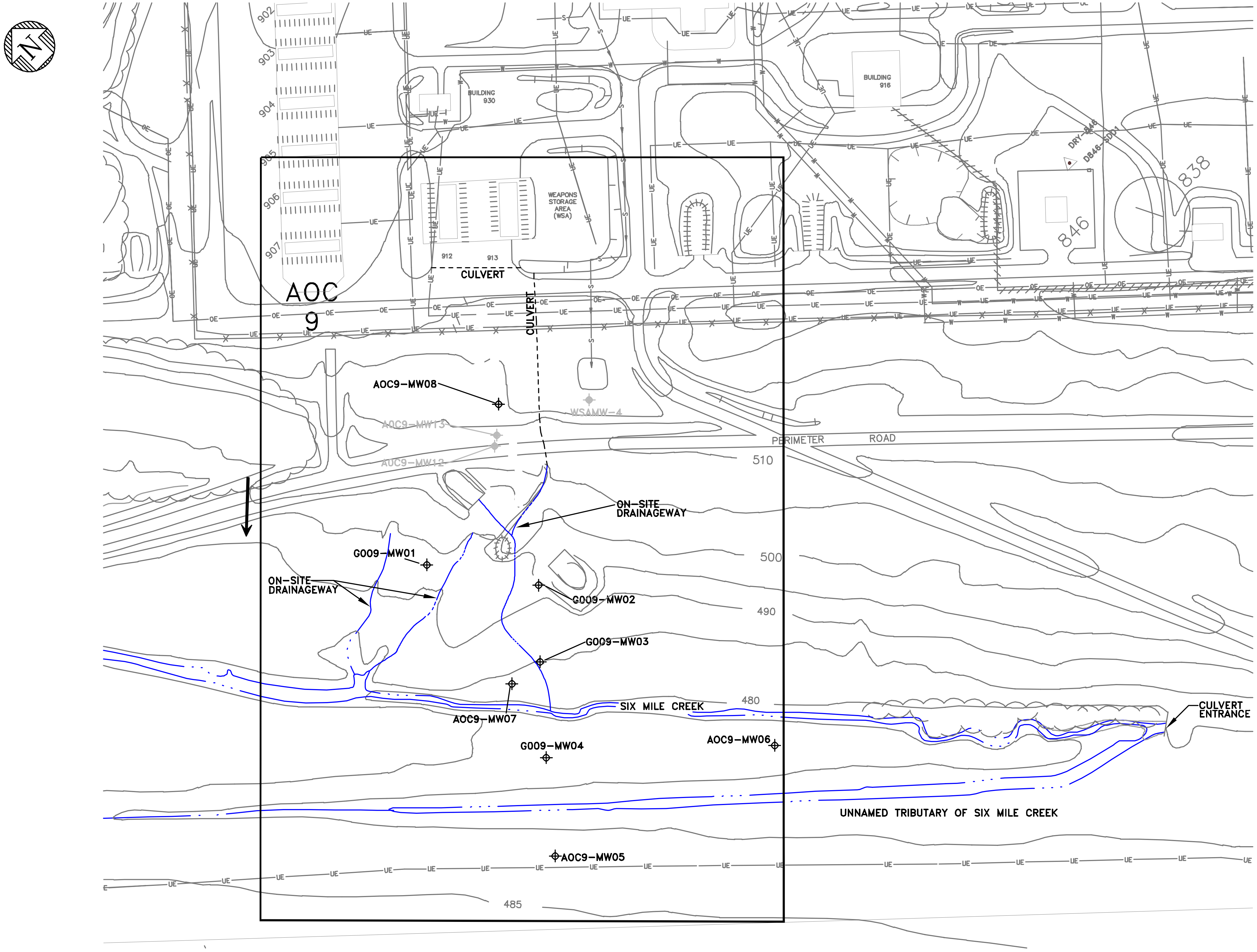
There are no costs associated with this alternative.

5.2 Alternative 2: Institutional Controls/Long-term Monitoring

5.2.1 Description

Institutional controls such as access/use and deed restrictions would control excavation work that could result in encountering on-site groundwater. A long-term monitoring program will be implemented at the site to evaluate the extent of contamination migration and attenuation.

These controls are considered effective in minimizing the potential for direct contact with on-site contaminated groundwater. Bi-annual groundwater monitoring of eight of the existing on-site groundwater monitoring wells would be part of the long-term groundwater monitoring program. G009-MW01, G009-MW02, G009-MW03, G009-MW04, AOC9-MW05, AOC9-MW06, AOC9-MW07, and AOC9-MW08 would be monitored for an assumed duration of 30 years (see Figure 5-1). As concluded in the *Final AOC 9 Bedrock Groundwater Study* (E & E December 2002), vertical migration of site contaminants does not appear to extend to site bedrock, and since no modifications to site stratigraphy are expected, only overburden groundwater monitoring wells will be included in the long-term monitoring program. Groundwater samples would be analyzed for VOCs using method SW8260B. It is assumed routine O&M would be required on the monitoring wells.



LEGEND

EXISTING GROUNDWATER MONITORING WELL

GROUNDWATER MONITORING WELL TO BE INCLUDED IN LONG-TERM MONITORING PROGRAM

DIRECTION OF GROUNDWATER FLOW

SCALE IN FEET
0 100 200 300

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FIGURE 5-1 ALTERNATIVE 2
INSTITUTIONAL CONTROLS AND
LONG-TERM MONITORING
AOC9 FORMER GRIFFISS AFB
ROME, NEW YORK

5.2.2 Evaluation of Criteria

Overall Protection of Human Health and the Environment

Because this alternative includes placement of institutional controls (i.e., deed restrictions) that would restrict and prevent future uses and exposures, it is protective of human health and the environment. Under existing conditions, the HHRA and ERA concluded that there are currently no on-site human and only limited environmental receptors. There are no additional environmental receptors anticipated in the foreseeable future. Although this alternative would be protective of human health and the environment on-site, the plume is expected to continue to discharge into Six Mile Creek where there would be a continued potential for exposure.

Compliance with Applicable Standards, Criteria, and Guidelines

Because no action will be taken, this alternative does not comply with ARARs for site COCs, and RAOs would not be achieved. Contaminated groundwater and/or vapors from volatile groundwater contaminants can diffuse to the surface, where they may be released to ambient air.

Long-term Effectiveness and Performance

Although groundwater contamination will remain on-site, institutional controls, if properly maintained, are an effective mechanism to prevent future exposure to contaminated groundwater. Because municipal water is available in this area and there are no plans for future development at the site, this alternative would be effective in the long-term.

Reduction in Toxicity, Mobility, or Volume through Treatment

This alternative does not involve removal or treatment of contaminated groundwater, and therefore the toxicity, mobility, and volume of contamination will not be reduced.

Short-term Effectiveness

No short-term impacts are anticipated during implementation of this alternative, since no groundwater treatment activities are involved with the alternative. In addition, no new monitoring wells will be installed to implement the long-term monitoring program.

Implementability

This alternative is readily implemented using standard groundwater monitoring methods. Furthermore, all wells proposed for the monitoring program exist on-site.

Costs

The total present worth cost of this alternative based on a 30-year period at a discount rate of 3.2% is $510,000. Table 5-1 presents the quantities, unit costs, and subtotal for the various work items in this alternative. Annual groundwater monitoring costs and renewal of institutional controls were assumed for this alternative.

5.3 Alternative 3: In situ Chemical Oxidation

5.3.1 Description

This alternative involves the delivery of a strong oxidizing agent into the subsurface through temporary injection points (i.e., direct push points) to oxidize contaminants of concern to non-toxic compounds. In addition, institutional controls, including long-term monitoring of groundwater, would be placed to minimize the potential for future exposure to contaminated groundwater until it had reached cleanup goals. During this action there would be continued monitoring of the extent and natural attenuation of the plume.

Between February 2002 and December 2003, bench-scale and pilot studies were performed at the site to assess the effectiveness of this technology in remediating contaminants of concern. Based on the results of the bench-scale study for contaminated soil/groundwater in June 2002, Fenton's reagent was selected as the most effective oxidizing agent. The Fenton's process is based on the application of hydrogen peroxide and an iron catalyst to yield hydroxyl radicals, which act as strong, non-specific oxidizing agents that are capable of degrading a wide variety of compounds. Based on the results of the bench-scale study, a pilot study conducted at the site in two phases in October 2002 and November 2003 targeted an area in the vicinity of AOC9-MW8, where one of the highest VOC concentrations (primarily chlorobenzene [greater than 2,000 µg/L]) has been detected. The results of the bench-scale and pilot studies were presented in the *Final Groundwater Treatability Pilot Study Report* (E & E June 2004) and are summarized below.

Bench-scale tests on groundwater at AOC 9 using potassium permanganate and Fenton's reagent were completed by ISOTEC^{TM} in June 2002 (E & E March 2003). Results from the Fenton-based tests on the site's groundwater indicated a 99.9% destruction of VOCs, while potassium permanganate showed no VOC reduction.

Table 5-1 Alternative 2 - Institutional Controls / Long-term Monitoring, AOC9 Former Griffiss AFB, Rome, NY

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Capital Costs					
Work Plan		LS	1	NA	$8,000
Institutional Controls		Each	1	$2,500.00	$2,500
Subtotal					$10,500
Capital Cost Subtotal:					$10,500
Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924):					$9,702
10% Legal, administrative, engineering fees, construction management:					$970
15% Contingency:					$1,601
Total Capital Cost:					**$13,000**
Annual Costs (30 Years)					
Monitoring					
Monitoring Well Sampling (Labor)	2-persons @ $65/hr, 10hr/day; 8 total wells - assume 2 wells per day, twice per year	Day	8	$1,300.00	$10,400
Sampling Equipment (Rental)	Groundwater level indicator, multi-parameter instrument, twice per year	Day	8	$150.00	$1,200
Parameter Analyses (VOC)	Includes TCL VOCs (Method SW8260B); assume 1 groundwater sample per well for 8 wells, twice per year	Each	16	$200.00	$3,200
Data Evaluation and Reporting		HR	72	$90.00	$6,500
Monitoring Well Maintenance		LS	1	NA	$200
Institutional Controls	Maintain/update documentation	LS	1	NA	$500
Subtotal					$22,000
Annual Cost Subtotal:					$22,000
Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924):					$20,328
10% Legal, administrative, engineering fees:					$2,033
15% Contingency:					$3,354
Annual Cost Total:					**$26,000**
Present Worth of Annual Costs:					**$497,000**
Total Present Worth Cost:					**$510,000**

Assumptions

1. Unit costs obtained from RS Means ECHOS Cost Reference Books were marked up by 30% to account for Contractor O&P (except for analytical analyses).
2. 30-year present worth of costs assumes 3.2% annual interest rate per "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA 540-R-00-002 July 2000) and the Office of Management and Budget Real Discount Rates last updated January 2003 (http://www.whitehouse.gov/OMB/circulars/a094/a094.html).

Abbreviations:

LS = lump sum
LF = linear foot
HR = hour

Groundwater and soil samples used in the bench-scale study were obtained from a borehole near AOC 9-MW8, where the highest chlorobenzene concentration was detected in groundwater. The successful bench-scale results using Fenton's reagent prompted the performance of a field pilot-scale study.

The purpose of the pilot study was to identify and collect data/information needed to assess the potential full-scale application of in situ chemical oxidation at the site. In October 2002, a total of 44 temporary injection points were advanced at the site in six rows perpendicular to the groundwater flow direction in the area just north of Perimeter Road in the vicinity of AOC9-MW08. This area was selected because it exhibited one of the highest concentrations of chlorobenzene at the site. The points were installed to target two saturated intervals: 10 to 15 feet BGS and 15 to 20 feet BGS. The injection points were installed in rows spaced 15 feet apart, with shallow and deep injections points spaced 7.5 feet apart within each row. Injection activities consisted of delivering 17,280 gallons of 12.5% ISOTEC reagents (5,280 gallons of ISOTEC series catalyst 4,260 and 12,000 gallons of oxidizer [hydrogen peroxide]) under low-pressure conditions (15 to 40 psi).

In November 2003, a second injection event occurred in which an additional 44 temporary injection points were advanced in the same general area as the injection event in October 2002. The injection points were installed in eight rows perpendicular to the groundwater flow. These rows were also spaced 15 feet apart, with injection points spaced 7.5 feet apart within each row and injection intervals similar to those installed in October 2002. During the second injection event, approximately 15,840 gallons of 12.5% ISOTEC reagents (5,280 gallons of catalyst and 10,560 gallons of peroxide) were pressure injected in the 44 temporary injector points.

Three groundwater monitoring wells and three piezometers were selected to monitor VOCs, DOC, TAL metals, sulfate, and ferrous iron levels during baseline sampling and one or more of the seven subsequent sampling rounds. Baseline groundwater sampling was conducted in July and October 2002 before injection activities, while the first, second, third, and fourth rounds of post-first injection sampling were conducted at two, four, eight, and twelve weeks respectively. A second baseline sampling round (Round 5) was conducted in November 2003, prior to the second injection event. Two additional sampling rounds were conducted two and four weeks after injection activities occurred (Rounds 6 and 7, respectively).

The results of the pilot study generally indicated a decrease in VOC concentrations from the study area. Overall, 1,2-DCB decreased 10% to 53%, 1,3-DCB decreased 9% to 50%, 1,4-DCB decreased 14% to 49%, and chlorobenzene decreased 5% to 65% from baseline samples to monitoring samples collected eight weeks (i.e., Round 3 samples) after the first injection event. After the second injection event, there was an overall total VOC reduction from baseline conditions (prior to the first injection event) of 99% in wells ACO9-MW12 and -MW13, 86% in AOC9-GP47I, 77% in AOC9-MW8, 38% in AOC0-GP48D1, and 35% in AOC9-GP44S. A comparison between pre- and post-treatment analytical results from the first injection indicated an estimated mass removal of about 5.9 to 10.5 pounds of VOCs (or about 27% to 50% reduction in mass), and the second injection resulted in an estimated mass removal of 17 pounds of VOCs (or about 81% reduction of mass) from baseline conditions (prior to the first injection) from site soil and groundwater (E & E June 2004). In general, the pilot study results indicated that conditions at the site are conducive to treating chlorobenzene and other VOCs and to reducing the mass of contamination at the site.

This alternative assumes a 15-foot spacing in areas with VOC concentrations (using chlorobenzene contour intervals as an indicator) greater than 600 µg/L, and 30-foot spacing otherwise for the injection points based on data and observations made during the pilot study. Injection points would be installed using direct push methodology, which was effective during the pilot study and would be more cost-effective than installing permanent injection wells. Since the plume exhibits localized areas of high contamination, and because the cost of implementing in situ technologies is proportional to the area, a more cost-effective approach involves targeting the areas with high levels of VOC contamination.

This FS assumes full-scale remediation using this technology for the area contained within the 100-µg/L VOC concentrations contour line (estimated by chlorobenzene contour intervals [see Figure 5-2]). Completely remediating this area is expected to remove 99% of the contaminant mass and approximately 28% (or 2.3 acres) of the plume area (see Table 5-2). Although biological activity would be reduced in those areas directly affected by Fenton's reagent, contaminant concentrations remaining on site above ARARs after injection event(s) have occurred are expected to attenuate naturally (by biological and other processes). Contaminated areas outside the treatment area are expected to attenuate naturally overtime.

Table 5-2 Comparison of Contaminant Mass per Depth to Areas Described by Different Intervals of Contaminant Concentration at AOC 9

Contour Interval (µg/L)	Lower Bound Concentration of Contour Interval (µg/L)	Area of Contour Interval (ft2)	Cumulative Percent Area of Contour Interval Compared to Entire Plume Area (%)	Mass of Contaminants per Foot Within Interval (lb/ft) (lower bound concentration multiplied by incremental contour interval area)	Cumulative Percentage of Total Mass of Contaminants Per Depth (%)
>2000	2000	4,200	1.1	0.52	19.9
1000-2000	1000	2,705	1.9	0.17	26.3
800-1000	800	7,156	3.8	0.36	39.8
600-800	600	17,143	8.5	0.64	64.2
400-600	400	17,449	13.3	0.44	80.7
200-400	200	24,522	20.0	0.31	92.3
100-200	100	27,175	27.4	0.17	98.7
5-100	5	106,814	56.5	0.03	100.0
ND-5	ND	159,476	100.0	—	—
Total		**366,639**			

Note: Contour interval areas determined by E & E and AutoCAD file associated with Figure 2-2 of this report.

The number of temporary injection points required to effectively cover this area is approximately 352. For the area north of Perimeter Road, where VOC concentrations are greater than 600 µg/L and vertically distributed over a 20-foot interval, temporary injection points will be installed to target two saturated intervals similar to the pilot study. For areas south of Perimeter Road and areas with VOC concentrations between 100 µg/L and 600 µg/L north of Perimeter Road, injection points will target one interval containing the highest VOC concentration levels. Field parameters such as oxidation-reduction potential (ORP), conductivity, and water levels will be collected during the injection activities to assess reagent distribution in the subsurface. In addition, groundwater samples from selected monitoring points within the injection area will be analyzed using field test kits for iron and hydrogen peroxide to assess the distribution of the oxidant in the subsurface.

For purposes of costing this alternative, two primary injection events and one secondary event were assumed. The secondary injection event is intended as a polishing step to target areas where contaminant concentrations and mass were not reduced to acceptable levels. The primary and secondary injection events are assumed to occur within approximately one year.

Due to the observed upward gradient groundwater flow near Six Mile Creek and in order to eliminate the potential for oxidizing agents or contaminants to migrate off-site when injecting near the downgradient edge of the plume, a section of Six Mile Creek will be diverted around the proposed injection area as shown in Figure 5-2. A series of three 1-inch-diameter piezometers will be installed downgradient of the diverted creek section to monitor for downgradient migration of oxidizing agents or contaminants. If such migration is observed, injection activities would be modified (e.g., installing additional injection points with a smaller volume of reagents and reducing injection pressures). In the unlikely event of downgradient migration of VOCs due to desorption of contaminants from the solid phase (associated with oxidizing organic carbon of the soil and shift in equilibrium partitioning), hydrogen peroxide would be injected into the downgradient monitoring wells, effectively creating an in situ treatment wall.

Monitoring of plume treatment during full-scale implementation would be performed from four existing monitoring wells (G009-MW03, AOC9-MW07, AOC9-MW08 and AOC9-MW12), two existing 1-inch piezometers (AOC9-GP44 and AOC9-GP48), two new 2-inch monitoring wells, and from 13 new 1-inch piezometers, as shown in Figure 5-2. Baseline sampling and three rounds of monitoring sampling were assumed for this alternative for the first year. Each sampling event would consist of VOC analysis from the 21 monitoring locations. In addition, metals and dissolved organic carbon samples will be collected from six of the monitoring well/piezometers.

For purposes of this FS, institutional controls and a long-term monitoring program will be implemented similar to that described in Alternative 2. Because this alternative involves active treatment, the majority of contaminant mass will be destroyed, and residual contamination will remain, maintenance of institutional controls and the long-term monitoring program was assumed for 10 years. However, if contaminants of concern remain above proposed concentrations cleanup goals after the assumed 10-year period, additional monitoring should be considered.

5.3.2 Evaluation of Criteria

Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment as in situ chemical oxidation would destroy contaminants of concern in groundwater. This alternative would also minimize potential exposure to groundwater from on-site drainageways and Six Mile Creek where site groundwater discharges to the surface/creek as the creek will be diverted.

Compliance with Applicable Standards, Criteria, and Guidelines

Through destruction of site contaminants via chemical oxidation, concentrations in the saturated zone would be reduced; however, chemical-specific ARARs would not be met immediately. However, by focusing on treatment of the most contaminated portion of the plume defined by the 100 µg/L chlorobenzene contaminant contour interval, this alternative is expected to remove approximately 99% of the contaminant mass. Some areas with contaminant concentrations between 5 and 100 µg/L would remain; however, these would represent less than 1% of the original contaminant mass and are expected to naturally attenuate to ARARs over time.

Long-term Effectiveness and Performance

Because 99% of the contaminants would be permanently destroyed, this alternative is effective in the long-term. Furthermore, institutional controls are effective mechanisms in preventing potential exposure to residual (approximately 1%) contaminated groundwater. Data collection and evaluation will be used to illustrate the performance of this alternative.

Reduction in Toxicity, Mobility, or Volume through Treatment

This alternative employs chemical oxidation to destroy the contaminants of concern, thus resulting in a reduction of toxicity, mobility, and volume through treatment.

Short-term Effectiveness

Implementation of this alternative would require the installation of approximately 352 injection points in the plume. In addition, fifteen new 1-inch piezometers will be installed for the long-term monitoring program. Considering that AOC 9 is an open, vacant area, short-term impacts to install these wells and to inject the reagent (two primary and one secondary injection) would be minor.

The duration of the piezometer construction and injection activities mentioned above would be completed within approximately six to eight months. The long-term monitoring program would occur over an assumed ten-year period.

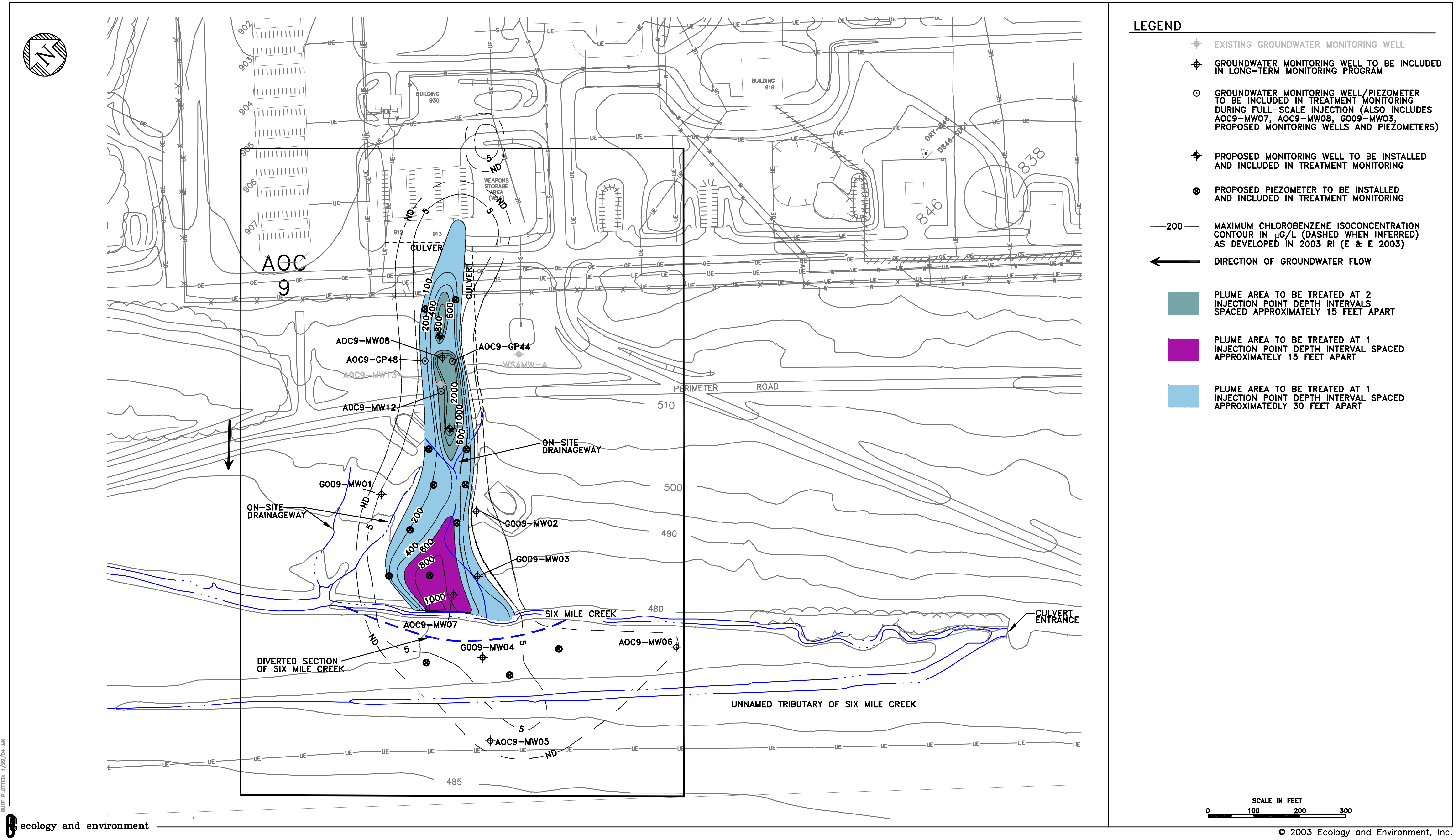

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FIGURE 5-2 ALTERNATIVE 3
IN-SITU CHEMICAL OXIDATION
AOC9 FORMER GRIFFISS AFB
ROME, NEW YORK

Implementability

This alternative is readily implemented using standard construction means and methods. Since a chemical oxidation pilot study has already been performed at the site, there is a better understanding of the physical (topography and stratigraphy) and chemical (type and amount of reagent) requirements necessary to treat the contaminants of concern at this site.

Costs

The total present-worth cost of this alternative based on a ten-year period at a discount rate of 2.5% is $2,149,000, including capital and O&M costs. Table 5-3 presents the quantities, unit costs, and subtotal for the various work items in this alternative. It was assumed that the injection points during full-scale implementation would be temporary-type wells installed using direct push. Institutional controls and annual groundwater monitoring costs were assumed for ten years.

5.4 Alternative 4: In situ Air Sparging/Soil Vapor Extraction (AS/SVE)

5.4.1 Description

This alternative would be designed to remove contaminants of concern by injecting air through injection wells into the saturated zone, volatilizing contaminants from the liquid phase to the vapor phase and thereby allowing removal of contaminants in the vadose zone. In addition, institutional controls, including long-term monitoring of groundwater, would be placed to minimize the potential for future exposure to contaminated groundwater and to monitor the extent of migration or natural attenuation of the plume. Because the success of this alternative depends greatly on the heterogeneity of the soil, site-specific characteristics, including the air flow rate and radius of influence of the injection wells, must be determined before full-scale treatment. Therefore, an on-site pilot study is recommended.

The pilot study would consist of one injection well, one soil vapor extraction well, several vapor probes, blowers for the air sparging and vapor extraction, and activated carbon to treat the off-gases. The wells would be located in an area where average contaminant concentrations have been detected because testing in areas of low concentrations may not provide sufficient data and testing in areas of high concentrations may induce migration of contaminants. Once the system has been set up, the system would run for several days, and groundwater and soil vapor samples would be collected. Potential fouling issues identified during the study would be taken into consideration for full-scale treatment recommendations. It is

Table 5-3 Alternative 3 - In Situ Chemical Oxidation, AOC9 Former Griffiss AFB, Rome, NY

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Capital Costs					
Work Plan / Final Report	Includes submittals, reporting, meetings	LS	1	NA	$75,000
Institutional Controls	Includes deed restrictions	Each	1	$2,500.00	$2,500
Subtotal					$77,500
Health and Safety					
Construct Decontamination Pad & Containment	For equipment & personnel	Setups	2	$2,000.00	$4,000
Air Monitoring	Organic Vapor Analyzer (4 units)	months	6	$4,000.00	$24,000
Health and Safety Plan and Management	Includes development of plan and medical surveillance of on-site personnel	LS	1	NA	$10,000
Site Safety Officer	10 hrs/day, 5days/wk, $65/hr	manweeks	24	$3,250.00	$78,000
Personal Protective Equipment	Includes coveralls, hard hats, safety glasses, reusable boots, gloves	LS	1	NA	$2,500
Subtotal					$118,500
Site Preparation					
Fencing	Temporary fence for on-site storage; includes installation	LF	500	$3.71	$1,900
Subtotal					$1,900
Diversion of Six Mile Creek					
Excavate Diversion Trench	Assume similar cross section of existing Six Mile Creek: 3 foot depth, 10 foot width for approx 375 foot length; excavated soil to be used as fill for portion of creek to be cut-off; 1/2 CY tractor loader/backhoe	BCY	420	$4.85	$2,100
Backfill Existing Six Mile Creek	75 HP Front End Loader with 50 foot haul; 2-man Crew (B-10L)	Day	1	$1,000.00	$1,000
Compaction	Vibrating Roller, 2 feet wide, 6-inch lifts, 2 passes	BCY	420	$1.51	$700
Subtotal					$3,800
Full-Scale Implementation					
Geoprobe Installation					
Mobilization/Demobilization (Geoprobes)		LS	1	$3,500.00	$3,500
Additional Drilling Equipment	Screen attachment for Geoprobe drill rod	LS	1	$2,000.00	$2,000
Installation of Injection Points, Primary Injection #1	Assume Geoprobe injection points to max depth of 22 ft BGS	Each	352	$150.00	$52,800
Installation of Injection Points, Primary Injection #2	Assume Geoprobe injection points to max depth of 22 ft BGS	Each	352	$150.00	$52,800
Installation of Injection Points, Secondary Injection	Assume Geoprobe injection points to max depth of 22 ft BGS, approx 65% of original injections point locations	Each	230	$150.00	$34,500
Chemical Oxidation Injection					
In Situ Chemical Oxidation Treatment, Primary Injection #1	Includes ISOTEC prep fee, mob/demob of ISOTEC labor, equipment, and reagents to site for injection treatment, and monitoring of field parameters	Each	352	$764.00	$269,000
In Situ Chemical Oxidation Treatment, Primary Injection #2	Includes ISOTEC prep fee, mob/demob of ISOTEC labor, equipment, and reagents to site for injection treatment, and monitoring of field parameters	Each	352	$764.00	$269,000
In Situ Chemical Oxidation Treatment, Secondary Injection	Includes ISOTEC prep fee, mob/demob of ISOTEC labor, equipment, and reagents to site for injection treatment, and monitoring of field parameters	Each	230	$813.00	$187,000
Oversight	Installation of injection points approx 15 per day, primary injection treatments approx 8 weeks each, secondary injection treatment approx 4 weeks; assume 2-persons @ $65/hr, 5days/week, 8hr/day	Day	320	$1,040.00	$332,800
Monitoring Equipment (Rental)	5 total multi-parameter instruments (pH, OR, conductivity, temperature, dissolved oxygen, turbidity) for wells and piezometers	Month	5	$6,415.00	$32,100
Generator Rental	Diesel generator, 20 KW; includes operating costs	Month	5	$1,665.00	$8,400
Water Truck	Assume 2 trucks; 6,000 gallon capacity; includes operating costs	Month	5	$14,330.00	$71,700
Subtotal					$1,315,600

Table 5-3 Alternative 3 - In Situ Chemical Oxidation, AOC9 Former Griffiss AFB, Rome, NY

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Full-Scale Monitoring					
Well Installation					
Mobilization/Demobilization (Piezometers)		LS	1	$1,000.00	$1,000
Installation of Piezometers	Assume 13 total 1-inch overburden wells (10 in plume and 3 downgradient of diverted Six Mile Creek), max depth of 22 feet; includes drilling and well construction	Each	13	$200.00	$2,600
Installation of Monitoring Wells	Assume two 2-inch overburden monitoring wells in plume, max depth of 22 feet; includes drilling and well construction	Each	2	$700.00	$1,400
Treatment Monitoring					
Groundwater Sampling (Labor)	2-person @ $65/hr, 10hr/day; 21 total wells - assume 2 wells per day, 4 sampling rounds	Day	42	$1,300.00	$54,600
Groundwater Sampling (Equipment)	Groundwater level indicator, multi-parameter instrument, low-flow pump	Day	42	$200.00	$8,400
Parameter Analyses (VOC)	Includes TCL VOCs (Method SW8260B); assume 1 groundwater sample per well/piezometer for 21 wells for 4 sampling rounds	Each	84	$200.00	$16,800
Parameter Analyses (Metals and DOC)	Includes TAL Metals and DOC; assume 1 groundwater sample per well/piezometer for 6 wells for 4 sampling rounds	Each	24	$340.00	$8,200
Data Evaluation and Reporting		HR	120	$90.00	$10,800
Subtotal					$103,800
Capital Cost Subtotal:					$1,621,100
Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924):					$1,497,896
10% Legal, administrative, engineering fees, construction management:					$149,790
15% Contingency:					$247,153
Total Capital Cost:					**$1,895,000**
Annual Costs (Years 1 through 10)					
Monitoring					
Groundwater Sampling (Labor)	2-person @ $65/hr, 10hr/day; 8 total wells - assume 2 wells per day, twice per year	Day	8	$1,300.00	$10,400
Groundwater Sampling (Equipment)	Groundwater level indicator, multi-parameter instrument, twice per year	Day	8	$150.00	$1,200
Parameter Analyses (VOC)	Includes TCL VOCs (Method SW8260B); assume 1 groundwater sample per well for 8 wells, twice per year	Each	16	$200.00	$3,200
Data Evaluation and Reporting		HR	96	$90.00	$8,700
Monitoring Well Maintenance		LS	1	NA	$200
Institutional Controls	Maintain/update documentation	LS	1	NA	$500
Subtotal					$24,200
Annual Cost Subtotal:					$24,200
Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924):					$22,361
10% Legal, administrative, engineering fees:					$2,236
15% Contingency:					$3,690
Annual Cost Total:					**$29,000**
Present Worth of Annual Costs:					**$254,000**
Total Present Worth Cost:					**$2,149,000**

Assumptions

1. Assume no site clearing necessary.
2. Assume long-term monitoring will be required for the first 10 years only.
3. Unit costs obtained from RS Means ECHOS Cost Reference Books were marked up by 30% to account for Contractor O&P (except for analytical analyses).
4. 10-year present worth of costs assumes 2.5% annual interest rate per "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA 540-R-00-002 July 2000) and the Office of Management and Budget Real Discount Rates last updated January 2003 (http://www.whitehouse.gov/OMB/circulars/a094/a094.html).

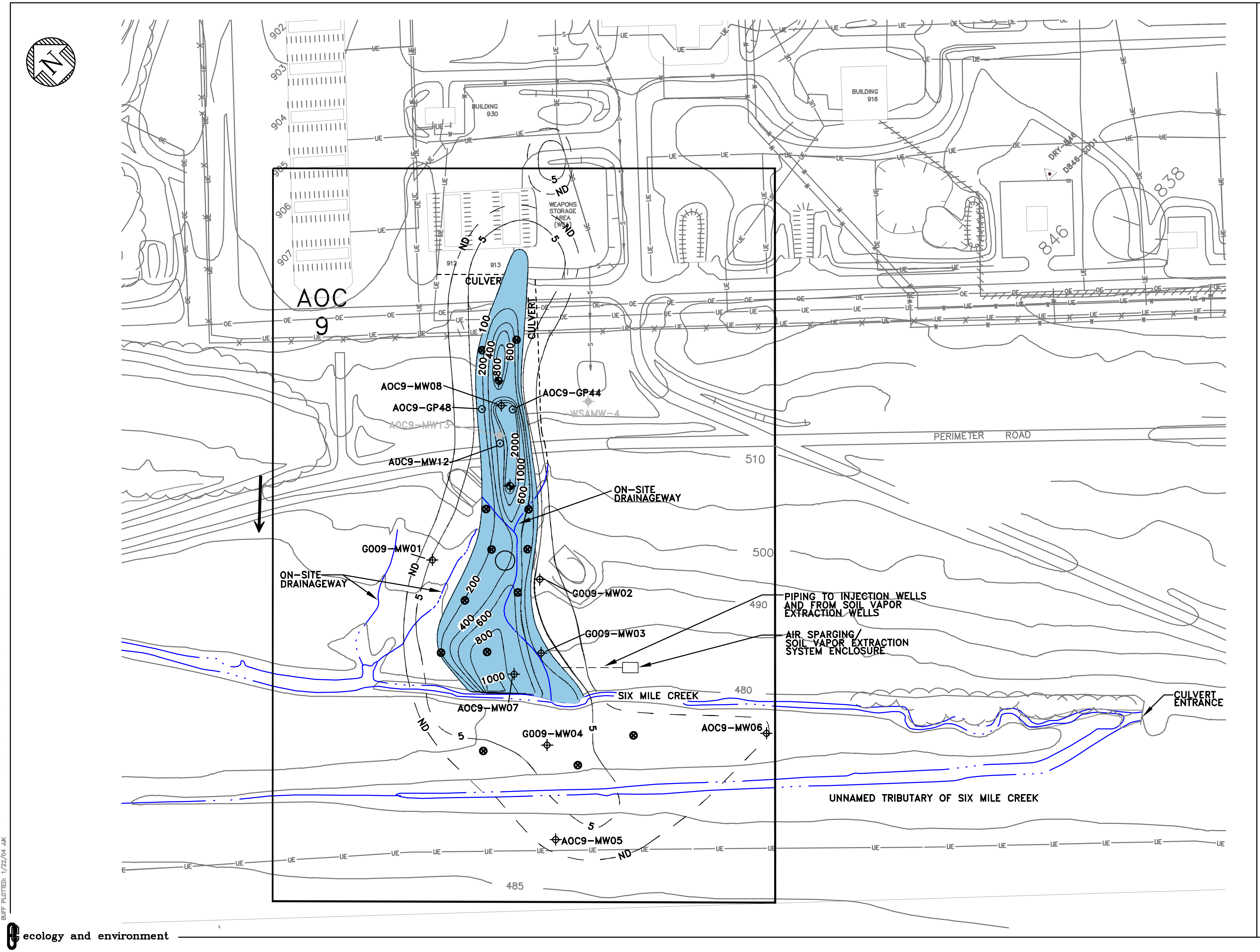
Abbreviations:

BCY = bank cubic yards
HR = hour
LCY = loose cubic yards
LS = lump sum
LF = linear foot
SY = square yard

anticipated the pilot study and associated tasks (including reports) would take less than three months to complete. Because AOC 9 is a large, open area with minimal human presence, it may be possible to eliminate the vapor extraction component of this alternative and release the vapors to the ambient air. However, this is subject to regulatory review and acceptance. For costing purposes, the vapor extraction component has been included.

Upon successful results from the pilot study, a full-scale, on-site AS/SVE treatment system will be installed. The system would consist of a series of strategically placed injection wells throughout the plume, air compressors or blowers to supply injection air and collect vapors, and monitoring sensors and equipment, as shown in Figure 5-3. Similar to Alternative 3, full-scale remediation of this technology was assumed for the area contained within the 100 μg/L VOC concentrations contour line (estimated by chlorobenzene contour intervals [see Figure 5-3]). Remediating this area is expected to remove 99% of the contaminant mass and approximately 28% (or 2.3 acres) of the plume area (see Table 5-2). Contaminant concentrations remaining on-site above ARARs after the remediation duration would likely attenuate naturally over time.

Assuming an average radius of influence of 20 feet, approximately 320 one-inch injection wells would be installed in a triangular pattern, using direct push. A 2-foot screen per well will be installed to begin at approximately 5 feet below the target treatment area (approximately located in the middle of the groundwater column, the depth of which varies across the site). It is expected air will be injected at a flow-rate ranging from 5 to 10 cfm (cubic feet per minute) per injection well (to be further defined by the pilot study). Assuming a 30-foot radius of influence for the vapor extraction wells, approximately 145 two-inch wells would be installed. These wells will be screened above the seasonably high water table (less than 4 feet below ground surface near Six Mile Creek and less than 9.5 feet below ground surface, based on groundwater data obtained in May 2000 and July 2002 from the 2004 RI) to avoid flooding of the wells. Soil vapors would be extracted and treated through activated carbon at approximately two to three times the air injection flow-rate per injection well. A process diagram for the described AS/SVE system is shown in Figure 5-4. Piping that connects the compressors and blowers to the injection and SVE wells is assumed to be underground. The compressors, blowers, carbon, and controls for the AS/SVE system will be housed in a pre-fabricated housing structure to protect them from the climate and reduce noise during operation. The system will operate 24 hours per day, year-round for an assumed treatment period of five years. Electric



LEGEND

⊕	EXISTING GROUNDWATER MONITORING WELL
⊕	GROUNDWATER MONITORING WELL TO BE INCLUDED IN LONG-TERM MONITORING PROGRAM
⊙	GROUNDWATER MONITORING WELL/PIEZOMETER TO BE INCLUDED IN TREATMENT MONITORING DURING FULL-SCALE REMEDIATION (ALSO INCLUDES AOC9-MW07, AOC9-MW08, G009-MW03, PROPOSED MONITORING WELLS AND PIEZOMETERS)
⊕	PROPOSED MONITORING WELL TO BE INSTALLED AND INCLUDED IN TREATMENT MONITORING
⊗	PROPOSED PIEZOMETER TO BE INSTALLED AND INCLUDED IN TREATMENT MONITORING
—200—	MAXIMUM CHLOROBENZENE ISOCONCENTRATION CONTOUR IN μG/L (DASHED WHEN INFERRED) AS DEVELOPED IN 2003 RI (E & E 2003)
←	DIRECTION OF GROUNDWATER FLOW
🟦	PLUME AREA TO BE TREATED WITH INJECTION AND SOIL VAPOR EXTACTION WELLS SPACED 20 AND 30 FEET APART, RESPECTIVELY

SCALE IN FEET

0 100 200 300

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FIGURE 5-3 ALTERNATIVE 4
AIR SPARGING/SOIL
VAPOR EXTRACTION
AOC9 FORMER GRIFFISS AFB
ROME, NEW YORK

service would be provided to the system from the existing overhead power source north of Perimeter Road. E & E assumed that sufficient capacity is available from the existing service lines to feed the treatment building. Temperature control would be provided inside the enclosure to prevent system components from freezing. Any external piping would be heat-traced and insulated to prevent freezing.

This preliminary design must be re-evaluated upon successful results of the pilot study to ensure accuracy of the design and to refine remedial costs. It is presented as a typical design for the type of groundwater contamination found at AOC 9 and serves as a basis for conceptual cost estimating.

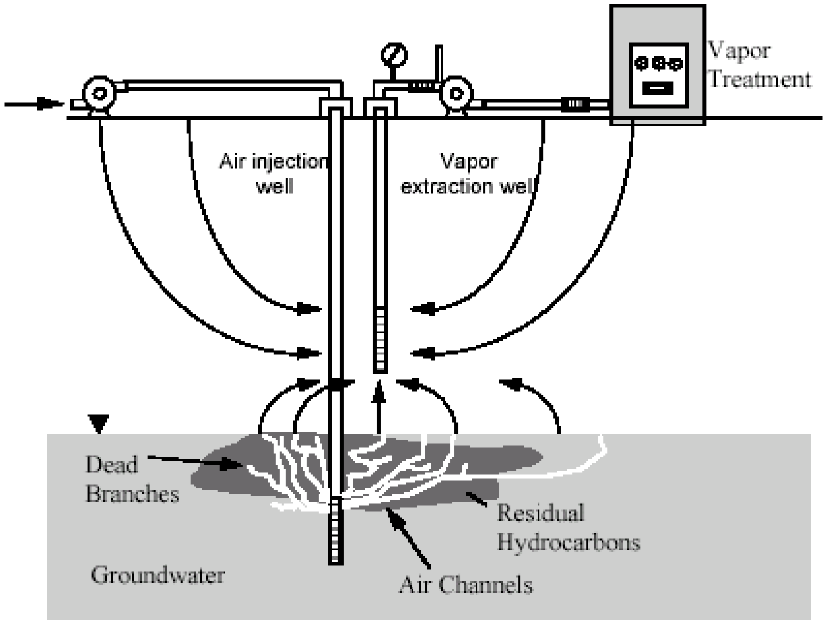


Figure 5-4 **Conceptual Design of Air Sparging/Soil Vapor Extraction System (Source: Leeson, et al., August 2002)**

Monitoring of plume treatment during full-scale implementation would be performed from four existing monitoring wells (G009-MW03, AOC9-MW07, AOC9-MW08 and AOC9-MW12), two existing 1-inch piezometers (AOC9-GP44 and AOC9-GP48), two new 2-inch monitoring wells, and from 13 new 1-inch piezometers (ten within the plume and three downgradient of Six Mile Creek), as shown in Figure 5-3. Sampling would be conducted quarterly over the assumed five years of operation of the system and reduced to annual sampling events thereafter. Groundwater samples would be analyzed for VOCs from the 21 monitoring locations and soil vapor (VOCs) from the effluent of the SVE system.

For purposes of this FS, institutional controls and a long-term monitoring program would be implemented similar to that described in Alternative 2. Because this alternative involves active treatment, the majority of contaminant mass will be removed, and residual contamination will remain, maintenance of institutional controls and the long-term monitoring program was assumed for 10 years. However, if concentrations of contaminants of concern remain above cleanup goals after the assumed 10-year period, additional monitoring should be considered.

5.4.2 Evaluation of Criteria

Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment because air sparging would remove contaminants of concern in groundwater. This alternative would also minimize potential exposure because the placement of institutional controls (deed restrictions) would restrict and prevent future uses of and exposures to contaminated site groundwater and therefore would be protective of human health and the environment.

Compliance with Applicable Standards, Criteria, and Guidelines

Through removal of site contaminants via air sparging, concentrations in the saturated zone would be reduced. However, chemical-specific ARARs would not be met immediately. By focusing on treatment of the most contaminated portion of the plume defined by the 100 μg/L chlorobenzene contaminant contour interval, this alternative is expected to remove approximately 99% of the contaminant mass. Some areas with contaminant concentrations between 5 and 100 μg/L would remain; however, these would represent less than 1% of the original contaminant mass and are expected to naturally attenuate to within ARARs over time.

Long-term Effectiveness and Performance

Because 99% of the contaminants would be permanently removed, this alternative is effective in the long-term. Furthermore, institutional controls are effective mechanisms for preventing potential exposure to residual (approximately 1%) contaminated groundwater. Data collection and evaluation will be used to illustrate the performance of this alternative.

Reduction in Toxicity, Mobility, or Volume through Treatment

Through implementation of this alternative, contaminants of concern would be removed from the groundwater and captured on activated carbon, which would then be sent for treatment and disposal at a permitted facility, thereby reducing toxicity, mobility, and volume through treatment.

Short-term Effectiveness

Implementation of this alternative would require the installation of approximately 320 injection and 145 soil vapor extraction wells in the plume. In addition, fifteen new 1-inch piezometers would be installed for the long-term monitoring program. Because AOC 9 is an open, vacant area, short-term impacts from installing these wells would be minor.

The duration of the well construction above would be completed within approximately 1 to 2 months. Operation and maintenance of the AS/SVE system was assumed to be five years. The long-term monitoring program would occur over an assumed 10-year period.

Implementability

This alternative is readily implemented using standard construction means and methods because air sparging is an established technology. However, further refining of this analysis using results from a pilot study would be required before selection of this alternative. No delay is anticipated in obtaining appropriate air quality permits from state and/or local agencies, if necessary.

Costs

The total present-worth cost of this alternative based on a 15-year period (first 5 years of treatment followed by 10 years of monitoring) at a discount rate of 2.675% is $2,099,000. Table 5-4 presents the quantities, unit costs, and subtotal for the various work items in this alternative. Considerable O&M activities associated with the AS/SVE and carbon treatment system are anticipated with this alternative, resulting in significant annual costs. O&M and treatment monitoring costs were assumed for five years, while institutional controls and annual groundwater monitoring costs were assumed for ten years.

For comparison purposes, costs were developed assuming that regulatory review deemed that SVE would be unnecessary. The design and process of the AS system would be the same; however, the SVE and associated components were eliminated. The total

Table 5-4 Alternative 4 - Air Soil/Soil Vapor Extraction, AOC9 Former Griffiss AFB, Rome, NY

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Capital Costs					
Work Plan / Final Report	Includes submittals, reporting, meetings	LS	1	NA	$75,000
Pilot Study	Includes labor, equipment, and materials for the conceptual design, installation of sparge, soil vapor extraction, and monitoring wells, sampling, analytical, observation, documentation, and reports	LS	1	NA	$35,000
Permit Equivalency	State/federal review process for treatment system; may require application and maintenance of an air quality permit equivalency	LS	1	NA	$5,000
Institutional Controls	Includes deed restrictions	Each	1	$2,500.00	$2,500
Subtotal					$117,500
Health and Safety					
Construct Decontamination Pad & Containment	For equipment & personnel	Setups	2	$2,000.00	$4,000
Air Monitoring	Organic Vapor Analyzer (4 units)	months	3	$4,000.00	$12,000
Health and Safety Plan and Management	Includes development of plan and medical surveillance of on-site personnel	LS	1	NA	$10,000
Site Safety Officer	10 hrs/day, 5days/wk, $65/hr	manweeks	12	$3,250.00	$39,000
Personal Protective Equipment	Includes coveralls, hard hats, safety glasses, reusable boots, gloves	LS	1	NA	$2,500
Subtotal					$67,500
Full-Scale Implementation					
Well Installation					
Mobilization/Demobilization (Geoprobes)		LS	1	$3,500.00	$3,500
Installation of Air Sparing Injection Wells	Assume 1-inch injection wells to max depth of 22 ft BGS; includes drilling, well construction	Each	320	$200.00	$64,000
Installation of Soil Vapor Extraction Wells	Assume 2-inch wells to max depth of 22 ft BGS; includes drilling, well construction	Each	145	$700.00	$101,500
Air Sparging/Soil Vapor Extraction System					
Air Sparging Blower	4,000 CFM, 8" pressure, 15 HP blower system	Each	2	$4,800.00	$9,600
Soil Vapor Extraction Blower	5,000 CFM, 8" pressure, 20 HP blower system	Each	3	$6,800.00	$20,400
Piping / Connections / Controls	Includes materials for piping, connections, and controls from injection wells to AS/SVE system	LS	1	$196,000.00	$196,000
Trenching for Underground Piping	1/2 CY track loader/backhoe; 18,000' L x 1' W' X 3' D	BCY	2,000	$4.85	$9,700
Backfill Trench	1/2 CY track loader/backhoe	BCY	2,000	$4.85	$9,700
Carbon Treatment System	5,000 CFM, 4,700 lb carbon adsorption system	Each	2	$17,600.00	$35,200
Prefilter and Internal Piping		Each	1	$1,500.00	$1,500
Postfilter and Internal Piping		Each	1	$1,500.00	$1,500
Interconnection Piping Kit		Each	1	$1,000.00	$1,000
Pre-Fabricated Enclosure	Includes installation, insulation, piping	LS	1	$30,000.00	$30,000
Installation of System	Includes labor to install blowers, piping, connections, controls, carbon system and piping; 4-man Crew (B-20A)	Day	5	$1,500.00	$7,500
Oversight	Installation of injection (approx 15 per day), soil vapor extraction wells (approx 5 per day), system (assume 15 days), and piping (assume 20 days); assume 2-persons @ $65/hr, 5days/week, 8hr/day	Day	85	$1,040.00	$88,400
Subtotal					$579,500
Electrical Distribution					
Underground Electrical Distribution	Excavate trench for underground service line, 500' L x 1' W' X 3' D; 1/2 CY Tractor Loader/Backhoe	Day	2	$1,000.00	$2,000
Conduit and Tubing	2" dia rigid galvanized steel	LF	500	$8.60	$4,300
Electrical Wiring		LF	500	$5.00	$2,500
Panel Board		Ea	1	$2,500.00	$2,500
Transformer		Ea	1	$7,500.00	$7,500
Electrical Connection Fee	Power source is north of Perimeter Road (overhead lines)	LS	1	NA	$1,500
Install Electrical Connections/Testing	Assume 3- man crew; 8-hr day (1 Electrician @ $55/ hr and 2 helpers @ $25/hr)	Day	5	$840.00	$4,200
Subtotal					$24,500

Table 5-4 Alternative 4 - Air Soil/Soil Vapor Extraction, AOC9 Former Griffiss AFB, Rome, NY

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Full-Scale Monitoring Well Installation					
Mobilization/Demobilization		LS	1	$1,000.00	$1,000
Installation of Piezometers	Assume 13 total 1-inch overburden wells (10 in plume and 3 downgradient of Six Mile Creek), max depth of 22 feet; includes drilling and well construction	Each	13	$200.00	$2,600
Installation of Monitoring Wells	Assume two 2-inch overburden monitoring wells in plume, max depth of 22 feet; includes drilling and well construction	Each	2	$700.00	$1,400
Subtotal					$5,000
Capital Cost Subtotal:					$794,000
Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924):					$733,656
Legal, administrative, engineering fees, construction management:					$150,000
15% Contingency:					$132,548
Total Capital Cost:					**$1,017,000**
Annual Costs (Years 1 through 5)					
Operation & Maintenance					
Air Sparing/Soil Vapor Extraction System Operation & Maintenance	1-person @ $65/hr, 10hr/day, 1 day/week; add 10 days/year for extended and emergency maintenance	Day	62	$650.00	$40,300
Electricity		LS	1	$5,000.00	$5,000
Carbon - Replacement	Assume replacement of carbon once per 12 months; includes reactivation of spent carbon, assume labor included in operation and maintenance	LB	4,700	$1.15	$5,500
Carbon - Transportation and Fees	Includes round trip transportation from Darlington, PA to Rome, NY; documentation fee	LS	1	$1,400.00	$1,400
Carbon - Characterization Analysis	Includes TCLP, Metals, RCRA ignitability, corrosivity, reactivity; sampling labor to be included in operation and maintenance	LS	1	$1,000.00	$1,000
Treatment Monitoring					
Groundwater & Soil Vapor Sampling (Labor)	2-persons @ $65/hr, 10hr/day; 21 total wells - assume 2 wells per day, add 2 days per event for soil vapor sample and groundwater elevation data collection, 4 times per year	Day	50	$1,300.00	$65,000
Groundwater & Soil Vapor Sampling (Equipment)	Groundwater level indicator, multi-parameter instrument, low-flow pump, soil vapor sampling supplies	Day	50	$250.00	$12,500
Groundwater Parameter Analyses (VOC)	Includes TCL VOCs (Method SW8260B); assume 1 groundwater sample per well/piezometers for 21 wells for 4 times per year	Each	84	$200.00	$16,800
Soil Vapor Parameter Analysis (VOCs)	Includes VOCs; assume 1 soil vapor sample per event for 4 times per year	Each	4	$150.00	$600
Data Evaluation and Reporting		HR	96	$90.00	$8,700
Monitoring Well Maintenance		LS	1	NA	$200
Institutional Controls	Maintain/update documentation	LS	1	NA	$500
Subtotal					$157,500
Annual Cost Subtotal:					$157,500
Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924):					$145,530
10% Legal, administrative, engineering fees:					$14,553
15% Contingency:					$24,012
Annual Cost Total:					**$185,000**
Present Worth of Annual Costs:					**$856,000**

Table 5-4 Alternative 4 - Air Soil/Soil Vapor Extraction, AOC9 Former Griffiss AFB, Rome, NY

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Annual Costs (Years 6 through 15)					
Monitoring					
Groundwater Sampling (Labor)	2-persons @ $65/hr, 10hr/day; 8 total wells - assume 2 wells per day, twice per year	Day	8	$1,300.00	$10,400
Groundwater Sampling (Equipment)	Groundwater level indicator, multi-parameter instrument, twice per year	Day	8	$150.00	$1,200
Parameter Analyses (VOC)	Includes TCL VOCs (Method SW8260B); assume 1 groundwater sample per well for 8 wells, twice per year	Each	16	$200.00	$3,200
Data Evaluation and Reporting		HR	72	$90.00	$6,500
Monitoring Well Maintenance		LS	1	NA	$200
Institutional Controls	Maintain/update documentation	LS	1	NA	$500
Subtotal					$22,000
Annual Cost Subtotal:					$22,000
Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924):					$20,328
10% Legal, administrative, engineering fees:					$2,033
15% Contingency:					$3,354
Annual Cost Total:					**$26,000**
Present Worth of Annual Costs:					**$226,000**
Total Present Worth Cost:					**$2,099,000**

Assumptions

1. Assume no site clearing necessary.
2. Assume Air Soil/Soil Vapor Extraction System to operate for 5 years.
3. Assume long-term monitoring will be required for the 10 years only.
4. Unit costs obtained from RS Means ECHOS Cost Reference Books were marked up by 30% to account for Contractor O&P (except for analytical analyses).
5. Engineering estimate of legal, administrative, engineering fees, construction management assumed at $150,000.
6. 15-year present worth of costs assumes 2.675% annual interest rate per "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA 540-R-00-002 July 2000) and the Office of Management and Budget Real Discount Rates last updated January 2003 (http://www.whitehouse.gov/OMB/circulars/a094/a094.html).

Abbreviations:

BCY = bank cubic yards
HR = hour
LB = pound
LCY = loose cubic yards
LS = lump sum
LF = linear foot
SY = square yard

present-worth cost of this modified alternative based on a 15-year period at a discount rate of 2.675% is $1,664,000. (Appendix C includes cost estimates that support this total.) O&M and treatment monitoring costs were assumed for five years, while institutional controls and annual groundwater monitoring costs were assumed for ten years.

5.5 Alternative 5: Extraction, Treatment, and Disposal

5.5.1 Description

This alternative involves collecting and extracting contaminated groundwater using an intercepting trench, followed by treatment with a carbon-adsorption system. Treated groundwater would then be discharged to Six Mile Creek. In addition, this alternative also includes placement of institutional controls and groundwater monitoring similar to Alternative 2, to prevent use of and exposure to on-site contaminated groundwater.

Based on the topography of the site and the groundwater flow direction, the intercepting trench would be located northeast of Six Mile Creek, as shown in Figure 5-5. The trench would extend 250 feet along the width of the plume and perpendicular to groundwater flow and will have a maximum depth of 15 feet. A 6-inch perforated PVC pipe would be installed near the trench bottom to increase the available pore space and water flow. A geomembrane would be used on the downgradient side of the trench to minimize the impact on Six Mile Creek water levels. The collection trench would be backfilled with 14 feet of a highly permeable granular material such as gravel. The upper foot of the trench would be backfilled with topsoil for establishing vegetation. Geotextile filter fabric would be placed around the perforated PVC pipe to minimize fine particles clogging the trench drain system. The trench would have a collection point, where a submersible-type pump would be used to pump the contaminated water through the carbon treatment system housed on a prefabricated structure above grade. Using a trench length of 250 feet and width of 5 feet, and given a hydraulic conductivity and gradient of 0.002 ft/min (10^{-3} cm/s) and 0.042 ft/ft respectively (E & E May 2004), the required pumping rate from the trench was estimated at approximately 10 gpm. Further refining of this analysis using numerical modeling tools and/or aquifer and pilot tests would be required to optimize field parameters and pumping rates if this alternative is selected.

The extracted groundwater would be pumped through a carbon adsorption system comprising two 1,000-lb carbon vessels in series.

The second in-series carbon drum would provide redundancy in the system if breakthrough occurs in the first unit. Pre- and post-filters would be installed to minimize fouling of the carbon vessels by fine sediments. The treatment system would be housed in a prefabricated protective and insulated enclosure. Electric service would be provided to the treatment system and the interceptor trench pump from the existing overhead power source north of Perimeter Road. E & E assumed that sufficient capacity is available from the existing service lines to feed the treatment building. Temperature control would be provided inside the enclosure to prevent system components from freezing. Any external piping would be heat-traced and insulated to prevent freezing.

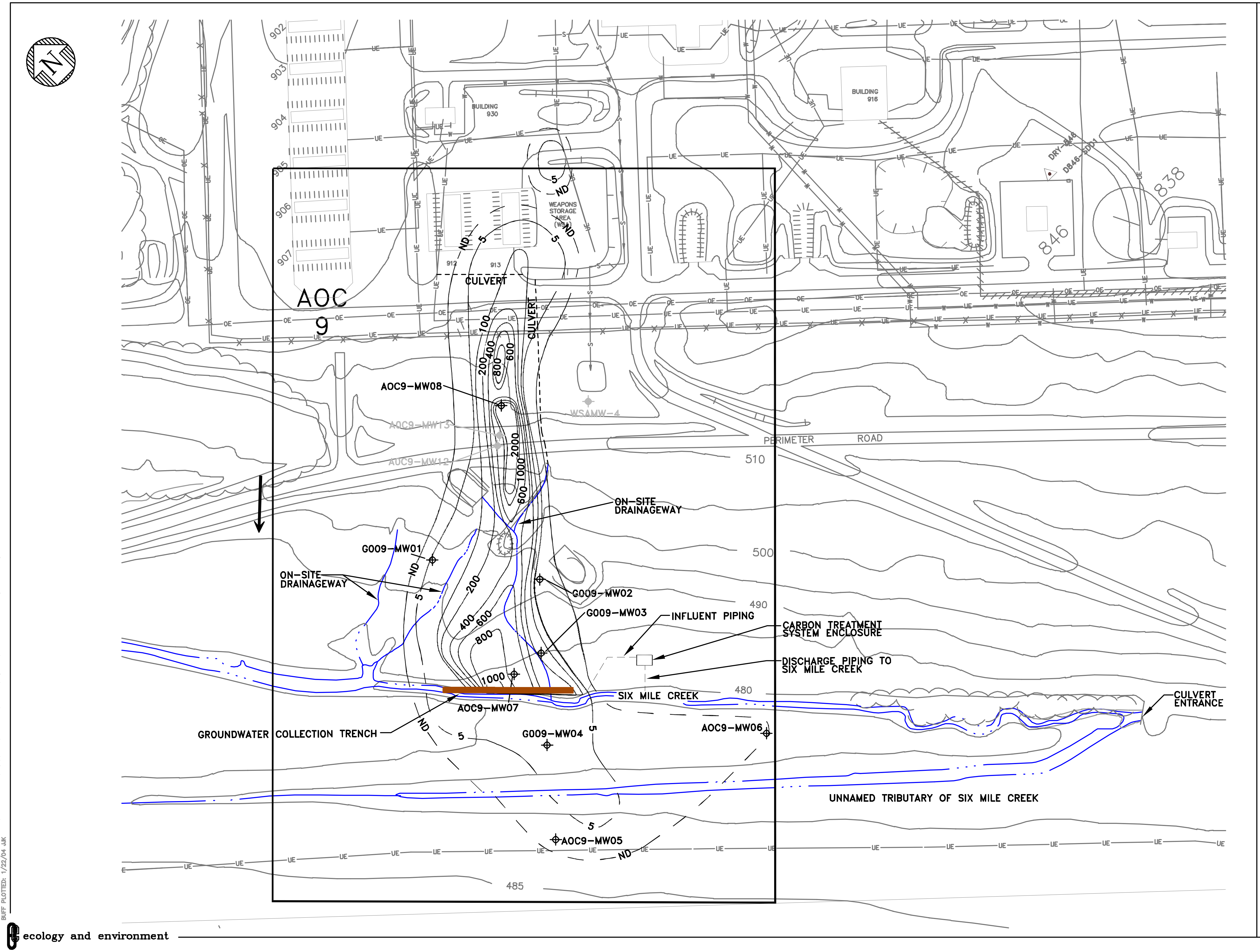
The maximum VOC concentration expected in the extracted groundwater was assumed to be half the maximum VOC concentration detected in the plume for the three of the highest VOC concentrations detected (chlorobenzene, TCE, and DCE). Given these concentrations and a pumping rate of 10 gpm, the carbon usage per day was estimated at 6 pounds of carbon. This amounts to a carbon lifetime of approximately 165 days. Spent carbon would be removed, properly disposed, and replaced with new carbon. Long-term maintenance of the system would require replacing the filters weekly and sampling the influent and effluent for VOC concentrations monthly.

Treated groundwater would be discharged to Six Mile Creek, at an outfall location, via a new underground 3-inch PVC pipe. Institutional controls and monitoring the plume would consist of a program similar to that described in Alternative 2. Eight monitoring wells would be sampled quarterly for the first three years (for VOCs and metals), and annually thereafter (VOCs only). In addition, monthly sampling of the outfall influent and effluent would be performed.

5.5.2 Evaluation of Criteria

Overall Protection of Human Health and the Environment

This alternative would remove contaminants from the subsurface through direct extraction, eliminating future potential exposure threats. Additionally, placement of institutional controls with this alternative would restrict use of contaminated groundwater during cleanup and is therefore protective of human health and the environment.



LEGEND

⌖	EXISTING GROUNDWATER MONITORING WELL
⌖	GROUNDWATER MONITORING WELL TO BE INCLUDED IN LONG-TERM MONITORING PROGRAM
←	DIRECTION OF GROUNDWATER FLOW
—200—	MAXIMUM CHLOROBENZENE ISOCONCENTRATION CONTOUR IN μG/L (DASHED WHEN INFERRED)

SCALE IN FEET
0 100 200 300

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FIGURE 5-5 ALTERNATIVE 5
EXTRACTION, TREATMENT, AND DISPOSAL
AOC9 FORMER GRIFFISS AFB
ROME, NEW YORK

Compliance with Applicable Standards, Criteria, and Guidelines

Through removal of contaminants via extraction, contaminant concentrations in the aquifer would be reduced over time to levels below groundwater standards, thus meeting chemical-specific ARARs. It is anticipated that there will be no issues associated with obtaining necessary approvals/permit equivalency from the state and local agencies to discharge treated water into Six Mile Creek, therefore complying with action-specific ARARs.

Long-term Effectiveness and Performance

Because this alternative includes active treatment of contaminated groundwater and placement of institutional controls that would restrict use of the groundwater, it is protective of human health. Extraction and treatment of the contaminated groundwater will also minimize off-site migration and potential off-site exposure risks.

Reduction in Toxicity, Mobility, or Volume through Treatment

This alternative removes contaminants from the aquifer by adsorption to activated carbon, therefore practically reducing the volume of contamination at the site. Consequently, the toxicity and mobility of contamination will be reduced.

Short-term Effectiveness

Minimal short-term impacts are anticipated during implementation of this alternative. The construction of an intercepting trench and installation of a carbon treatment system would not have substantial impact on the surrounding environment, provided that worker health and safety protection is followed. In addition, no new monitoring wells will be installed to implement the long-term monitoring program.

The duration of construction activities described above would be within approximately 2 to 3 months. Operation and maintenance of the extraction, treatment, and disposal system was assumed to be 30 years.

Implementability

Based on a preliminary groundwater analysis, this alternative is readily implemented using standard construction means and methods. However, further refining of this analysis using numerical modeling tools and/or aquifer tests would be required before selecting this alternative.

Costs

The total present-worth cost of this alternative based on a 30-year period at a discount rate of 3.2% is $2,503,000. Table 5-5 presents the quantities, unit costs, and subtotal costs for the various work items in this alternative. Considerable O&M activities associated with the extraction and carbon treatment system are anticipated with this alternative, resulting in significant annual costs. Annual groundwater monitoring costs and renewal of institutional controls were also assumed for 30 years.

5.6 Alternative 6: Constructed Treatment Wetland

5.6.1 Description

As previously stated in Section 3.2.7, there is evidence that constructed treatment wetlands are successful in treating many VOCs. AOC 9 groundwater primarily contains chlorinated benzenes as well as chlorinated ethenes. The effectiveness of treatment wetlands for chlorinated ethenes has previously been demonstrated. However, removal mechanisms for chlorinated benzenes are less understood. Therefore before constructing a full-scale treatment wetland it is necessary to conduct a pilot study to investigate the feasibility of using CTW technology for groundwater remediation at AOC 9. Furthermore, if this alternative is selected for further analysis, applicable state, federal, local, and Air Force aviation regulations would need to be considered for applicability of a CTW at AOC 9 due to its proximity to a runway (i.e., bird air strike hazard [BASH] concerns). However, it is likely that air hazards could be addressed by constructing a CTW that does not encourage waterfowl habitation.

A small-scale pilot study performed in a laboratory will assist in confirming evidence of biodegradation processes, examining transformation patterns using anaerobic and aerobic microcosms, and estimating degradation rates. Assuming that it would take about one month to establish a microbial population, data would likely be collected for at least six months. Information provided by the pilot study would be used to establish the feasibility of a full-scale CTW. Upon successful study results, a full-scale CTW would be constructed at AOC 9. In addition, it is recommended that an ecological risk screening be performed to verify that the CTW will not result in any adverse impact to wildlife. The following describes components and operations of the CTW.

Table 5-5 Alternative 5 - Extraction, Treatment, and Disposal, AOC9 Former Griffiss AFB, Rome, NY

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Capital Costs					
Work Plan / Final Report	Includes submittals, reporting, meetings	LS	1	NA	$75,000
Pre-Design Investigation	Numerical modeling or aquifer test	LS	1	NA	$50,000
Permits	Assume state/federal water quality permit required; includes permit application and maintenance	LS	1	NA	$5,000
Institutional Controls	Includes deed restrictions	Each	1	$2,500.00	$2,500
Subtotal					$132,500
Health and Safety					
Construct Decontamination Pad & Containment	For equipment & personnel	Setups	2	$2,000.00	$4,000
Air Monitoring	Organic Vapor Analyzer (4 units)	months	2	$4,000.00	$8,000
Health and Safety Plan and Management	Includes development of plan and medical surveillance of on-site personnel	LS	1	NA	$20,000
Site Safety Officer	10 hrs/day, 5days/wk, $65/hr	manweeks	8	$3,250.00	$26,000
Personal Protective Equipment	Includes coveralls, hard hats, safety glasses, reusable boots, gloves	LS	1	NA	$5,000
Subtotal					$63,000
Site Preparation					
Fencing	Temporary fence for on-site storage; includes installation	LF	500	$3.71	$1,900
Subtotal					$1,900
Diversion of Six Mile Creek					
Excavate Diversion Trench	Assume similar cross section of existing Six Mile Creek: 3 foot depth, 10 foot width for approx 375 foot length; excavated soil to be used as fill for portion of creek to be cut-off; 1/2 CY tractor loader/backhoe	BCY	420	$4.85	$2,100
Backfill Existing Six Mile Creek	75 HP Front End Loader with 50 foot haul	BCY	420	$0.94	$400
Compaction	Vibrating Roller, 2 feet wide, 6-inch lifts, 2 passes	BCY	420	$1.51	$700
Subtotal					$3,200

Table 5-5 Alternative 5 - Extraction, Treatment, and Disposal, AOC9 Former Griffiss AFB, Rome, NY

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Collection Trench Construction					
Trench Box	7’ deep, 6’ x 20’, assume rental of 2 trench boxes - monthly rate	months	2	$1,550.00	$3,100
Excavate Trench	250’ L x 5’ W x 15’ D; 1/2 CY track loader/backhoe; (Crew B-11M)	Day	10	$1,000.00	$10,000
6" dia. Perforated Pipe - incl. Installation	250’ L	LF	250	$11.22	$2,900
Haul Excavated Material to Stockpile	1.5 CY front end loader; assume 23% swell factor	LCY	900	$1.88	$1,700
Characterization Sampling	Includes TCLP, Metals, RCRA ignitability, corrosivity, reactivity	LS	4	$1,000.00	$4,000
Load Soil onto Dump Trucks	75 HP front end loader; swell factor of 23%	LCY	900	$1.88	$1,700
Haul Soil to Landfill	Includes round trip haul; 1.30 tons/BCY	Ton	950	$25.00	$23,800
Landfill Disposal Fee	Assume non-hazardous	Ton	950	$35.00	$33,300
Filter Fabric	Includes polypropylene fabric material and installation around perforated pipe + 10% for overlap	SY	50	$1.64	$100
Geomembrane	60 mil thick includes installation, 250’L x 15’D	SF	3,750	$1.35	$5,100
Gravel (Material)	1"-rounded, includes delivery; assume 14’ gravel fill; 1.43 ton/LCY	Ton	1,000	$10.50	$10,500
Topsoil (Material)	Assume 1’ topsoil fill, includes delivery; 1.43 tons/LCY	Ton	100	$12.90	$1,300
Placement of Gravel / Topsoil	1.5 CY front end loader	LCY	770	$1.88	$1,500
Compaction of Gravel / Backfill	Vibrating Roller, 2 feet wide, 6-inch lifts, 2 passes	BCY	730	$1.51	$1,200
Seeding	Bluegrass 4#, spread with push spreader	MSF	2	$54.50	$100
Installation of Riser Pipe	10" PVC Pipe , includes installation	LS	1	NA	$3,500
Installation of Hot Box	Includes piping, valves, flow meter, heat tracing	LS	1	NA	$7,500
Pump and Controls	4" submersible pump; 1/2 HP; 8-14 gpm w/ controls; up to 140’ head	Each	1	$2,200.00	$2,200
Dewatering	Two-4" diaphragm pumps used for 8 hrs/day; includes labor	Day	20	$258.00	$5,200
Water Tank	10,000 gal, aboveground	months	2	$2,050.00	$4,100
Carbon Drum (for Dewatering)	55-gal drum (200 lb carbon); assume no carbon replacement	Each	2	$500.00	$1,000
Prefilter and Internal Piping	Bag Filter Type +10% for Delivery	Each	1	$1,100.00	$1,100
Postfilter and Internal Piping	Bag Filter Type +10% for Delivery	Each	1	$1,100.00	$1,100
Interconnection Piping Kit		Each	1	$650.00	$700
Carbon - Disposal	Includes transportation	LB	400	$1.00	$400
Carbon - Characterization Analysis	Includes TCLP, Metals, RCRA ignitability, corrosivity, reactivity; sampling labor to be included in operation and maintenance	LS	1	$1,000.00	$1,000
Pre-Fabricated Enclosure	Includes installation, insulation, piping	LS	1	$15,000.00	$15,000
Oversight	During construction of collection trench, Six Mile Creek diversion, and other activities (approx 60 days); assume 2-persons @ $65/hr, 5days/week, 8hr/day	Day	60	$1,040.00	$62,400
Subtotal					$205,500
Carbon Treatment System					
Carbon Adsorption System	CARBTROL, HP-1000 Water Purification Adsorber Unit, 1,000 lbs of Carbon, +10% for Delivery	Each	2	$4,730.00	$9,500
Prefilter and Internal Piping	Bag Filter Type +10% for Delivery	Each	2	$1,100.00	$2,200
Postfilter and Internal Piping	Bag Filter Type +10% for Delivery	Each	2	$1,100.00	$2,200
Interconnection Piping Kit		Each	2	$650.00	$1,300
Pre-Fabricated Enclosure	Includes Installation, insulation, piping	LS	1	$40,000.00	$40,000
Installation of Carbon System and Piping	4-man Crew (B-20A)	Day	8	$1,500.00	$12,000
Subtotal					$67,200
Discharge Pipe					
Discharge Pipe Trenching (from treatment system to Six Mile Creek)	1/2 CY Tractor Loader/Backhoe, 100’ L x 1’ W x 3’ D (Crew B-11 M)	Day	3	$1,000.00	$3,000
4" dia HDPE Pipe - Installed		LF	100	$10.45	$1,100
Gravel (Material Only)	Assume 1.43 Ton/BCY	Ton	20	$10.50	$300
Placement of Gravel	FEL, 1.5 CY Bucket. (Crew B-10S)	Day	1	$900.00	$900
Subtotal					$5,300

Table 5-5 Alternative 5 - Extraction, Treatment, and Disposal, AOC9 Former Griffiss AFB, Rome, NY

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Electrical Distribution					
Underground Electrical Distribution	Excavate trench for underground service line, 500' L x 1' W' X 3' D; 1/2 CY Tractor Loader/Backhoe	Day	2	$1,000.00	$2,000
Conduit and Tubing	2" dia rigid galvanized steel	LF	500	$8.60	$4,300
Electrical Wiring		LF	500	$5.00	$2,500
Panel Board		Ea	1	$2,500.00	$2,500
Transformer		Ea	1	$7,500.00	$7,500
Electrical Connection Fee	Power source is north of Perimeter Road (overhead lines)	LS	1	NA	$1,500
Install Electrical Connections/Testing	Assume 3- man crew; 8-hr day (1 Electrician @ $55/ hr and 2 helpers @ $25/hr)	Day	5	$840.00	$4,200
Subtotal					$24,500
				Capital Cost Subtotal:	$503,100
				Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924):	$464,864
				Legal, administrative, engineering fees, construction management:	$125,000
				15% Contingency:	$88,480
				Total Capital Cost:	**$679,000**
<u>Annual Costs (Years 1 through 3)</u>					
Carbon Treatment System Maintenance					
Weekly replacement of filters	Assume 1 person @ $65/hr, 4 hrs/wk	wk	52	$260.00	$13,600
Carbon - Replacement (Material)	Assume twice a year	LB	2,000	$1.15	$2,300
Carbon - Replacement (Labor)	Assume 2 people, 10-hr days @ $65/hr + vacuum truck; 2 times per year	Day	2	$3,500.00	$7,000
Carbon - Transportation and Fees	Includes round trip transportation from Darlington, PA to Rome, NY; documentation fee; 2 times per year	LS	2	$1,400.00	$2,800
Carbon - Characterization Analysis	Includes TCLP, Metals, RCRA ignitability, corrosivity, reactivity; sampling labor to be included in operation and maintenance; two times per year	LS	2	$1,000.00	$2,000
Electricity		LS	1	$5,000.00	$5,000
Monthly system sampling	Analyze effluent for VOCs; labor included in weekly system maintenance	Each	12	$200.00	$2,400
Monitoring					
Groundwater Sampling (Labor)	2-person @ $65/hr, 8hr/day 8 monitoring wells 4 times per year - assume 8 days per year; 8hr/day 2 samples per outfall (influent/effluent) once per month - assume 12 days per year	Day	20	$1,040.00	$20,800
Groundwater Sampling (Equipment)	Groundwater level indicator, multi-parameter instrument, low-flow pump	Day	20	$200.00	$4,000
Parameter Analyses (VOC)	Includes TCL VOCs (Method SW8260B); assume 1 groundwater sample from 8 monitoring wells 4 times per year and 2 groundwater samples from the outfall 12 times per year	Each	56	$200.00	$11,200
Parameter Analyses (Metals)	Includes TAL Metals; assume 1 groundwater sample from 8 monitoring wells 4 times per year and 2 groundwater samples from the outfall 12 times per year	Each	32	$320.00	$10,300
Data Evaluation and Reporting		HR	96	$90.00	$8,700
Monitoring Well Maintenance		LS	1	NA	$200
Institutional Controls	Maintain/update documentation	LS	1	NA	$500
Permits	Water permit; maintain/update documentation	LS	1	NA	$500
Subtotal					$91,300
				Annual Cost Subtotal:	$91,300
				Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924):	$84,361
				10% Legal, administrative, engineering fees:	$8,436
				15% Contingencies:	$13,920
				Annual Cost Total:	**$107,000**
				Present Worth of Annual Costs:	**$302,000**

Table 5-5 Alternative 5 - Extraction, Treatment, and Disposal, AOC9 Former Griffiss AFB, Rome, NY

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
<u>Annual Costs (Years 4 through 30)</u>					
Carbon Treatment System Maintenance					
Weekly replacement of filters	Assume 1 person @ $65/hr, 4 hrs/wk	wk	52	$260.00	$13,600
Carbon - Replacement (Material)	Assume twice a year	LB	2,000	$1.15	$2,300
Carbon - Replacement (Labor)	Assume 2 people, 10-hr days @ $65/hr + vacuum truck; 2 times per year	Day	2	$3,500.00	$7,000
Carbon - Transportation and Fees	Includes round trip transportation from Darlington, PA to Rome, NY; documentation fee; 2 times per year	LS	2	$1,400.00	$2,800
Carbon - Characterization Analysis	Includes TCLP, Metals, RCRA ignitability, corrosivity, reactivity; sampling labor to be included in operation and maintenance; two times per year	LS	2	$1,000.00	$2,000
Electricity		LS	1	$5,000.00	$5,000
Monthly system sampling	Analyze effluent for VOCs; labor included in weekly system maintenance	Each	12	$200.00	$2,400
Monitoring					
Groundwater Sampling (Labor)	2-person @ $65/hr, 8hr/day 8 monitoring wells once per year - assume 2 days per year; 8hr/day 2 samples per outfall (influent/effluent) once per month - assume 12 days per year	Day	14	$1,300.00	$18,200
Groundwater Sampling (Equipment)	Groundwater level indicator, multi-parameter instrument, low-flow pump	Day	14	$200.00	$2,800
Parameter Analyses (VOC)	Includes TCL VOCs (Method SW8260B); 1 groundwater sample from 8 monitoring wells per year and 2 groundwater samples from the outfall 12 times per year	Each	32	$200.00	$6,400
Data Evaluation and Reporting		HR	96	$90.00	$8,700
Monitoring Well Maintenance		LS	1	NA	$200
Institutional Controls	Maintain/update documentation	LS	1	NA	$500
Permits	Water permit; maintain/update documentation	LS	1	NA	$500
Subtotal					$72,400
Annual Cost Subtotal:					$72,400
Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924):					$66,898
10% Legal, administrative, engineering fees:					$6,690
15% Contingencies:					$11,038
Annual Cost Total:					**$85,000**
Present Worth of Annual Costs:					**$1,522,000**
Total Present Worth Cost:					**$2,503,000**

<u>Assumptions</u>

1. Assume no site clearing necessary.
2. For moist to wet soil, assume swell factor of 23% (<u>Means Estimating Handbook</u>. United States of America : Means Southern Construction Information Network, 1990, page 46).
3. For site soils, assume 96 lb/CF (or 1.30 Tons/BCY) (<u>Means Estimating Handbook</u>. United States of America : Means Southern Construction Information Network, 1990, page 833).
4. For topsoil, assume 1.43 Tons/LCY per quote from Alliance Paving Materials Inc. Rome, NY.
5. For dry, loose, gravel, assume 1.43 Tons/LCY per quote from Alliance Paving Materials Inc. Rome, NY.
6. Unit costs obtained from RS Means ECHOS Cost Reference Books were marked up by 30% to account for Contractor O&P
7. Assume long-term monitoring will be required for the first 10 years only.
8. Engineering estimate of legal, administrative, engineering fees, construction management assumed at $125,000.
9. 30-year present worth of costs assumes 3.2% annual interest rate per "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA 540-R-00-002 July 2000) and the Office of Management and Budget Real Discount Rates last updated January 2003 (http://www.whitehouse.gov/OMB/circulars/a094/a094.html).

<u>Abbreviations:</u>

BCY = bank cubic yards
HR = hour
LB = pound
LCY = loose cubic yards
LS = lump sum
LF = linear foot
SY = square yard

This alternative involves the construction of a treatment wetland designed to capture on-site contaminated groundwater and reduce contaminants of concern, primarily total VOCs, to acceptable levels for discharge to surface water. A preliminary conceptual design for the surface flow wetland system at AOC 9 includes a groundwater collection trench, a primary treatment cell, auxiliary cells, and a monitoring outfall. Based on the topography of the site and the groundwater flow direction, the collection trench would be located northeast of Six Mile Creek, as shown in Figure 5-6. The trench would extend 250 feet along the width of the plume and would have a maximum depth of 15 feet. A geomembrane would be used on the downgradient side of the trench to minimize the impact on Six Mile Creek water levels. The collection trench would be backfilled with 14 feet of highly permeable granular material such as stone and cobble. The upper foot of the trench would be backfilled with topsoil for establishing vegetation. This trench will be constructed to intercept the groundwater plume and collect contaminated groundwater for distribution to the surface of the constructed treatment wetland cells.

Water will then flow from the trench into the treatment cell. The cell was preliminarily sized based on assumed VOC degradation rates, hydraulic loadings, maximum total VOC concentrations expected in the groundwater near Six Mile Creek (assumed to be half the maximum VOC concentration detected in the plume), and surface water cleanup criteria. An internal full-scale pilot study performed by E & E estimated the degradation rate for DCE to be 0.06 ft/day (E & E April 2002). DCE was selected as the design degradation rate for AOC 9 VOCs of concern as degradation rates and removal mechanisms for VOCs of concern, particularly chlorobenzene, are not well understood and have not been published. Based on a literature review and some field measurements this rate may be conservative and will likely change seasonally (Jackson et al. 2000). The selected degradation rate would be verified during the pilot study.

The hydraulic loading is defined as the volume of water flowing into the wetland from the collection trench per unit time and is controlled by the hydrology of the system and time of year. Based on a field pump test, the average hydraulic conductivity at AOC 9 is 1.8 x 10^{-3} cm/s (E & E May 2004). The average site groundwater hydraulic gradient estimated in the 2003 RI was 0.042 ft/ft. Therefore with the cross sectional area of the plume estimated as 3,750 ft^2 (250 feet wide by 15 feet deep) the hydraulic loading to the wetland is approximately 8,400 gallons per day (or 1,100 ft^3/day). Target effluent concentrations are based on proposed surface water cleanup goals of 5 µg/L for chlorobenzene and 1,4-dichlorobenzene and 1 µg/L for tetrachloroethene, which will result in a contaminant mass reduction of approximately 0.06 lb/day for chlorobenzene and less than 0.01 lb/day each for 1,4-dichlorobenzene and tetrachloroethene. It is possible that these proposed cleanup goals may be increased, potentially up to 100 µg/L for chlorobenzene, because once groundwater concentrations have reached this level, the majority of contaminant mass would be remediated. For purposes of this FS, CTW sizing and costs will be conservatively presented with proposed cleanup goals of 5 µg/L for chlorobenzene and associated COCs indicated above.

Based on the design criteria and assumptions discussed above, the CTW would be approximately 2 acres in size and have a hydraulic retention time of 45 days (assuming 6 inches of standing water) to reduce VOC mass loadings by approximately 99%. One 1-acre treatment cell will be constructed to treat the groundwater plume, with two 0.5-acre auxiliary cells on either side to maintain a consistent hydraulic gradient across the cells. Prefabricated flow control boxes with weirs would be installed at the outlet to each of these cells. Each flow control box contains a series of weir plates to control the surface water level in the wetland cell. Excavated soils will be disposed off-site at a nearby landfill. Treated water flowing out of the wetland cells through the flow control boxes will be hard-piped to a single monitored discharge point (regulated outfall) that would discharge to the diverted section of Six Mile Creek. The regulated outfall would also comprise a prefabricated flow control box with a weir. Preliminary sizing calculations are included in Appendix B and the proposed layout of the collection trench and surface flow treatment wetland system is depicted in Figure 5-6.

In order to take advantage of existing topography to construct the treatment wetland, the existing portion of Six Mile Creek that intersects the groundwater plume at AOC 9 would be diverted to the southeast to the unnamed tributary of Six Mile Creek (see Figure 5-6).

Water quality samples to be collected monthly during the first year of operation would be from the regulated outfall and six new 1-inch piezometers. Three piezometers will be installed in the collection trench and three downstream of the regulated outfall near the diverted section of Six Mile Creek. Monthly water quality sampling for the first year was assumed for this alternative. Each sampling event would consist of VOC and metals analysis from the regulated outfall and six new piezometers.

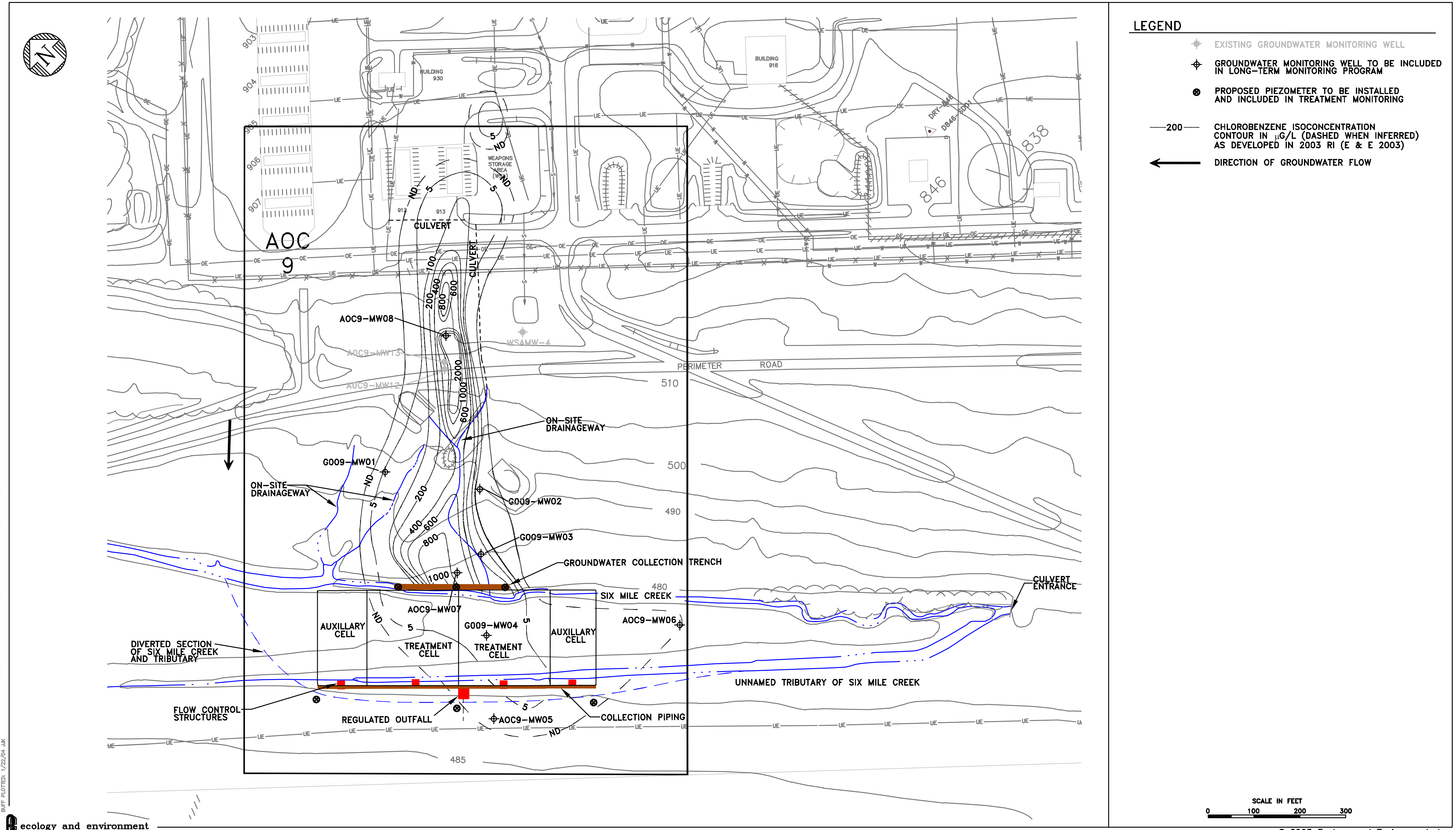

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FIGURE 5–6 ALTERNATIVE 6
CONSTRUCTED TREATMENT WETLAND
AOC9 FORMER GRIFFISS AFB
ROME, NEW YORK

Institutional controls and a long-term monitoring program would be implemented similar to that described in Alternative 2. Eight monitoring wells and six new piezometers would be sampled quarterly for the first three years (for VOCs and metals), and annually thereafter (VOCs only). In addition, monthly sampling of the outfall influent and effluent would be performed. For purposes of this FS, it is assumed that long-term monitoring and associated O&M will be performed for 30 years because of the passive nature of this technology.

5.6.2 Evaluation of Criteria

Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment because the passive treatment of contaminated groundwater in the CTW is expected to reduce contaminant levels below proposed cleanup goals. This alternative would also minimize potential exposure to groundwater from on-site drainageways and Six Mile Creek where site groundwater discharges to the surface/creek as the creek will be diverted. Furthermore, the placement of institutional controls (deed restrictions) would restrict and help minimize future uses/exposures and therefore this alternative is protective of human health and the environment.

Any adverse impact to Six Mile Creek from AOC 9 would be minimized by remediating groundwater before discharge into Six Mile Creek. While it has been E & E’s experience that this type of a CTW will provide minimal impacts to wildlife, it is recommended that ecological risk screening be performed to verify that the CTW will not result in any adverse impact to wildlife.

Compliance with Applicable Standards, Criteria, and Guidelines

Through removal of contaminants via natural processes enhanced by the construction of a wetland, contaminant concentrations in the aquifer are expected to be reduced over time to levels below groundwater standards, thus meeting chemical-specific ARARs. It is anticipated that there will be no issues associated with obtaining necessary approvals/permits from the state and local agencies to discharge treated water into Six Mile Creek, therefore complying with action-specific ARARs.

Long-term Effectiveness and Performance

Because this alternative includes passive treatment of contaminated groundwater and placement of institutional controls that would restrict use of the groundwater, this alternative would be effective in the long-term. The treatment of contaminated groundwater would also minimize off-site migration and potential off-site exposure risks.

Reduction in Toxicity, Mobility, or Volume through Treatment

By removing contamination in the aquifer, this alternative reduces the volume of contaminated groundwater on site. By constructing a treatment wetland, the discharge of groundwater would be controlled and mobility of contaminated groundwater reduced. This alternative would also reduce toxicity levels of contaminated groundwater through natural processes such as biodegradation, volatilization, and photochemical oxidation.

Short-term Effectiveness

Due to the locale of AOC 9 and activities required to implement this alternative, short-term impacts to the surrounding community and workers would be minimal. However, there would be short-term impacts to the environment during construction of the collection trench, wetland, and diversion of Six Mile Creek, which would disrupt more than 2 acres of land. Sediment and erosion controls would be placed to minimize impacts to the environment associated with these construction activities.

Before construction associated with the CTW can start, a pilot study and ecological risk screening for a CTW at AOC 9 must be performed, which would take approximately 6 months. Construction of the CTW described above would be completed within approximately 6 to 8 months, which includes about a month of start-up once the CTW has been constructed.

Implementability

Based on a preliminary groundwater analysis, this alternative is readily implemented using standard construction means and methods. However, BASH issues would need to be addressed and further refining of this analysis using results from a pilot study and ecological risk screening would be required before this alternative is selected.

Costs

The total present-worth cost of this alternative based on a 30-year period at a discount rate of 3.2% is $2,789,000. Table 5-6 presents the quantities, unit costs, and subtotal costs for the various work items in this alternative. Annual O&M, water quality monitoring costs, and renewal of institutional controls and permits were also assumed for 30 years with this alternative.

Table 5-6 Alternative 6 - Constructed Treatment Wetland, AOC9 Former Griffiss AFB, Rome, NY

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Capital Costs					
Work Plan / Final Report	Includes submittals, reporting, meetings	LS	1	NA	$75,000
Small-Scale Pilot Study	Includes conceptual design, laboratory tests, documentation, and reports	LS	1	NA	$50,000
Ecological Risk Screening	Includes development of report	LS	1	NA	$15,000
Permits	Assume state/federal water quality permit required; includes permit application and maintenance	LS	1	NA	$5,000
Institutional Controls	Includes deed restrictions	Each	1	$2,500.00	$2,500
Subtotal					$147,500
Health and Safety					
Construct Decontamination Pad & Containment	For equipment & personnel	Setups	2	$2,000.00	$4,000
Air Monitoring	Organic Vapor Analyzer (4 units)	months	2	$4,000.00	$8,000
Health and Safety Plan and Management	Includes development of plan and medical surveillance of on-site personnel	LS	1	NA	$20,000
Site Safety Officer	10 hrs/day, 5days/wk, $65/hr	manweeks	8	$3,250.00	$26,000
Personal Protective Equipment	Includes coveralls, hard hats, safety glasses, reusable boots, gloves	LS	1	NA	$5,000
Subtotal					$63,000
Site Preparation					
Survey (Labor)	Pre-construction survey, 3 person crew	Day	5	$1,275.00	$6,400
Survey (Equipment)	Includes total station, tripod and rod	Day	5	$225.00	$1,200
Topsoil Stripping	Strip 6" over 2 acres	BCY	1,700	$1.32	$2,244
Erosion and sedimentation controls	Silt fencing, straw mat, and straw bales	LS	1	NA	$2,000
Subtotal					$11,900
Diversion of Six Mile Creek					
Excavate Diversion Trench	Assume similar cross section of existing Six Mile Creek: 3 foot depth, 10 foot width for approx 1,500 foot length; excavated soil to be used as fill for portion of creek to be cut-off; 1/2 CY track loader/backhoe	BCY	1,700	$4.85	$8,300
Backfill Existing Six Mile Creek	75 HP Front End Loader with 300 foot haul	BCY	1,700	$2.78	$4,800
Compaction	Vibrating Roller, 2 feet wide, 6-inch lifts, 2 passes	BCY	1,700	$1.51	$2,600
Subtotal					$15,700
Collection Trench Construction					
Trench Box	7’ deep, 6’ x 20’, assume rental of 2 trench boxes - monthly rate	months	2	$1,550.00	$3,100
Excavate Trench	250’ L x 5’ W x 15’ D; 1/2 CY track loader/backhoe; (Crew B-11M)	Day	10	$1,000.00	$10,000
Haul Excavated Material to Stockpile	1.5 CY front end loader; assume 23% swell factor	LCY	900	$1.88	$1,700
Characterization Sampling	Includes TCLP, Metals, RCRA ignitability, corrosivity, reactivity	LS	4	$1,000.00	$4,000
Load Soil onto Dump Trucks	75 HP front end loader; swell factor of 23%	LCY	900	$1.88	$1,700
Haul Soil to Landfill	Includes round trip haul; 1.30 tons/BCY	Ton	950	$25.00	$23,800
Landfill Disposal Fee	Assume non-hazardous	Ton	950	$35.00	$33,300
Geomembrane	60 mil thick includes installation, 250’L x 15’D	SF	3,750	$1.35	$5,100
Gravel (Material)	1"-rounded, includes delivery; assume 14’ gravel fill; 1.43 ton/LCY	Ton	1,000	$10.50	$10,500
Topsoil (Material)	Assume 1’ topsoil fill, includes delivery; 1.43 tons/LCY	Ton	100	$12.90	$1,300
Placement of Gravel / Topsoil	1.5 CY front end loader	LCY	770	$1.88	$1,500
Compaction of Gravel / Backfill	Vibrating Roller, 2 feet wide, 6-inch lifts, 2 passes	BCY	730	$1.51	$1,200
Seeding	Bluegrass 4#, spread with push spreader	MSF	2	$54.50	$100
Dewatering	Two-4" diaphragm pumps used for 8 hrs/day; includes labor	Day	20	$258.00	$5,200
Water Tank	10,000 gal, aboveground	months	2	$2,050.00	$4,100
Carbon Drum (for Dewatering)	55-gal drum (200 lb carbon); assume no carbon replacement	Each	2	$500.00	$1,000
Prefilter and Internal Piping	Bag Filter Type +10% for Delivery	Each	1	$1,100.00	$1,100
Postfilter and Internal Piping	Bag Filter Type +10% for Delivery	Each	1	$1,100.00	$1,100
Interconnection Piping Kit		Each	1	$650.00	$700
Carbon - Disposal	Includes transportation	LB	400	$1.00	$400
Carbon - Characterization Analysis	Includes TCLP, Metals, RCRA ignitability, corrosivity, reactivity	LS	1	$1,000.00	$1,000
Subtotal					$111,900

Table 5-6 Alternative 6 - Constructed Treatment Wetland, AOC9 Former Griffiss AFB, Rome, NY

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Wetland Construction					
Excavation and Stockpile Soil	Excavate 2 acres; 3' bgs; 3 CY excavator; 3:1 side slopes	BCY	10,100	$2.32	$23,500
Haul Excavated Soil to Stockpile	1.5 CY front end loader; assume 23% swell factor	LCY	12,500	$1.88	$23,500
Characterization Sampling	Includes TCLP, Metals, RCRA ignitability, corrosivity, reactivity	LS	8	$1,000.00	$8,000
Load Soil onto Dump Trucks	75 HP front end loader; 23% swell factor	LCY	12,500	$1.88	$23,500
Haul Soil to Landfill	Includes round trip haul; 1.30 tons/BCY	Ton	13,130	$25.00	$328,300
Landfill Disposal Fee	1.30 tons/BCY; assume non-hazardous	Ton	13,130	$35.00	$459,600
Grading subbase of wetland	Fine grading	SY	9,700	$0.60	$5,900
Compact wetland subbase	Vibrating Roller, 2 feet wide, 6-inch lifts, 2 passes	BCY	1,700	$1.51	$2,600
Haul topsoil from stockpile	Assume 16.5 CY truck, less than 1 mile round trip	BCY	3,300	$2.84	$9,400
Spread topsoil and medium grading	1.5 CY front end loader; assume 23% swell factor	LCY	4,100	$1.88	$7,800
Flow Control Structures (Material)	V-Notch weirs and boxes; 3 weirs (one for each cell) and 1 for outfall	Each	4	$1,000.00	$4,000
Flow Control Structures (Labor)	2-prerson crew; assume skilled labor @ $50.50/hr for 8 hr/day	Day	5	$808.00	$4,100
8" Perforated PVC Pipe	Includes installation	LF	300	$11.83	$3,600
Wetland Planting	Assorted wetland mixture to include cattails	Acre	2	$10,000.00	$20,000
Documentation Survey (Labor)	Assume 3 survey documentations; each 3 days; 3 person crew	Day	9	$1,275.00	$11,500
Documentation Survey (Equipment)	Includes total station, tripod and rod	Day	9	$225.00	$2,100
Dewatering	Two-4" diaphragm pumps used for 8 hrs/day; includes labor	Day	30	$258.00	$7,800
Water Tank	10,000 gal, aboveground (included under Collection Trench Construction)	months	0	$2,050.00	$0
Carbon Drum (for Dewatering)	55-gal drum (200 lb carbon); assume no carbon replacement	Each	2	$500.00	$1,000
Prefilter and Internal Piping	Bag Filter Type +10% for Delivery	Each	1	$1,100.00	$1,100
Postfilter and Internal Piping	Bag Filter Type +10% for Delivery	Each	1	$1,100.00	$1,100
Interconnection Piping Kit		Each	1	$650.00	$700
Carbon - Disposal	Includes transportation	LB	400	$1.00	$400
Carbon - Characterization Analysis	Includes TCLP, Metals, RCRA ignitability, corrosivity, reactivity; sampling labor to be included in operation and maintenance	LS	1	$1,000.00	$1,000
Fencing	Perimeter fence around wetland and outfall; includes installation	LF	1,200	$3.71	$4,500
Mobilization/Demobilization (Piezometers)		LS	1	$1,000.00	$1,000
Installation of Piezometers	Assume 6 total 1-inch piezometers (3 in collection trench and 3 downgradient of diverted Six Mile Creek), max depth of 22 feet; includes drilling, well construction	Each	6	$200.00	$1,200
Oversight	During construction of CTW, collection trench, Six Mile Creek diversion, and other activities (approx 2 months); assume 2-persons @ $65/hr, 5days/week, 8hr/day	Day	44	$1,040.00	$45,760
Subtotal					$1,002,960
Capital Cost Subtotal:					$1,352,960
Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924):					$1,250,135
15% Legal, administrative, engineering fees, construction management:					$187,520
15% Contingencies:					$215,648
Total Capital Cost:					**$1,654,000**

Table 5-6 Alternative 6 - Constructed Treatment Wetland, AOC9 Former Griffiss AFB, Rome, NY

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Annual Costs (Years 1 through 3)					
Operation and Maintenance					
Quarterly Wetland Inspections	1-person @ $65/hr, 8hr/day	Day	4	$520.00	$2,100
Replacement of Damaged Vegetation		Acre	0.1	$10,000.00	$1,000
Fence Maintenance		LS	1	NA	$100
Maintenance of Flow Control Structures		LS	1	NA	$500
Monitoring					
Groundwater Sampling (Labor)	2-person @ $65/hr, 8hr/day 8 monitoring wells + 6 piezometers 4 times per year - assume 8 days per year; 8hr/day 2 samples per outfall (influent/effluent) once per month - assume 12 days per year	Day	20	$1,040.00	$20,800
Groundwater Sampling (Equipment)	Groundwater level indicator, multi-parameter instrument, low-flow pump	Day	20	$200.00	$4,000
Parameter Analyses (VOC)	Includes TCL VOCs (Method SW8260B); assume 1 groundwater sample from 8 monitoring wells + 6 piezometers 4 times per year and 2 groundwater samples from the outfall 12 times per year	Each	80	$200.00	$16,000
Parameter Analyses (Metals)	Includes TAL Metals; assume 1 groundwater sample from 8 monitoring wells 4 times per year and 2 groundwater samples from the outfall 12 times per year	Each	56	$320.00	$18,000
Data Evaluation and Reporting		HR	96	$90.00	$8,700
Monitoring Well Maintenance		LS	1	NA	$200
Institutional Controls	Maintain/update documentation	LS	1	NA	$500
Permits	Water permit; maintain/update documentation	LS	1	NA	$500
Subtotal					$72,400
Annual Cost Subtotal:					$72,400
Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924):					$66,898
10% Legal, administrative, engineering fees:					$6,690
15% Contingencies:					$11,038
Annual Cost Total:					**$85,000**
Present Worth of Annual Costs:					**$240,000**
Annual Costs (Years 4 through 30)					
Operation and Maintenance					
Quarterly Wetland Inspections	1-person @ $65/hr, 8hr/day	Day	4	$520.00	$2,100
Replacement of Damaged Vegetation		Acre	0.1	$10,000.00	$1,000
Fence Maintenance		LS	1	NA	$100
Maintenance of Flow Control Structures		LS	1	NA	$500
Monitoring					
Groundwater Sampling (Labor)	2-person @ $65/hr, 8hr/day 8 monitoring wells + 6 piezometers once per year - assume 2 days per year; 8hr/day 2 samples per outfall (influent/effluent) once per month - assume 12 days per year	Day	14	$1,300.00	$18,200
Groundwater Sampling (Equipment)	Groundwater level indicator, multi-parameter instrument, low-flow pump	Day	14	$200.00	$2,800
Parameter Analyses (VOC)	Includes TCL VOCs (Method SW8260B); 1 groundwater sample from 8 monitoring wells + 6 piezometers per year and 2 groundwater samples from the outfall 12 times per year	Each	38	$200.00	$7,600
Data Evaluation and Reporting		HR	96	$90.00	$8,700
Monitoring Well Maintenance		LS	1	NA	$200
Institutional Controls	Maintain/update documentation	LS	1	NA	$500
Permits	Water permit; maintain/update documentation	LS	1	NA	$500
Subtotal					$42,200
Annual Cost Subtotal:					$42,200
Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924):					$38,993
10% Legal, administrative, engineering fees:					$3,899
15% Contingencies:					$6,434
Annual Cost Total:					**$50,000**
Present Worth of Annual Costs:					**$895,000**
Total Present Worth Cost:					**$2,789,000**

Table 5-6 Alternative 6 - Constructed Treatment Wetland, AOC9 Former Griffiss AFB, Rome, NY

Item Description	Comment	Unit	Quantity	Unit Cost	Cost

Assumptions

1. For moist to wet soil, assume swell factor of 23% (Means Estimating Handbook. United States of America : Means Southern Construction Information Network, 1990, page 46).

2. For site soils, assume 96 lb/CF (or 1.30 Tons/BCY) (Means Estimating Handbook. United States of America : Means Southern Construction Information Network, 1990, page 833).

3. For topsoil, assume 1.43 Tons/LCY per quote from Alliance Paving Materials Inc. Rome, NY.

4. For dry, loose, gravel, assume 1.43 Tons/LCY per quote from Alliance Paving Materials Inc. Rome, NY.

5. Unit costs obtained from RS Means ECHOS Cost Reference Books were marked up by 30% to account for Contractor O&P (except for analytical analyses).

6. Legal, administrative, engineering, and construction management fees for capital costs estimated at 15% due to the detailed engineering involved with the CTW design and additional regulatory interaction.

7. 30-year present worth of costs assumes 3.2% annual interest rate per "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA 540-R-00-002 July 2000) and the Office of Management and Budget Real Discount Rates last updated January 2003 (http://www.whitehouse.gov/OMB/circulars/a094/a094.html).

Abbreviations:

BCY = bank cubic yards
HR = hour
LCY = loose cubic yards
LS = lump sum
LF = linear foot
MSF = thousand square feet
SY = square yard

6

Comparison of Alternatives

6.1 Overall Protection of Human Health and the Environment

Under existing site conditions, there are currently no on-site human or environmental receptors in direct contact with overburden groundwater contamination. However, site groundwater discharges to the surface in certain areas and to Six Mile Creek, allowing the potential for exposure to site contaminants by site visitors. Alternative 1 will not prevent possible future exposures to on-site contaminated groundwater. Alternative 2 includes institutional controls and a monitoring program to minimize potential future exposures to contaminants. Although no efforts would be made to eliminate the existing groundwater contamination, current and potential future uses of the site would permit this alternative to be protective of human health and the environment. Alternatives 3, 4, and 5 employ active treatment, while Alternative 6 employs passive treatment to eliminate contaminated groundwater and institutional controls, providing the highest level of protection.

6.2 Compliance with Applicable Standards, Criteria, and Guidelines

Groundwater standards comprise the chemical-specific ARARs for contamination at this site. Alternatives 1 and 2 do not comply with ARARs since contaminated groundwater will not be treated. Alternatives 3 through 5 employ active treatment and Alternative 6 employs passive treatment and will reduce concentrations below ARARs. Alternatives 3 and 4 would reduce COC concentrations below ARARs within an assumed shorter period of time than Alternatives 5 and 6. These in situ treatments are expected to remove 99% of the contaminant mass, leaving approximately 1% of the original contaminant mass to naturally attenuate over an assumed ten-year period. Alternatives 5 and 6 would also reduce COC concentrations below ARARs over an assumed 30-year treatment period.

6.3 Long-term Effectiveness

Because Alternatives 1 and 2 do not involve the removal or treatment of contaminated groundwater, contamination will remain essentially the same. However, institutional controls combined with long-term monitoring in Alternative 2 provide an effective long-term mechanism to protect human health and the environment.

Alternatives 3 and 4 use active technologies while Alternative 6 employs passive in situ treatment technologies. As with any in situ technology, effectiveness cannot be well predicted until after pilot studies and/or initial implementations of the technology. The in situ chemical oxidation pilot study at AOC 9, as briefly described in Alternative 3, has proven thus far to be effective in reducing COC concentrations. Air sparging described in Alternative 4 is a proven technology that has been used at many sites with similar COCs and is expected to be reasonably effective. Full-scale CTWs have been used at a limited number of sites and the technology's effectiveness is more difficult to predict. Because an on-site chemical oxidation pilot study has already been performed and results indicate this technology is effective, Alternative 3 is one step ahead of the other technologies in proving its long-term effectiveness. Pending successful implementation of Alternatives 4 and 6 technologies, both would represent effective, long-term effective solutions.

Alternative 5 employs a more established technology and thus its effectiveness is easier to predict. Extraction and treatment is a well-established technology that is known to control plume migration and thus increase protectiveness. Over the long term it would provide effective protection. However, its ability to completely reduce concentrations to levels below groundwater standards throughout the aquifer is somewhat limited by the long time frames required to reduce concentrations.

6.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 1 and 2 do not involve removal and treatment of contaminated groundwater and, therefore, the toxicity, mobility, and volume of contamination will not be reduced. Alternatives 3 through 6 employ treatment mechanisms to reduce toxicity of contaminants in the plume. Alternatives 3 and 4 treat the contaminants directly in situ, thus providing the most effective and rapid toxicity reduction. Alternatives 5 and 6 rely on migration of contaminants to an extraction well or collection trench followed by treatment aboveground. This provides effective treatment, but at a slower rate.

6.5 Short-term Effectiveness

No short-term impacts are anticipated during implementation of Alternatives 1 and 2 as Alternative 1 involves no action and Alternative 2 utilizes existing site wells for a long-term monitoring program. Because AOC 9 is an open area, the remaining alternatives (3, 4, 5, and 6) will result in minor impacts associated with the installation of wells, construction of a collection trench, or development of a CTW. Alternative 6 will disturb the largest surface area at the site.

Alternatives 3 and 4 would also provide the shortest duration of implementation. In situ chemical oxidation treatment (Alternative 3) at the site is assumed to be complete within one year, with no structures to remain on-site, although monitoring would continue for ten years. AS/SVE treatment is assumed for five years, with a treatment enclosure to remain on-site and a long-term monitoring program to continue for 10 years. Although construction activities for Alternatives 5 and 6 are assumed to be complete within a year, the duration of treatment has not been estimated but is assumed to require decades before standards are met due to mass transfer limitations.

6.6 Implementability

There are no actions to implement for Alternative 1. Alternatives 2 and 3 are readily implemented. Alternatives 4, 5, and 6 employ in situ and ex situ treatment technologies, which would require pilot-scale testing (and/or numerical modeling for Alternative 5) to demonstrate effectiveness prior to implementation. The technology used to remediate site COCs as described in Alternative 6 is developmental. There is a possibility that this testing would reveal technical problems that may limit the ability to implement these technologies or require significant changes from the assumptions that have been made regarding, for example, degradation rates, that may increase costs or time of implementation.

6.7 Cost

Alternative 1 calls for no action and thus incurs no costs. Alternative 2, which includes long-term monitoring, is the least expensive of the remaining alternatives at a present-worth cost of $510,000, including a 30-year monitoring program that uses existing wells.

Alternatives 3, 4, and 6 call for active or passive in situ treatment. Estimates of the costs for these alternatives depend greatly on input from vendors of the respective technologies. One vendor/professional was contacted for each technology and historical project costing information (if available) was recorded. The cost estimate obtained from the chemical oxidation vendor is relatively realistic as pilot studies performed (by this vendor) were taken into consideration before costing the full-scale implementation of this technology. On the other hand, the cost estimate for full-scale implementation obtained from the AS/SVE vendor is an order of magnitude cost estimate, not fully representing site-specific conditions and subsequently not used in the estimate developed as part of this FS. This is because a cost estimate for in situ treatment cannot be very reliable before bench- and/or pilot-scale testing. Standard construction costs were assumed for full-scale implementation of the CTW. Therefore, a direct comparison of separate in situ treatment technology costs should be performed with the awareness of the uncertainties involved in their estimate assumptions.

Considering these issues, the AS/SVE technology employed by Alternative 4 is estimated to be the least expensive (present worth of $2,099,000) of the three in situ technologies, followed by chemical oxidation (present worth of $2,149,000), which are in turn estimated to be less than the CTW (present worth of $2,789,000). The cost savings between the similar Alternatives 3 and 4 lie primarily in the costs of reagent and number of injection wells for chemical oxidation. Even though AS/SVE is estimated to take longer to complete, its fewer points of treatment make for a lower total cost.

Alternative 5 employs extraction and treatment to remediate on-site groundwater contamination. Its present-worth cost is estimated to be greater than any of the in situ treatment technologies. Most of its $2,503,000 estimated present worth is due to the present worth of 30 years of operation and maintenance.

Cost estimates for AOC 9 groundwater remediation alternatives are summarized in Table 6-1.

Table 6-1 Summary of Total Present Values at AOC 9, Former Griffiss AFB, Rome, New York

Description	Alternative 1 No Action	Alternative 2 Institutional Controls and Long-term Monitoring	Alternative 3 In Situ Chemical Oxidation	Alternative 4 Air Sparging/ Soil Vapor Extraction	Alternative 5 Extraction, Treatment, and Disposal	Alternative 6 Constructed Treatment Wetland
Total Project Duration (Years)	0	30	10	15	30	30
Capital Cost	$0	$13,000	$1,895,000	$1,017,000	$679,000	$1,654,000
Annual Costs	$0	$26,000	$29,000	Years 1-5 $185,000	Years 1-3 $107,000	Years 1-3 $85,000
				Years 6-15 $26,000	Years 4-30 $85,000	Years 4-30 $50,000
Total Present Value of Alternative	**$0**	**$510,000**	**$2,149,000**	**$2,099,000**	**$2,503,000**	**$2,789,000**

7

Recommendation

Considering the RAOs for AOC 9 and the remedial alternative evaluation completed in Sections 5 and 6, the recommended remedy for AOC 9 is in situ chemical oxidation (Alternative 3).

In situ chemical oxidation of contaminated groundwater represents an active remedial approach to permanently reduce the toxicity, mobility, and volume of site contaminants of concern, which per NYSDEC TAGM 4030 is a preferred technology when practical. This alternative also provides for protection of human health and the environment, has the ability to have the shortest treatment duration of the alternatives, and does not place restrictions on future use of the site (site expected to remain vacant; see Section 1.2). Although in situ chemical oxidation was not the least expensive alternative, it was in the same order of magnitude as the other active treatment alternatives (Alternatives 4, 5, and 6). The chemical oxidation pilot study performed at the site proved successful, with up to 99% contaminant removal.

The no action and institutional controls/long-term monitoring alternatives do not comply with ARARs; therefore, RAOs will not be achieved. AS/SVE provides the same level of protection to human health and the environment as the in situ chemical oxidation alternative, but would require the performance of a pilot study to determine site-specific effectiveness and the remedial duration is expected to be 5 years longer than in situ chemical oxidation due to O&M of the AS/SVE system. Extraction, treatment, and disposal also provides the same level of protection to human health and the environment as the in situ chemical oxidation alternative, but is a more costly alternative that will require treatment/O&M activities over 30 years as opposed to the expected 10 years for the proven in situ chemical oxidation technology. Additionally, both AS/SVE and extraction, treatment, and disposal alternatives are less desirable in the hierarchy of remedial technologies as per NYSDEC TAGM 4030 since these technologies would generate wastes that would need to be properly disposed. Implementing a CTW would also require the performance of a pilot study on a technology that has not been successfully demonstrated on a full-scale basis for the contaminants of concern at AOC 9. Other issues, such as BASH concerns and greater costs than all of the other alternatives, suggests a CTW to be less desirable than other alternatives.

8

References

Duffield, G.M., 1998. Aqtesolve for Windows, Version 2.13 – Professional Software. Hydro SOLVE, Inc.

Ecology and Environment (E & E), June 2004, *Final Groundwater Treatability Pilot Study Report, Former Griffiss Air Force Base, Rome, New York,* Lancaster, New York.

__________, May 2004, *AOC 9: Weapons Storage Area (WSA) Landfill, Final 2002 Remedial Investigation Report, Former Griffiss Air Force Base, Rome, New York,* Lancaster, New York.

__________, December 2003, *Final Records of Decision for Areas of Concern (AOCs), Three Mile Creek and Six Mile Creek Former Griffiss Air Force Base, Rome, New York*, Lancaster, New York.

___________, December 2002, *Final Landfill 6, Building 775, AOC 9, and Building 817 Weapons Storage Area (WSA), Technical Memorandum No. 1: Bedrock Groundwater Study,* Lancaster, New York.

__________, October 2002, *AOC 9: Weapons Storage Area (WSA) Landfill Supplemental Investigation Draft 2002 Data Summary Report, Former Griffiss Air Force Base, Rome, New York*, Lancaster, New York.

___________, April 2002, *Draft Remedial Action Plan, Schilling Farm Site, Hillsdale, Michigan*, Lancaster, New York.

___________, August 2001, *AOC 9: Weapons Storage Area (WSA) Landfill Supplemental Investigation Final Data Summary Report, Former Griffiss Air Force Base, Rome, New York,* Lancaster, New York.

__________, July 1998a, *Draft Report for Expanded Site Investigation and Confirmatory Sampling of Areas of Interest and Drywell/Wastewater-Related Systems, Former Griffiss Air Force Base, Rome New York*, Lancaster, New York.

__________, July 1998b, *Final Report for Supplemental Investigation of Areas of Concern, Griffiss Air Force Base, Rome, New York*, Lancaster, New York.

__________, December 1997, *Final Screening Table for Drywells, Grease Traps, Silver Recovery Units, and Miscellaneous Waste Water - Related Systems, Former Griffiss Air Force Base, Rome, New York*, Lancaster, New York.

_________, 1996, *Confirmatory Sampling Report for 15 Areas of Interest (AOIs), Group I AOIs, Griffiss Air Force Base, Rome New York*, Lancaster, New York.

Jackson, W.A., and J.H. Pardue, 2000, Natural Attenuation Case Study for Chlorobenzenes in a Forested Wetland, *Wetlands & Remediation, An International Conference*, Battelle Press.

Kruseman and de Ridder, 1991, Analysis and Evaluation of Pumping Test Data, 2nd ed.

Law Environmental, Inc. (Law), 1996, *United States Air Force, Griffiss Air Force Base, New York, Draft Final Report, Volume 6, Remedial Investigation, Six Mile Creek Area of Concern*, Kennesaw, Georgia, Law Environmental Inc.

Leeson, A., et al., August 2002, Air Sparging Design Paradigm, Columbus, Ohio.

Lorah, et al., n.d., *USGS Natural Attenuation of Chlorinated Organic Compounds in a Freshwater Tidal Wetland, Aberdeen Proving Ground, Maryland 1997.*

Means, Jeffrey L., and Robert E. Hinchee, eds., 2000, *Wetlands and Remediation: An International Conference, November 16-17, 1999, Salt Lake City, Utah*, Columbus, Ohio, Battelle Press.

Naval Facilities Engineering Service Center, August 2001, Air Sparging Guidance Document, (Technical Report TR-2193-ENV), Port Hueneme, California.

Nishino, et al., 1992, Chlorobenzene Degradation by Bacteria Isolated From Contaminated Groundwater, *Applied and Environmental Microbiology*, Volume 58, No. 5, pp 1719-1726.

New York State Department of Environmental Conservation, 1990, Technical and Administrative Guidance Memorandum (TAGM) No. 4030, “Selection of Remedial Actions at Inactive Hazardous Waste Sites,” Albany, New York.

__________, 1994, *Fish and Wildlife Impact Analysis for Inactive Hazardous Waste Sites (FIWA),* Albany, New York, New York State Department of Environmental Conservation Division of Fish and Wildlife.

__________, June 1998, Ambient Water Quality Standard and Guidance Values, and Groundwater Effluent Limitations, April 2000 addendum.

__________, January 1999, *Technical Guidance for Screening Contaminated Sediments,* Albany, NY, New York State Department of Environmental Conservation Division of Fish and Wildlife and Division of Marine Resources.

Roberson, et al., 1998, *Hydraulic Engineering,* 2nd ed., New York, New York.

Tetra Tech, 1994, *Basewide Environmental Baseline Survey, Griffiss Air Force Base, Rome, New York*, San Bernardino, California.

U.S. Air Force, 1995, *Final Supplemental Environmental Impact Statement for the Disposal and Reuse Griffiss AFB, New York,* Washington D.C.

_________, September 1999, *Final Supplemental Environmental Impact Statement for the Disposal and Reuse of Airfield Property at Griffiss AFB, New York*, Washington D.C.

U.S. Environmental Protection Agency, October 1988, Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, EPA 1540/8-891004, Washington, D.C., Office of Emergency and Remedial Response.

__________, 1989, *Risk Assessment Guidance for Superfund (RAGS): Volume 1 - Human Health Evaluation Manual (Part A, Interim Final).* Washington, D.C., Office of Emergency and Remedial Response.

__________, 1996, North American Treatment Wetland Database, <http://firehole.humboldt.edu/wetland/twdb.html> Website last updated 1 November 2000 and as accessed May 13, 2003.

__________, 2001, Risk Assessment Issue Paper for: Derivation of Provisional Inhalation RfC for Aluminum (CASRN 7429-90-5), Cincinnati, Ohio, Superfund Technical Support Center, National Center for Environmental Assessment.

__________, December 2001, *Risk Assessment Guidance for Superfund (RAGS): Volume 1 - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting and Review of Superfund Risk Assessment),* Washington, D.C., Office of Emergency and Remedial Response.

__________, January 2002, U.S. Department of Environmental Protection Office of Solid Waste and Emergency Response, Field Applications of In Situ Remediation Technologies: Permeable Reactive Barriers.

U.S. Geological Survey, October 1998, *The Use of Treatment Wetlands for Petroleum Effluents,* Health and Environmental Sciences Department, Publication Number 4672, API Publishing Services.

van der Meer, et al., 1998, Evolution of a Pathway for Chlorobenzene Metabolism Leads to Natural Attenuation in Contaminated Groundwater, in *Applied and Environmental Microbiology*, Vol. 64, No. 11, pp 4185-4193.

A

Contaminated Groundwater Volume Calculations

02:1391001.CDR-10/19/01-GRA

ecology and environment

Computation Sheet

Project No.		
Preliminary ☐		
Final ☐		
Void ☐		
Sheet ______ of ______		
Rev.	Completed By: KMP	Checked By: JJF
☒	Initials: 5 / 19 / 03	Initials: W / 30 / 03
	Initials: / /	Initials: / /

Project Name Griffis AFB - AOC9 FS

Subject Estimation of Contaminated Groundwater (Chlorobenzene)

Objective: Determine Volume of Contaminated groundwater at AOC9

Assumptions:

1. Surface area defined by 5 μg/L Contour for chlorobenzene developed on Figure 4-3 of 2003 RI (E&E 2003) and reproduced as Figure 2-3 of this report.

2. Depth to groundwater 11' BGS north of Perimeter Road, and 3.5' BGS South of Perimeter Road. (See Section 5.1 of 2003 RI [E&E 2003]).

3. Depth to bedrock approximately 15' below the water table (See Cross-section Figures 4-4 through 4-6 of 2003 RI [E&E 2003]).

4. Attached is table of Contour interval areas of Chlorobenzene as shown in Figure 2-3 of this report. (included as Table 5-2 of this Report)

5. Assume porosity of 0.35 for silty sand and sand (2003 RI [E&E 2003])

Calculations:

Total Area: $A_T = (4,200 + 2,705 + 7,156 + 17,143 + 17,449 + 24,522 + 27,175 + 106,814)\ ft^2$

$A_T = 207,163\ ft^2$

Contaminated groundwater Depth

$D = 15 ft$

$V = A_T D = (207,163\ ft^2)(15 ft)(0.35) = \boxed{1,087,605\ ft^3 = 8,135,856\ gal}$

Table 5-2 Comparison of Contaminant Mass per Depth to Areas Described by Different Intervals of Contaminant Concentration at AOC 9

Contour Interval (ug/L)	Lower Bound Concentration of Contour Interval (ug/L)	Area of Contour Interval (ft2)	Percent Area of Contour Interval Compared to Entire Plume Area (%)	Mass of Contaminants per Foot Within Interval (lb/ft) (lower bound concentration multiplied by incremental contour interval area)	Cumulative Percentage of Total Mass of Contaminants Per Depth (%)
>2000	2000	4,200	1.1	0.52	19.9
1000-2000	1000	2,705	1.9	0.17	26.3
800-1000	800	7,156	3.8	0.36	39.8
600-800	600	17,143	8.5	0.64	64.2
400-600	400	17,449	13.3	0.44	80.7
200-400	200	24,522	20.0	0.31	92.3
100-200	100	27,175	27.4	0.17	98.7
5-100	5	106,814	56.5	0.03	100.0
ND-5	ND	159,476	100.0	-	-
Total		**366,639**			

Note:

1. Contour interval areas determined by E&E and AutoCAD file associated with Figure 2-3 of this report.

B

Constructed Treatment Wetland Sizing Calculations

Appendix B

Surface Water Flow Constructed Treatment Wetland Sizing Calculations

Parameter	Symbol	Data Source	Units	Values		
Hydraulic conductivity of AOC 9 soils	k	AOC 9 field data[1]	cm/s	0.0018		
			ft/day	5.10		
Cross sectional area of plume (250' x 15')	A	AOC 9 field data[1]	ft^2	3750		
Hydraulic gradient of groundwater	I	AOC 9 field data[1]	ft/ft	0.042		
Design flow	Q	Q = k*I*A	m^3/day	23		
			ft^3/day	804		
			gpd	6,011		
				CB	**PCE**	**1,4 DCE**
Influent concentration	Ci	maximum concentration[2]	mg/L	1176	87	114
Target effluent concentration	Ce	surface water standards[3]	mg/L	5	1	5
Wetland background limit	C*	zero background for VOCs	mg/L	0	0	0
Reduction fraction to target	Fe	Fe = 1-Ce/Ci	%	99.6%	98.8%	95.6%
Area rate constant	k	previous pilot study results[4]	m/yr	6.7	6.7	6.7
Required wetland area	Areq	A = Q/k * ln (Ci-C*/Ce-C*)	ha	0.7	0.6	0.4
			acres	1.7	1.4	1.0
Necessary area	A	largest required area, > Are	ha	0.7		
			acres	1.7		
Hydraulic loading rate	HLR	HLR = Q/A	cm/day	0.34		
Mass of Contaminant Treated			grams/day	26.8	2.0	2.6
			pounds/day	0.06	0.004	0.01
Hydraulic retention time (6" water)	HRT	HRT = water depth*A/Q	days	45.5		
Effluent concentrations	Co	Co = C*+(Ci-C*) xp (-kA/Q)	mg/L	5.0	0	0

Key:

CB = Chlorobenzene
PCE = Tetrachloroethene
1,4 DCE = 1,4 - Dichlorobenzene

cm = centimeters
ft = feet
ft^2 = square feet
ft^3 = cubic feet
gpd = gallons per day
ha = hectare
L = liter
m = meter
m^3 = cubic meter
s = seconds
mg = micrograms

Notes:

1. Hydraulic gradient obtained from July 2003 pump test (E&E 2003).
2. Maximum groundwater concentrations detected within 75 feet northeast of Six Mile Creek (within plume) from Geoprobe/Hydropunch data obtained from 2000 and 2002 SI (E & E).
3. NYSDEC, June 1998, Ambient Water Quality Standard and Guidance Values, most stringent of the Class C or D Aquatic or Human Health Standards
4. Decay rate constants for the listed VOCs were taken from a 4-year pilot study of a treatment wetland treating those VOCs (E & E April 2002). Decay rates are field-derived for all seasons in a northern climate and for all degradation mechanisms.
5. Conversion Rates

1 gal = 3.785 L
1 lb = 453.6 grams